SPPY 101/SPPC 101

POSTGRADUATE COURSE

M.Sc. - Psychology / M.Sc., Counselling Psychology

FIRST YEAR

FIRST SEMESTER

CORE PAPER - I

ADVANCED GENERAL PSYCHOLOGY - 1

INSTITUTE OF DISTANCE EDUCATION

UNIVERSITY OF MADRAS

M.Sc. Psychology /
M.Sc., Counselling Psychology

CORE PAPER - I
ADVANCED GENERAL PSYCHOLOGY-1

FIRST YEAR - FIRST SEMESTER

WELCOME

Warm Greetings.

It is with a great pleasure to welcome you as a student of Institute of Distance Education, University of Madras. It is a proud moment for the Institute of distance education as you are entering into a cafeteria system of learning process as envisaged by the University Grants Commission. Yes, we have framed and introduced Choice Based Credit System(CBCS) in Semester pattern from the academic year 2018-19. You are free to choose courses, as per the Regulations, to attain the target of total number of credits set for each course and also each degree programme. What is a credit? To earn one credit in a semester you have to spend 30 hours of learning process. Each course has a weightage in terms of credits. Credits are assigned by taking into account of its level of subject content. For instance, if one particular course or paper has 4 credits then you have to spend 120 hours of self-learning in a semester. You are advised to plan the strategy to devote hours of self-study in the learning process. You will be assessed periodically by means of tests, assignments and quizzes either in class room or laboratory or field work. In the case of PG (UG), Continuous Internal Assessment for 20(25) percentage and End Semester University Examination for 80 (75) percentage of the maximum score for a course / paper. The theory paper in the end semester examination will bring out your various skills: namely basic knowledge about subject, memory recall, application, analysis, comprehension and descriptive writing. We will always have in mind while training you in conducting experiments, analyzing the performance during laboratory work, and observing the outcomes to bring out the truth from the experiment, and we measure these skills in the end semester examination. You will be guided by well experienced faculty.

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With best wishes from mind and heart,

DIRECTOR i/c

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M.A. DEGREE COURSE

FIRST YEAR

FIRST SEMESTER

Core Paper - I

ADVANCED GENERAL PSYCHOLOGY - I

SYLLABUS

Objectives: This paper enables students to learn psychological processes in detail and to appreciate different approaches to psychological processes.

UNIT –I:

Definition of psychology: Sub-fields of psychology – Experimental, Biological, Personality, Social, Clinical and Counseling, Development and quantitative psychology - Methods in psychology –Survey, Case Study, Naturalistic, Observation, Experiment.

UNIT – II:

The Nervous system: Communication in the Nervous system and interaction between neuron - Neurotransmitters and its functions - The Spinal cord and its functions - the Brian and its functions -

UNIT-III:

The five senses – its characteristics - Definition of perception - Features of perception - Approaches to perception - Constructional view of perception- Ecological view of perception -Psychophysics. Attention – Determinants of attention - Selective, focused and divided attention.

UNIT –IV:

Definition of Learning - Classical Learning - Instrumental and perant conditioning Learning - Observational Learning - Cognitive Process in Learning.

UNIT –V:

Types of Memory – Stages of Memory – Sensory Memory – Short-term Memory and Long-term Memory – Causes of forgetting – Constructing Memory – Improving Memory.

Reference

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M.A. DEGREE COURSE

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Core Paper - I

ADVANCED GENERAL PSYCHOLOGY - 1

SCHEME OF LESSONS

LESSON 1
INTRODUCTION TO PSYCHOLOGY

INTRODUCTION

Psychology interests people because it asks questions that virtually every aspect of human life. Psychology also affects human lives through its influence laws and public policy. Because psychology affects so many aspects of human life, even people who do not intend to specialize in it need to know something about this dynamic field. In this lesson the meaning of psychology and its major subfields are explained briefly.

LEARNING OBJECTIVES

After completing this lesson you will be able to understand

- the definition of psychology
- the fields of psychology.
- the subfields of psychology

PLAN OF THE LESSON

1.1 Definition of Psychology

The word “psychology comes from the Greek words “psyche , meaning life, and “logos, meaning explanation. Psychology is literally the study of the mind or soul, and people de?ned it that way until the early 1900s. Around 1920, psychologists became disenchanted with the idea of studying the mind. The reason why is that, first, research deals with what we observe, and the mind is unobservable. Second, talking about “the mind” implies it is a thing or object. Mental activity is a process. It is not like the river but like the ?ow of the river; not like the automobile but like the movement of the automobile. Beginning in the early 1900s, psychologists de?ned their ?eld as the study of behavior. So for a compromise, psychology is defined as the systematic study of behavior and experience. Psychology is concerned with the experience and behaviour of the individual. Behaviour is the expression of experience, which belongs to a subject, and which is due to the interaction of subject and object. It implies the duality of subject and object. If there were no subject and object, there would be no experience.

Therefore, Psychology is defined as the scientific study of human behaviour and mental processes. The word human behavior means everything that we do and that can be observed directly. Mental processes refers to the thoughts, feelings, and motives that are not directly observable. Since psychology is a science, systematic methods are used to observe, describe, predict, and explain behavior.

1.2 Fields of Psychology

Psychology is a huge, diverse ?eld that is difficult to summarize. Nevertheless, let’s start with three of the most general statements about psychology. “It Depends.” Hardly anything is true about the behavior of all people at all times. Almost every aspect of behavior depends on age. Behavior also varies with people’s genetics, health, past experiences, and whether they are currently awake or asleep. In some ways, behavior differs between males and females or from one culture to another. Some aspects depend on the time of day, the temperature of the room, or how recently someone ate. The way people answer a question depends on exactly how the question is worded, what other questions they have already answered, and who is asking the question. When I describe “it depends” as a general truth of psychology, you may think I am suggesting that psychology has no real answers. On the contrary, “it depends” is a serious point. The key is to know what it depends on.

Psychology as a field of enquiry has grown in many directions, during its journey for more than hundred years. In contemporary times a number of specialized fields which focuses on the area of application have developed. The emergence of different fields in psychology indicates the importance and relevance of these areas in our daily life.

During the 20th century, the focus of psychology was on solving psychological problems, such as mental disorders and social disturbances. Generally, psychologists were associated with the changing of bad behaviors and problematic mental processes; however, psychologists also study and work with psychologically healthy people.

1.3 Subfields of Psychology

Psychology is a meeting ground for different disciplines. Association for Psychological Science president John Cacioppo (2007) described psychology as a hub scientific discipline. The tribe of psychology is united by a common quest: describing and explaining behavior and the mind underlying it through their diverse activities, from biological experimentation to cultural comparisons. Thus, it's a perfect home for those with wide-ranging interests.

A person with an undergraduate degree in psychology will be able to apply the knowledge of behaviors and mental processes to a variety of job possibilities in business, service areas, and research. However, having a graduate degree in psychology expands job opportunities and options. A student considering graduate studies in psychology has many areas of specialization from which to choose. Psychology's main fields include basic research, applied research, clinical science and its applications.

Psychology's subfields encompass basic research (often done by biological, developmental, cognitive, personality, and social psychologists), applied research (sometimes conducted by industrial/ organizational psychologists), and clinical science and applications (the work of counseling psychologists and clinical psychologists).

Some psychologists conduct basic research that builds psychology's knowledgebase.

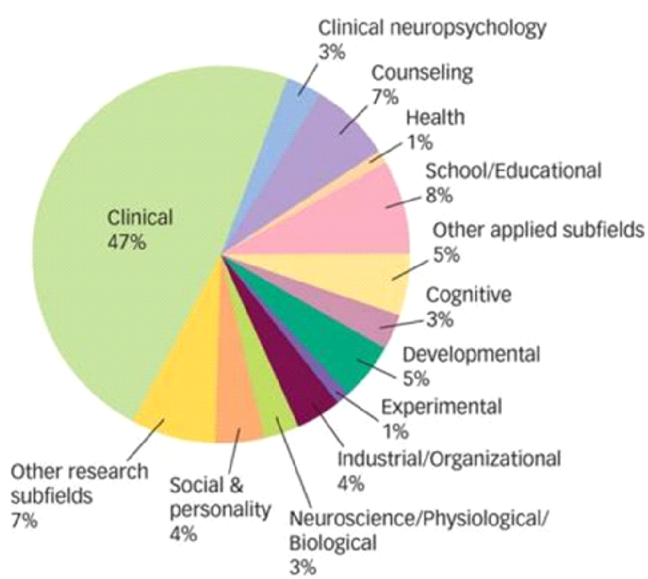
- biological psychologists explore the links between brain and mind.
- developmental psychologists studying our changing abilities from womb to tomb.
- cognitive psychologists experimenting with how we perceive, think, and solve problems.

- personality psychologists investigating our persistent traits.
- social psychologists exploring how we view and affect one another.

These psychologists also may conduct applied research that tackles practical problems. So do other psychologists, including industrial/organizational psychologists, who use psychology's concepts and methods in the workplace to help organizations and companies select and train employees, boost morale and productivity, design products, and implement systems.

Psychology is also a helping profession devoted to such practical issues as how to have a happy marriage, how to overcome anxiety or depression, and how to raise thriving children. As a science, psychology at its best bases such interventions on evidence of effectiveness.

Counseling psychologists help people to cope with challenges and crises (including academic, vocational, and marital issues) and to improve their personal and social functioning. Clinical psychologists assess and treat mental, emotional, and behavior disorders (APA, 2003). Both counseling and clinical psychologists administer and interpret tests, provide counseling and therapy, and sometimes conduct basic and applied research. By contrast, psychiatrists, who also often provide psychotherapy, are medical doctors licensed to prescribe drugs and otherwise treat physical causes of psychological disorders. Let us see each subfield in detail. It is easy to understand the subfields of psychology if you look at some of the basic questions about behaviour that they address.



Diagrametic representation of subfields of psychology

1.3.1 Biological Psychology:

In the most fundamental sense, people are biological organisms. Biological psychology is the study of the biological substrates of behavior and mental processes. Biological psychology is also known as behavioral neuroscience. Behavioral neuroscience is the subfield of psychology that mainly examines how the brain and the nervous system—but other biological processes as well—determine behavior. Thus, neuroscientists consider how our bodies influence our behavior. For example, they may examine the link between specific sites in the brain and the muscular tremors of people affected by Parkinson's disease or attempt to determine how our emotions are related to physical sensations.

This sub field of psychology, the biological psychology includes different specialties like physiological psychology, cognitive neuroscience and neuro psychology. Physiological psychologists study the neural, genetic, and cellular mechanisms that underlie specific behaviors such as learning, memory and fear response susing animal models, typically rats. Cognitive neuroscientists study the psychological processes in humans by investigating the neural correlates of the psychological processes using neural imaging tools. Neuro-psychologists determines the specific characteristics and the extent of cognitive deficits due to brain damage or disease by conducting psychological assessments.

1.3.2 Clinical Psychology:

Clinical psychology is the study and application of psychology to understand, prevent, and relieve psychologically based distress or dysfunction and also helps to promote subjective well-being and personal development. Though clinical psychologists engage in research, teaching, consultation, forensic testimony, program development and administration, its main focus is, psychological assessment and psychotherapy. Clinical psychologists promote psychological health in individuals, groups, and organizations.

Some clinical psychologists specialize in specific psychological disorders. Others treat a range of disorders, from adjustment difficulties to severe psychopathology. Clinical psychologists might engage in research, teaching, assessment, and consultation. Some hold workshops and lectures on psychological issues for other professionals or for the public. Clinical psychologists work in a variety of settings, including private practice, mental health service organizations, schools, universities, industries, legal systems, medical systems, counseling centers, government agencies, and military services.

To become a clinical psychologist, you will need to earn a doctorate from a clinical psychology program. The APA sets the standards for clinical psychology graduate programs, offering accreditation (official recognition) to those who meet their standards. Clinical psychology is primarily concerned with diagnosis and treatment of various psychological disorders. Clinical psychologists are trained in psychotherapeutic techniques, using which they treat people suffering from psychological disorders. Mild problems pertaining to adjustment in social and emotional life are handled by counseling psychologists.

Counseling psychologists help people adjust to life transitions or make life-style changes. This field is very similar to clinical psychology, except that counseling psychologists typically help people with adjustment problems rather than severe psychopathology. Like clinical psychologists, counseling psychologists conduct therapy and provide assessments to individuals and groups. Counseling psychologist, would emphasize the clients' strengths, helping clients cope during a transitional time using their own skills, interests, and abilities. Counseling psychologist also provides specialized services to deal with marital problems, stress oriented problems and career choice. Clinical-neuro psychologists focus on the clinical management of patients with brain.

Clinical psychology is considered as a regulated mental health profession in many countries. Clinical psychologists perform their work using several therapeutic approaches, all of which involve a formal relationship enclosed by professional and client (usually an individual, couple, family, or small group). To form a therapeutic alliance, to explore the nature of psychological problems, and encourage the new methods of thinking, feeling, or behaving, the therapeutic approaches and practices are associated with different theoretical perspectives and employ different procedures.

Four major theoretical perspectives generally employed are psychodynamic, cognitive behavioral, existential–humanistic, and systems or family therapy. With an increased understanding of issues concerning culture, gender, spirituality, and sexual orientation, the integration of the different therapeutic approaches are on the rise. With the advent of more robust research findings concerning psychotherapy, there is proof that most of the major therapies are in relation to equal effectiveness, with the key common element being a strong therapeutic alliance. Because of this, more training programs and psychologists are now adopting an eclectic therapeutic orientation.

1.3.3 Health Psychology:

Health psychologists are researchers and practitioners concerned with psychology's contribution to promoting health and preventing disease. As applied psychologists or clinicians, they may help individuals lead healthier lives by designing, conducting, and evaluating programs to stop smoking, lose weight, improve sleep, manage pain, treat associated psychosocial problems with chronic and terminal illness, or prevent the spread of sexually transmitted infections. As researchers and clinicians, they identify conditions and practices associated with health and illness to help create effective interventions. In public service, health psychologists study and work to improve government policies and health-care systems. Health psychologists are employed in hospital, medical school, rehabilitation center, public health agency, college or university, or, if they are also a clinical psychologist, in private practice.

1.3.4 Experimental Psychology:

Experimental psychologists are a diverse group of scientists who investigate a variety of basic behavioral processes in research involving humans and/or other animals. Prominent areas of study in experimental research include comparative methods of science, motivation, learning, thought, attention, learning, memory, perception, and language. Most experimental psychologists identify with a particular subfield such as cognitive psychology, depending on their area of study. It is also important to note that the experimental method for conducting research studies is not limited to the field of experimental psychology, as many other subfields rely on experimental methodology to conduct studies. Experimental psychologists work in an academic setting, teaching courses and supervising students' research in addition to conducting their own research using experimental methodology. Or they might be employed by a research institution, zoo, business, industry affiliate, or government agency.

1.3.5Cognitive Psychology:

Cognitive psychologists study thought processes and focus on such topics as perception, language, attention, problem solving, memory, judgment and decision making, forgetting, and intelligence. Recent areas of research interest include designing computer-based models of thought processes and identifying biological correlates of cognition. As a cognitive psychologist, you might work as a professor, industrial consultant, or human factors specialist in an educational or business setting.

Adherents of cognitive psychology argue for an information processing model of mental function, informed through functionalism and experimental psychology. On a broader level, cognitive science is an interdisciplinary enterprise of cognitive psychologists, cognitive neuroscientists, researchers in artificial intelligence, linguists, human–computer interaction, computational neuroscience, logicians and social scientists. Computational models are sometimes used to simulate phenomena of interest. Computational models give a tool for studying the functional organization of the mind whereas neuroscience gives measures of brain activity.

1.3.6 Developmental Psychology:

A baby producing her first smile . . . taking his first step . . . saying its first word. These universal milestones in development are also singularly special and unique for each person. Developmental psychology studies how people grow and change from the moment of conception through death. It seeks to understand how people come to perceive, understand, and act within the world and how these processes change as they age.

Developmental psychologists conduct research in age-related behavioral changes and apply their scientific knowledge to educational, child care, policy, and related settings. Developmental psychologists investigate the changes across a broad range of topics, including the biological, social, psychological, and cognitive aspects of development. Developmental psychology informs a number of applied fields, including educational psychology, school psychology, child psychopathology, and gerontology. The field also informs public policy in areas such as education and childcare reform, maternal and child health and attachment and adoption. You would probably specialize in behavior during infancy, childhood, adolescence, or middle or late adulthood. Your work setting could be an educational institution, day-care center, youth group program, or senior center.

Developmental psychologists do this by focusing on cognitive, affective, moral, social, or neural development. To study children, researchers uses a number of unique research methods to create observations in natural settings or to engage them in experimental tasks. These tasks may include games and activities that are both enjoyable for the child and scientifically useful, and researchers have even devised clever methods to study the mental processes of infants. In addition to studying children, developmental psychologists also study aging and processes throughout the life span, especially at other times of rapid change (such as adolescence and old age). Developmental psychologists draw on the full range of psychological theories to inform their research.

1.3.7 Educational and school Psychology:

Educational psychologists mainly focuses their study on how humans learn in educational settings, the effectiveness of educational interventions, the psychology of teaching, and the social psychology of schools as organizations. The work of child psychologists such as Lev Vygotsky, Jean Piaget, Bernard Luskin, and Jerome Bruner has been influential in creating teaching methods and educational practices.

Educational psychologists study the relationship between learning and our physical and social environments. They study the psychological processes involved in learning and develop strategies for enhancing the learning process. As an educational psychologist, you might work in a university—in a psychology department or a school of education. Educational psychologists conduct basic research on topics related to learning or develop innovative methods of teaching to enhance the learning process. They also design effective tests including measures of aptitude and achievement. They are employed by a school or government agency or charged with designing and implementing effective employee-training programs in a business setting.

This field of psychology is mainly concerned with academic performance. It studies the role of various factors which influence learning processes in classroom setting. It focuses on assessing the aptitude, skills and intellectual potential of the students and evaluating their performance. An educational psychologist also helps students to overcome learning difficulties. Educational psychology is incorporated in teacher education programs in places such as North America, Australia, and New Zealand.

School psychologists are involved in the assessment of and intervention for children in educational settings. School psychologists combines principles from educational psychology and clinical psychology to understand and treat students with learning disabilities; to foster the intellectual growth of gifted students; to facilitate pro-social behaviors in adolescents; and otherwise to promote safe, supportive, and effective learning environments.

School psychologists are trained in educational and behavioral assessment, intervention, prevention, and consultation, and several have extensive training in research. They diagnose and treat cognitive, social, and emotional problems that may negatively influence children's learning or overall functioning at school. A school psychologist collaborate with teachers, parents, and administrators, making recommendations to improve student learning. They may also work in an academic setting, a federal or state government agency, a child guidance center, or a behavioral research laboratory.

1.3.8 Evolutionary Psychology:

Evolutionary psychology considers how behavior is influenced by our genetic inheritance from our ancestors. The evolutionary approach suggests that the chemical coding of information in our cells not only determines traits such as hair color and race but also holds the key to understand a broad variety of behaviors that helped our ancestors survive and reproduce. Evolutionary psychology stems from Charles Darwin’s arguments in his groundbreaking 1859 book, On the Origin of Species. Darwin suggested that a process of natural selection leads to the survival of the fittest and the development of traits that enable a species to adapt to its environment.

Evolutionary psychologists take Darwin’s arguments a step further. They argue that our genetic inheritance determines not only physical traits such as skin and eye color but certain personality traits and social behaviors as well. For example, evolutionary psychologists suggest that behavior such as shyness, jealousy, and cross cultural similarities in qualities desired in potential mates are at least partially determined by genetics, presumably because such behavior helped increase the survival rate of humans’ ancient relatives (Buss, 2003; Sefcek, Brumbach, & Vasquez, 2007). Although they are increasingly popular, evolutionary explanations of behavior have stirred controversy. By suggesting that many significant behaviors unfold automatically, because they are wired into the human species, evolutionary approaches minimize the role of environmental and social forces. Still, the evolutionary approach has stimulated a significant amount of research on how our biological inheritance influences our traits and behaviors (Begley, 2005; Buss, 2004; Neher, 2006).

Evolutionary psychologists study the psychological traits—such as memory, perception, or language—from a modern evolutionary perspective. It seeks to identify which human psychological traits are evolved adaptations, that is, the functional products of natural selection or sexual selection. From the point of evolutionary psychologists, the recurrent problems in human ancestral environments are solved through the evolution of psychological adaptations. Through focusing on the evolution of psychological traits and their adaptive functions, it offers complementary explanations for the mostly proximate or developmental explanations urbanized through other areas of psychology (that is, it focuses mostly on ultimate or "why?" questions, rather than proximate or "how?" questions).

1.3.8.1 Behavioral Genetics:

Behavioral genetics is another rapidly growing area in psychology which focuses on the biological mechanisms, such as genes and chromosomes, that enable inherited behavior to unfold. Behavioral genetics seeks to understand how we might inherit certain behavioral traits and how the environment influences whether we actually display such traits (Bjorklund & Ellis, 2005; Moffitt & Caspi, 2007; Rende, 2007).

1.3.9 Industrial–organizational Psychology:

The psychological study of people at work is known as industrial/organizational (I/O) psychology. It deals with such issues as hiring the right person for a job, training people for jobs, developing work teams, determining salaries and bonuses, providing feedback to workers about their performance, planning an organizational structure, and organizing the workplace so that workers will be productive and satis?ed. I/O psychologists study the behavior of both the individual and the organization, including the impact of economic conditions and government regulations.

Industrial/organizational (I/O) psychologists study the relationship between people and their working environments. They may develop new ways to increase productivity, improve personnel selection, or promote job satisfaction in a business setting. Their interests include organizational structure and change, consumer behavior, and personnel selection and training. I/O psychologists conduct workplace training or provide organizational analysis and development. They work in business, industry, the government, or a college or university. Or they may be self-employed as a consultant or work for a management counseling firm.

Industrial and organizational psychology (I–O) applies psychological concepts and methods to optimize human potential in the workplace. Personnel psychology, a subfield of I–O psychology, applies the methods and principles of psychology in selecting and evaluating workers. I–O psychology's other subfield, organizational psychology, examines the effects of work environments and management styles on worker motivation, job satisfaction, and productivity. This field is concerned with application of psychological principles and models to study the selection and performance of employees in organizational settings. It also studies the concepts of leadership, motivation, job satisfaction and performance appraisal.

1.3.10 Personality Psychology:

Personality psychology is concerned with enduring patterns of behavior, thought, and emotion—commonly referred to as personality—in individuals. Theories of personality vary crossways different psychological schools and orientations. They carry different assumptions in relation to the issues as the role of the unconscious and the importance of childhood experience. According to Freud, personality is based on the dynamic interactions of the id, ego, and super-ego. The number of proposed traits has varied widely. An early model, proposed through Hans Eysenck, suggested that there are three traits which comprise human personality: extraversion–introversion, neuroticism, and psychoticism. Raymond Cattell proposed a theory of 16 personality factors. Dimensional models of personality are getting increasing support, and some version of dimensional assessment will be incorporated in the forthcoming DSM-V.

1.3.11 Social Psychology:

Our complex networks of social interrelationships are the focus for many subfields of psychology. For example, social psychology is the study of how people's thoughts, feelings, and actions are affected by others. Social psychologists are interested in our interactions with others. It studies how humans think in relation to each other and how they relate to each other. Social psychologists study such topics as the influence of others on an individual's behavior (e.g. conventionality, persuasion), and the formation of beliefs, attitudes, and stereotypes in relation to the other people.

Social psychologists study how our beliefs, feelings, and behaviors are affected by and influence other people. They study topics such as attitudes, aggression, prejudice, interpersonal attraction, group behavior, and leadership. A social psychologist work in a college or university faculty member. They might also work in organizational consultation, marketing research, or other applied psychology fields including social neuroscience. Some social psychologists work for hospitals, federal agencies, or businesses performing applied research.

Social cognition fuses elements of social and cognitive psychology in order to understand how people process, keeps in mind, or distort social information. The study of group dynamics reveals information in relation to the nature and potential optimization of leadership, communication, and other phenomena that emerge at least at the micro social level. In recent years, several social psychologists have become increasingly interested in implicit measures, mediational models, and the interaction of both person and social variables in accounting for behavior. The study of human society is a potentially valuable source of information in relation to the causes of psychiatric disorder. Some of the sociological concepts applied to psychiatric disorders are the social role, sick role, social class, life event, culture, migration, social, and total institution.

1.3.12 Community Psychology:

Community psychologists move beyond focusing on specific individuals or families and deal with broad problems of mental health in community settings. These psychologists believe that human behavior is powerfully influenced by the interaction between people and their physical, social, political, and economic environments. They seek to improve individual functioning by enhancing environmental settings to promote psychological health.

Community psychologists focus on prevention, promotion of positive mental health, and crisis intervention, with special attention to the problems of underserved groups and ethnic minorities. Given the shared emphasis on prevention, some community psychologists collaborate with professionals in other areas, such as public health. The work settings of a community psychologist include federal, state, and local departments of mental health, corrections, and welfare systems. They also conduct research or help evaluate research in health service settings, serve as an independent consultant for a private or government agency, or teach and consult as a college or university faculty member.

1.3.13 Positive Psychology:

Positive psychology derives from Maslow's humanistic psychology. Positive psychology is a discipline that utilizes proof -based scientific methods to study factors that contribute to human happiness and strength. Different from clinical psychology, positive psychology is concerned with improving the mental well-being of healthy clients. Positive psychological interventions now have received tentative support for their beneficial effects on clients. In 2010 Clinical Psychological Review published a special issue devoted to positive psychological interventions, such as gratitude journaling and the physical expression of gratitude. There is, though, a need for further research on the effects of interventions. Positive psychological interventions have been limited in scope, but their effects are thought to be superior to that of placebos, especially with regard to helping people with body image problems.

1.3.14 Abnormal Psychology:

This branch of psychology tries to describe, assess, predict and control those categories of behaviors which are considered as unusual and non-normative. It also deals with various categories of psychological disorders which affect the mental health of the individual. It assesses abnormality in the individual through standardized psycho-diagnostic tools and suggests problem specific treatment.

1.3.15 Environmental Psychology:

This field is concerned with the study of interaction between physical environment and human behaviour. It studies the impact of noise, heat, humidity, pollution and crowding on human performance. It also focuses on the impact of physical environment on psychological health of individuals. Health Psychology: This field focuses on the impact of various psychological factors (e.g. stress) on the onset progress and treatment of illness. It also deals with various life style diseases such as hypertension, coronary heart disease, cancer and diabetes.

1.3.16 Psychometric Quantitative psychology:

Psychometric and quantitative psychologists study the methods and techniques used to acquire psychological knowledge. A psychometrician may update existing neurocognitive or personality tests or devise new tests for use in clinical and school settings or in business and industry. These psychologists also administer, score, and interpret such tests. Quantitative psychologists collaborate with researchers to design, analyze, and interpret the results of research programs. A psychometric or quantitative psychologist should be well trained in research methods, statistics, and computer technology. They are most likely be employed by a university or college, testing company, private research firm, or government agency.

1.3.17 Rehabilitation Psychology:

Rehabilitation psychologists are researchers and practitioners who work with people who have lost optimal functioning after an accident, illness, or other event. A rehabilitation psychologist work in a medical rehabilitation institution or hospital. They also work in a medical school, university, state or federal vocational rehabilitation agency, or in private practice serving people with physical disabilities.

1.4 Emerging Fields:

In addition to the fields mentioned above a number of new areas have emerged. Some of these fields are sports psychology, military psychology, aviation psychology, forensic psychology, peace psychology, neuropsychology, political psychology, and feminist psychology. Let us see a few of them in detail.

1.4.1 Forensic Psychology:

Forensic psychologists apply psychological principles to legal issues. They conduct research on the interface of law and psychology, help to create public policies related to mental health, help law-enforcement agencies in criminal investigations or assist in forensic consultation involving jury selection and deliberation research. They also provide therapy and assessment to assist the legal community. Some forensic psychologists hold law degrees and provide clients with legal services as well. Although most forensic psychologists are clinical psychologists, they might have expertise in other areas of psychology, such as social or cognitive psychology. Forensic psychologists work in a university psychology department, law school, research organization, community mental health agency, law-enforcement agency, court, or correctional setting.

1.4.2 Neuro psychology:

Neuropsychologists investigate the relationship between neurological processes (structure and function of the brain) and behavior. Neuropsychologists assess, diagnose, or treat disorders related to the central nervous system, such as Alzheimer's disease or stroke. They also evaluate individuals for evidence of head injuries, learning and developmental disabilities such as autism and other psychiatric disorders including ADHD. A clinical neuropsychologist work in the neurology, neurosurgery, or psychiatric unit of a hospital. Neuropsychologists also work in academic settings, where they conduct research and teach.

1.4.3 Sport Psychology:

Sport psychologists study the psychological factors that influence, and are influenced by, participation in sports and other physical activities. Professional activities of sports psychologists include coach education, athlete preparation, as well as research and teaching. Sports psychologists who also have a clinical or counseling degree can apply those skills to working with individuals with psychological problems such as anxiety or substance-abuse problems that might interfere with optimal performance. They may also work as part of a team or organization or in a private capacity.

1.5 Conclusion:

With perspectives ranging from the biological to the social, and with settings from the laboratory to the clinic, psychology relates to many fields, ranging from mathematics to biology to sociology to philosophy. And more and more, psychology's methods and findings aid other disciplines. Psychologists teach in medical schools, law schools, and theological seminaries, and they work in hospitals, factories, and corporate offices. They engage in interdisciplinary studies, such as psychohistory (the psychological analysis of historical characters), psycholinguistics (the study of language and thinking), and psychoceramics (the study of crackpots). Psychology also influences modern culture. Knowledge transforms us. Learning about the solar system and the germ theory of disease alters the way people think and act. Learning psychology's findings also changes people: They less often judge psychological disorders as moral failings, treatable by punishment and ostracism. They less often regard and treat women as men's mental inferiors. They less often view and rear children as ignorant, willful beasts in need of taming. "In each case," notes Morton Hunt (1990, p. 206), "knowledge has modified attitudes, and, through them, behavior." Once aware of psychology's well-researched ideas—about how body and mind connect, how a child's mind grows, how we construct our perceptions, how were member (and misremember) our experiences, how people across the world differ (and are alike)—your mind may never again be quite the same.

1.6 Summary

Psychology is a systematic and scientific study of mental processes, experiences and behaviors - both overt and covert – as they take place in a socio-cultural setting. The scope of psychology is wide as it addresses a variety of issues related to mental and behavioral functioning of the individuals. Study of psychology helps us to develop a basic understanding about human nature and facilitates dealing with a number of personal and social problems. Psychology has a number of specialized fields of study. Each field helps us understand human behavior in specific domain.

1.7 KEY WORDS:

::Abnormal Psychology describe, assess, predict and control those categories of behavior which are considered as unusual and non-normative

::Behavioral genetics

focuses on the biological mechanisms, such as genes and chromosomes, that enable inherited behavior to unfold.

:: Biological psychology

the study of the biological substrates of behavior and mental processes

:: Clinical psychology

study and application of psychology to understand, prevent, and relieve psychologically based distress or dysfunction and also helps to promote subjective well-being and personal development

::Cognitive neuroscience

study the psychological processes in humans by investigating the neural correlates of the psychological processes using neural imaging tools.

:: Cognitive psychology

study thought processes and focus on such topics as perception, language, attention, problem solving, memory, judgment and decision making, forgetting, and intelligence.

::Community Psychology

deal with broad problems of mental health in community settings.

::Counseling psychologist

help people adjust to life transitions or make life-style changes

::Developmental psychology

studies how people grow and change from the moment of conception through death.

::Educational psychology

study on how humans learn in educational settings, the effectiveness of educational interventions, the psychology of teaching, and the social psychology of schools as organizations

::Environmental Psychology

study of interaction between physical environment and human behaviour.

::Evolutionary Psychology

considers how behavior is influenced by our genetic inheritance from our ancestors.

::Experimental psychology

investigate a variety of basic behavioral processes in research involving humans and/or other animals

::Forensic psychology

apply psychological principles to legal issues.

::Health psychology

contributes to promoting health and preventing disease.

::Industrial–organizational Psychology

the psychological study of people at work

::Neuropsychologist

investigate the relationship between neurological processes (structure and function of the brain) and behavior.

::Personality psychology

concerned with enduring patterns of behavior, thought, and emotion—commonly referred to as personality—in individuals.

::Positive psychology

discipline that utilizes proof -based scientific methods to study factors that contribute to human happiness and strength.

::Psychology

the scientific study of human behaviour and mental processes.

::Psychometric and quantitative psychology

study the methods and techniques used to acquire psychological knowledge.

::Rehabilitation psychologist

work with people who have lost optimal functioning after an accident, illness, or other event.::School psychologist involved in the assessment of and intervention for children in educational settings.

::social psychologist

study of how people’s thoughts, feelings, and actions are affected by others.

::Sport Psychologist

study the psychological factors that influence, and are influenced by, participation in sports and other physical activities

1.8 7Check Your Progress

(1) Psychology is best defined as the

(a) study of perception and memory.

(b) investigation of the human psyche.

(c) scientific study of conscious and unconscious processes.

(d) scientific study of behavior and mental processes.

(2) Research into the mental processes associated with the learning and use of language is most closely aligned with which of the following subfields of psychology?

(a) cognitive

(b) educational

(c) social

(d) clinical

(3) Chemical changes in the brain associated with anxiety would be of most interest to a(n)

(a) evolutionary psychologist.

(b) cognitive psychologist.

(c) sociocultural psychologist.

(d) behavioral neuroscientist.

(4) The most widely practiced specialization in psychology is

(a) experimental psychology.

(b) physiological psychology.

(c) forensic psychology.

(d) clinical and counseling psychology

(5) What is the main difference between a clinical psychologist and a psychiatrist?

(a) their education

(b) their theoretical approach

(c) their research interests

(d) their number of publications

1.9 ANSWERS TO CHECK YOUR PROGRESS

1. (d)
2. (a)
3. (d)
4. (d)
5. (a)

1.10 MODEL QUESTIONS

1. Define psychology.
2. Describe any two fields of psychology and indicate their applications?

LESSON 2
METHODS OF PSYCHOLOGY

INTRODUCTION

The starting point of any science is description. In everyday life, all of us observe and describe people, often drawing conclusions about why they behave as they do. Professional psychologists do much the same, though more objectively and systematically. Most of the researches in psychology starts with description: What happens and under what circumstances? In this lesson you will learn in detail about the major methods used by psychologists.

LEARNING OBJECTIVES

At the end of this unit you will be able to understand

- the different research methods and explain their advantages and disadvantages
- the uses of correlational research
- the procedures of experimental research

PLAN OF THE LESSON

Psychologists use different methods of investigation, each with its advantages and disadvantages. The four main methods commonly used in psychological research are : the (true) experimental method, the quasi-experimental method, the observational method (sometimes called the survey or correlational method), and the case study method. Let's ?rst examine several kinds of observational studies. Later we consider experiments, which are designed to illuminate cause-and-effect relationships.

2.1 Naturalistic Observations

A naturalistic observation is a careful examination of what happens under more or less natural conditions. For example, biologist Jane Goodall (1971) spent years observing chimpanzees in the wild, recording their food habits, their social interactions, their gestures, and their whole way of life. Similarly, psychologists sometimes try to observe human behavior "as an outsider."

2.1.1The survey (or correlational) method

A survey is a study of the prevalence of certain beliefs, attitudes, or behaviors based on people's responses to questions. Surveys are common in Western society. You will also frequently read survey results in the newspaper or hear them reported on television.

The survey method is commonly used only to identify the naturally occurring patterning of variables in the 'real world' rather than to explain those patterns (though often people want to put an explanatory gloss on them). So to examine whether absence makes the heart grow fonder we could conduct a survey to see if people who are separated from their partners because of travelling away from home (group A) say more positive things about their partners than people who never travel away from home without their partners (group B).

This might be an interesting exercise, but the validity of any causal statements made on the basis of such ?ndings would be very limited. For example, if we found from our survey that group A said more positive things about their partners when they were travelling than group B, it would be impossible to demonstrate conclusively that absence was the cause of the difference between groups A and B. In other words, while our survey could show us that absence is associated with a fonder heart, it could not conclusively show that absence actually causes the heart to grow fonder.

It is quite possible (odd as it may sound) that the sorts of people who travel away from home without their partners are simply those that like their partners more (so fondness makes the heart go absent). Or perhaps both fondness and absence are caused by something else – for example, social class (i.e. being wealthy makes people both fond and absent). In large part, then, surveys rely on methodologies that identify relationships between variables but do not allow us to make conclusive causal inferences.You should be aware of the ways in which survey results can be misleading.

2.1.1.1 Sampling

Getting a random or representative sample is important in research, particularly with surveys.

In 1936 the Literary Digest mailed 10 million postcards, asking people their choice for president of the United States. Of the 2 million responses, 57% preferred the Republican candidate, Alfred Landon.Later that year, the Democratic candidate, Franklin Roosevelt, defeated Landon by a wide margin. The problem was that the Literary Digest had selected names from the telephone book and automobile registration lists. In 1936, at the end of the Great Depression, few poor people (who were mostly Democrats) owned telephones or cars. With any survey, researchers should acknowledge the limitations of their sample.

Even if one had a random sample of all adults in an entire country, the results apply only to that country at the time of the survey. It would be unwarranted to draw conclusions about other countries or other times.

2.1.1.2 The Seriousness of Those Being Interviewed

When you answer a survey, do you carefully consider your answers, or do you answer impulsively? In one survey, only 45% of the respondents said they believed in the existence of intelligent life on other planets. However, a few questions later on the survey, 82% said they believed the U.S. government was “hiding evidence of intelligent life in space” (Emery, 1997). Did 37% of the people really think that the U.S. government is hiding evidence of something that doesn’t exist? More likely, they were answering without much thought. Here’s another example: Which of the following programs would you most like to see on television reruns? Rate your choices from highest (1) to lowest (10). __ South Park __ Xena, Warrior Princess __ Lost __ The X-Files __ Cheers __ Teletubbies __ Seinfeld __ Space Doctor __ I Love Lucy __ Homicide

When this survey was conducted with students of North Carolina State University, nearly all did exactly what has been asked—they gave every program a rating, including Space Doctor, a program that never existed. Most rated it toward the bottom, but more than 10% rated it in the top ?ve, and a few ranked it as their top choice. (This survey was inspired by an old Candid Camera episode in which interviewers asked people their opinions of the nonexistent program Space Doctor and received many con?dent replies.) Students who rated Space Doctor did nothing wrong, of course. They have been asked to rank the programs, and they did. The fault lies with anyone who interprets such survey results as if they represented informed opinions. People frequently express opinions based on little or no knowledge.

2.1.1.3 The Wording of the Questions

Let's start with a little demonstration. Please answer these two questions:

1. I oppose raising taxes. (Circle one.) 1 2 3 4 5 6 7 Strongly agree Strongly disagree
2. I make it a practice to never lie. (Circle one.) 1 2 3 4 5 6 7 Strongly agree Strongly disagree Now cover up those answers and reply to these similar questions:
3. I would be willing to pay a few extra dollars in taxes to provide high-quality education to all children. (Circle one.) 1 2 3 4 5 6 7 Strongly agree Strongly disagree
4. Like all human beings, I occasionally tell a white lie. (Circle one.) 1 2 3 4 5 6 7 Strongly agree Strongly disagree

Some odd survey results merely reflect the fact that people did not take the questions seriously or did not understand the questions.

Most students at one college indicated agreement to all four items (Madson, 2005).

Note that item 1 contradicts 3, and 2 contradicts 4. You can't be opposed to raising taxes and in favor of raising taxes. You can't be honest all the time and occasionally lie. However, the wording of a question changes its connotation. Question 3 talks about raising taxes “a few extra dollars” for a worthy cause. That differs from raising taxes in general by some unknown amount for unknown reasons. Similarly, depending on what you mean by a “white lie,” you might tell one occasionally while still insisting that you “make it a practice to never lie”—at least not much. Still, the point is that someone can bias your answers one way or the other by rewording a question.

Here is another example. Some students are offered the ?rst pair of questions, and others are offered the second pair:

1. Suppose your professor tells you your rank in the class so far, on a scale from 1st percentile (worst) to 99th percentile (best). How would you feel if you were told you were in the 10th percentile? (Circle one.) 1 (worst) 2 3 4 5 6 7 (best) How would you feel if you were told you were in the 90th percentile? 1 (worst) 2 3 4 5 6 7 (best)

2. Suppose your professor tells you your rank in the class so far, on a scale from 1st percentile (worst) to 99th percentile (best). How would you feel if you were told you were in the 91st percentile? (Circle one.) 1 (worst) 2 3 4 5 6 7 (best) How would you feel if you were told you were in the 99th percentile? 1 (worst) 2 3 4 5 6 7 (best)

On the average, students offered the ?rst pair of questions rated their happiness as 6.46 if they were told they were in the 90th percentile. Students offered the second pair of questions rated their happiness as 5.89 if they were told they were in the 91st percentile (Hsee& Tang, 2007). Obviously, it doesn't make sense to be happier about being in the 90th percentile than the 91st. The wording of the question sets up an implicit comparison: The 90th percentile is much better than the 10th, but the 91st is worse than the 99th. In short, the next time you hear the results of some survey, be skeptical. Ask how the question was worded and what choices were offered. Even a slightly different wording could yield a different percentage.

2.1.1.4 Surveyor Biases

Sometimes, an organization words the questions of a survey to encourage the answers they hope to receive. Here is an example: According to a 1993 survey, 92% of high school boys and 98% of high school girls said they were victims of sexual harassment (Shogren, 1993). Shocking, isn't it? However, perhaps the designers of the survey wanted to show that sexual harassment is prevalent. The survey de?ned sexual harassment by a long list of acts ranging from serious offenses (e.g., having someone rip your clothes off in public) to minor annoyances. For example, if you didn't like the sexual scribbling on the restroom wall, you could consider yourself sexually harassed. If you tried to make yourself look sexually attractive (as most teenagers do, right?) and then attracted a suggestive look from someone you didn't want to attract, that stare would count as sexual harassment. (Does it mean to say about those who said they weren't sexually harassed! They liked all the scribbling on the restroom walls? No one ever looked at them in a sexual way?) Sexual harassment is, of course, a serious problem, but a survey that combines major and minor offenses is likely to mislead. Therefore when carrying out a survey research and generalizing the results of the survey, the researcher should be very cautious and be aware of the influence of the above mentioned factors.

2.2 Correlation Method

Another type of research is a correlational study. A correlation is a measure of the relationship between two variables. (we already know that a variable is anything measurable that differs among individuals, such as age, years of education, or reading speed.) A correlational study is a procedure in which investigators measure the correlation between two variables without controlling either of them. For example, investigators have observed correlations between people's height and weight. Similarly, one can ?nd a correlation between scores on personality tests and how many friends someone has.

2.2.1 The Correlation Coefficient

We would probably ?nd a strong positive correlation between hours per week reading and scores on a vocabulary test. We would expect a lower correlation between reading hours and scores on a chemistry test. To measure the strength of a correlation, researchers use a correlation coeffcient, a mathematical estimate of the relationship between two variables. The coeffcient can range from +1 to -1.

A correlation coeffcient indicates how accurately we can use a measurement of one variable to predict another. A correlation coeffcient of +1 for example, means that as one variable increases, the other increases also. A correlation coeffcient of -1 means that as one variable increases, the other decreases. A correlation of either +1 or -1 enables us to make perfect predictions of one variable from measurements of the other one. (In psychology you probably will never see a perfect +1 or -1 correlation coefficient.) A negative correlation is just as useful as a positive correlation and can indicate just as strong a relationship. In nations where people eat more seafood, depression is less common, so seafood consumption is negatively correlated with depression.

A 0 correlation indicates that measurements of one variable have no linear relationship to measurements of the other variable. As one variable goes up, the other does not consistently go up or down. A correlation near 0 can mean that two variables really are unrelated or that one or both of them were poorly measured. (If something is inaccurately measured, we can hardly expect it to predict anything else.)

2.2.2 Illusory Correlations

Sometimes with unsystematic observations, we “see” a correlation that doesn’t really exist. For example, many people believe that consuming sugar makes children hyperactive. However, extensive research found little effect of sugar on activity levels, and some studies found that sugar calms behavior (Milich, Wolraich, & Lindgren, 1986; Wolraich et al., 1994).

How, then, do we handle reports that sugar makes children hyperactive? Researchers watched two sets of mothers with their 5- to 7-year-old sons after telling one group that they had given the sons sugar and the other that they had given the sons a placebo. In fact, they had given both a placebo. The mothers who thought their sons had been given sugar rated their sons hyperactive during the observation period, whereas the other mothers did not (Hoover & Milich, 1994). That is, people see what they expect to see. When people expect to see a connection between two events (e.g., sugar and activity levels), they remember the cases that support the connection and disregard the exceptions, thus perceiving an illusory correlation, an apparent relationship based on casual observations of unrelated or weakly related events. Many stereotypes about groups of people can be regarded as illusory correlations.

2.2.3 Correlation and Causation

A correlation tells us how strongly two variables are related to each other. It does not tell us why. If two variables—let’s call them A and B—are positively correlated, it could be that A causes B, B causes A, or some third variable, C, causes both of them. Therefore, a correlational study does not justify a cause-and-effect conclusion. For example, there is a strong positive correlation between the number of books people own about chess and how good they are at playing chess. Does owning chess books make someone a better chess player? Does being a good chess player cause someone to buy chess books? Both hypotheses are partly true. People who start to like chess usually buy chess books, which improve their game. As they get better, they become even more interested and buy more books. But neither the chess books nor the skill exactly causes the other. “Then what good is a correlation?” The simplest answer is that correlations help us make useful predictions. If your friend has just challenged you to a game of chess, you could scan your friend’s bookshelves and estimate your chances of winning.

Following are the three more examples to illustrate why we cannot draw conclusions regarding cause and effect from correlational data

- Unmarried men are more likely than married men to spend time in a mental hospital or prison. That is, marriage is negatively correlated with men's mental illness and criminal activity. Does the correlation mean that marriage leads to mental health and good social adjustment? Or does it mean that the men in mental hospitals and prisons are unlikely to marry? (The second conclusion is certainly true. The ?rst may be also.)
- According to one study, people who sleep about 7 hours a night are less likely to die within the next few years than those who sleep either more or less (Kripke, Gar?nkel, Wingard, Klauber, &Marler, 2002). It's easy to believe that sleep deprivation impairs your health, but should we conclude (as some people did) that sleeping too much also impairs your health? Here is an alternative explanation: People who already have life-threatening illnesses tend to sleep more than healthy people. So perhaps illness causes extra sleep rather than extra sleep causing illness. Or perhaps advancing age increases the probability of both illness and extra sleep. (The study included people ranging from young adulthood through age 101!)
- On the average, the more often parents spank their children, the worse their children misbehave. Does this correlation indicate that spankings lead to misbehavior? Possibly, but an alternative explanation is that the parents resorted to spanking because their children were already misbehaving (Larzelere, Kuhn, & Johnson, 2004). Yet another possibility is that the parents had genes for "hostile" behavior that led them to spank, and the children inherited those genes, which led to misbehaviors.

Describing behavior is a first step toward predicting it. Surveys and naturalistic observations often show us that one trait or behavior is related to another. In such cases, we say the two correlate. A statistical measure (the correlation coefficient) helps us figure how closely two things vary together, and thus how well either one predicts the other.

Again, the results suggest cause and effect. Nevertheless, the point to remember is: We should almost always be skeptical of causal conclusions that anyone draws from a correlational study. To determine causation, an investigator needs to manipulate one of the variables directly through a research design known as an experiment. When an investigator manipulates one variable and then observes corresponding changes in another variable, a conclusion about causation can be justified, presuming, of course, that the experiment is well designed.

2.3 The case study method

Most of the above methods are used for studies involving large numbers of participants. But what if only a few are available? How, for example, would you do research if you were interested in the reading difficulties of people with particular forms of brain damage? To investigate questions like this, researchers often resort to the case study method, which involves intensive analysis of a very small sample. Among the oldest research methods, the case study examines one individual in depth in hopes of revealing things true of us all.

Some examples:

Much of our early knowledge about the brain came from case studies of individuals who suffered a particular impairment after damage to a certain brain region.

Jean Piaget taught us about children's thinking after carefully observing and questioning only a few children.

Studies of only a few chimpanzees have revealed their capacity for understanding and language. Intensive case studies are sometimes very revealing.

Case studies often suggest directions for further study, and they show us what can happen. But individual cases may mislead us if the individual being studied is atypical. Unrepresentative information can lead to mistaken judgments and false conclusions. Case studies have particular problems (often with reliability), but some of the most famous studies in psychology have used this method – in particular the work of Freud.

Indeed, anytime a researcher mentions a finding ("Smokers die younger: 95 percent of men over 85 are non smokers") someone is sure to offer a contradictory anecdote ("Well, I have an uncle who smoked two packs a day and lived to be 89"). As psychologist Gordon Allport (1954, p. 9) said, "Given a thimbleful (meaning a drop) of [dramatic] facts we rush to make generalizations as large as a tub."

2.3.1 Case Histories

Some fascinating conditions are rare. For example, some people are almost completely insensitive to pain. People with Capgras syndrome believe that some of their relatives have been replaced with impostors, who look, sound, and act like the real people. People with Cotard's syndrome insist that they are dead or do not exist. A psychologist who encounters someone with a rare condition may report a case history, a thorough description of the person, including abilities and disabilities, medical condition, life history, unusual experiences, and whatever else seems relevant. It is, of course, possible to report a case history of any person, not just the unusual, but the unusual cases attract more attention.

A case history is a kind of naturalistic observation, but we distinguish it because it focuses on a single individual. A case history can be valuable, but it runs the risk of being just an anecdote. Unless other observers examine this person or someone similar, we are at the mercy of the original investigator, who may have overlooked important points, exaggerated, or misunderstood. A good case history guides further research, but we should interpret a single report cautiously.

2.4 Qualitative approach

When researchers report and comment on behaviour, without attempting to quantify it, they are using a qualitative research method. This involves attempts to understand behaviour by doing more than merely converting evidence into numbers. Qualitative methods can include coding, grouping and collecting observations without assigning actual numbers to the observation. So a qualitative analysis of the speed of animals might result in the statement that the cheetah is a fast land animal, and a quantitative analysis might involve comparing the maximum speed of animals over (say) 20 meters.

To take an example of human behaviour, you probably take a qualitative approach to the friendliness of the people you meet. In other words, you probably judge people as relatively friendly or unfriendly, but you would be unlikely to come up with a number that expresses their friendliness quotient. Qualitative techniques are sometimes used in the initial stages of quantitative research programs to complement the quantitative techniques, but they are also used by psychologists who challenge conventional approaches to psychological research. This may be because they believe that the conventional methods are inadequate for addressing the richness and complexity of human behaviour. In turn, many mainstream psychologists are critical of qualitative methods. The point to remember is that Individual cases can suggest fruitful ideas. But to discern the general truths that cover individual cases, we must answer questions with other research methods.

2.5 The experimental method

An experiment is a study in which the investigator manipulates at least one variable while measuring at least one other variable. To do this, the researcher examines participants' responses in the presence and the absence of the manipulation. Researchers measure the language skills of some 5-year-old children, provide them with a 6-month special training program, and then ?nd that the children have increased their language skills. Can we conclude that the training program was effective? No, because the children probably would have improved their language during 6 months even without the training.

Instead of a before-and-after study, a better design is to compare two groups: An investigator might assemble a group of 5-year-old children, randomly divide them into two groups, and provide the training for one group (the experimental group) and not the other (the control group). Someone, preferably a blind observer, evaluates the language skills of the two groups. If the two groups become different in some consistent way, then the difference is probably the result of the experimental procedure.

With an experiment, as with any research, we should beware of generalizing the results too far. If the researchers studied 5-year-old children in the United States, the results might not apply, or might not apply equally well, to children in another country or even to children in the same country many years later. We gain con?dence in the generalizability of the results if researchers obtain similar results from a variety of samples, especially if they come from different cultures.

Experimental control is used to make the different situations identical in every respect except for the presence or absence of the manipulation. Experiments can involve different people in each situation or the same people in different situations. People who take part in experiments are called participants or subjects.

Here is an example. To test the effect of a new training method (a manipulation) on memory, we might take 100 people and expose half of them to the new method. To get accurate result, we would assign participants to the two groups on a random basis (e.g. by the toss of a coin). The ?rst group is called the experimental group, as it is subjected to a relevant experimental treatment. The other half of our participants would not be exposed to the new training method. As they receive no experimental treatment, they are referred to as a control group (discussed in more detail below). After administering the treatment, we would measure the performance of the two groups on a memory task and then compare the results. The various levels of treatment in an experiment (including the control) are referred to as conditions.

This experiment has two conditions and a between-subjects design(because the design involves making comparisons between different participants in different conditions). Note, however, that the same question could also have been addressed in a with in subjects design, which would involve comparing the memory performance of the same people with and without the new training method. The two basic designs have different strengths and weaknesses.

2.5.1 Variable

A variable is simply something that changes or varies (is not constant). The different conditions in the experiment make up the independent variable (or IV), sometimes called the treatment variable. In true experiments, the independent variable is systematically manipulated or varied by the experimenter. Experiments can (and typically do) have more than one independent variable.

Experiments also involve at least one dependent variable (or DV). This is an outcome or measurement variable, and it is this variable that the experimenters are interested in observing and which provides them with data. In our last example, the dependent variable is the level of memory performance. Use the initial letter 'd' to remember the link between the dependent variable and the data it provides.

Experiments examine the effect of one or more independent variables on some measurable behavior, called the dependent variable because it can vary depending on what takes place during the experiment. Both variables are given precise operational definitions, which specify the procedures that manipulate the independent variable or measure the dependent variable. These definitions answer the "What do you mean?" question with a level of precision that enables others to repeat the study.

2.5.2 Control

Control is the basis of experimental design. It involves making different conditions identical in every respect except the treatment (i.e. the independent variable). In a between-subjects experiment, this is achieved by a process of random assignment of participants to the different conditions. For example, people should be assigned at random (e.g. on the basis of coin tossing), rather than putting, say, the first 50 people in one condition and the second 50 in another. This practice rules out the possibility that there are systematic differences in, say, intelligence, personality or age between the groups. If there is a difference in results obtained from measuring the dependent variable for each group, and we have equated the groups in every respect by means of random assignment, we can infer that the difference must be due to our manipulation of the independent variable.

2.5.3 Random sample

To obtain a representative sample—say, of the students at any college or university, you would choose a random sample, in which every person in the entire group has an equal chance of participating. This means you would not send each student a questionnaire. (The conscientious people who return it would not be a random sample.) Rather, you might number the names in the general student listing and then use a random number generator to pick the participants for your survey.

Large representative samples are better than small ones, but a small representative sample of 100 is better than an unrepresentative sample of 500. Political pollsters sample voters in national election surveys just this way. Using only 1500 randomly sampled people, drawn from all areas of a country, they can provide a remarkably accurate snapshot of the nation's opinions. Without random sampling, large samples—including call-in phone samples and TV or Web site polls—often merely give misleading results.

To know how effective a therapy really is, researchers must control for a possible placebo effect. The double-blind procedure is one way to create an experimental group, in which people receive the treatment, and a contrasting control group that does not receive the treatment. By randomly assigning people to these conditions, researchers can be fairly certain the two groups are otherwise identical. Random assignment roughly equalizes the two groups in age, attitudes, and every other characteristic. With random assignment it can be concluded that any later differences between people in the experimental and control groups will usually be the result of the treatment

2.6 The quasi-experimental method

In quasi-experimental studies the independent variable is not (or cannot be) manipulated as such, and so assignment to experimental groups cannot be random. The fact that no manipulation occurs interferes dramatically with our ability to make conclusive causal inferences. Examples of independent variables that cannot be manipulated by an experimenter includes gender and age. Obviously experimenters cannot change the gender or age of participants, but they can compare the responses of groups of people with different ages or of different genders. Compared to the experimental method, there is no real control over the independent variable, so we cannot conclude that it is necessarily responsible for any change in the dependent variable. On this basis, the quasi-experimental method actually has more in common with survey methodology than with the experimental method. It has all the weaknesses of the experimental method, but it lacks the main strength. In practice, it is often conducted in conjunction with the experimental method. For example, in our learning study we might compare the effect of the new training method on both men and women.

2.7 Experiment Vs Survey

One common, but mistaken, belief is that the difference between surveys and experiments is a question of location, with surveys being conducted in the community and experiments in the laboratory. This is often the case, but not always. Experiments can be conducted outside laboratories, and surveys can be conducted in them.

The main differences between experiments and surveys relate to the sorts of questions that each can answer. As we suggested earlier, experiments tend to be concerned with establishing causal relationships between variables, and they achieve this by randomly assigning participants to different treatment conditions. Surveys, on the other hand, tend to be concerned with measuring naturally occurring and enduring relationships between variables. Researchers who use surveys usually want to generalize from the sample data they obtain to a wider population. They do this by using the sample to estimate the characteristics of the population they are interested in. Why choose to carry out a survey rather than an experiment? Two reasons: sometimes we are only interested in observing relationships, and sometimes manipulations simply are not possible.

Surveys can also allow researchers to eliminate some causal links. If there is no relationship (at least in the survey environment) between variables, this allows us to conclude that one does not cause the other. For example, if no relationship is found between age and intelligence, then it is impossible for intelligence to cause age, or vice versa (bearing in mind that a relationship could be concealed by a third, or background, variable).

Correlational research cannot control for all possible factors. But researchers can isolate cause and effect with an experiment. Experiments enable a researcher to focus on the possible effects of one or more factors by (1) manipulating the factors of interest and (2) holding constant ("controlling") other factors.

2.8 Conclusion

Conducting research is a formal and systematic exercise. The success of the research process depends on a confluence of conceptual, meta-theoretical, methodological, and statistical skills. Psychologists use a wide array of research methods which includes Observation, experimental and correlation. Depending on the nature of the research , the suitable methodology should be applied. Each method has its own advantages and disadvantages.

2.9 SUMMARY

Descriptive, correlational, and experimental research are the methods used in the study of psychology. Descriptive methods include case studies, surveys, and naturalistic observation. The goal of these designs is to get a picture of the current thoughts, feelings, or behaviors in a given group of people. Correlational research method find out the relationship between two or more variables. The variables may be presented on a scatter plot to visually show the relationships. The Pearson Correlation Coefficient (r) is a measure of the strength of linear relationship between two variables. Common-causal variables may cause both the predictor and outcome variable in a correlational design, producing a spurious relationship. The possibility of common-causal variables makes it impossible to draw causal conclusions from correlational research methods. Experimental research involves the manipulation of an independent variable and the measurement of a dependent variable. Random assignment to conditions is normally used to create initial equivalence between the groups, allowing researchers to draw causal conclusions.

2.10 KEY WORDS

::between-subjects design

a research study involving a systematic manipulation of an independent variable with different participants being exposed to different levels of that variable

::case study method

research method that involves a single participant or small group of participants who are typically studied quite intensively.

::condition

a situation in a research study in which participants are all treated the same way.

::control group

in an experiment, the group that is not exposed to the treatment; contrasts with the experimental group and serves as a comparison for evaluating the effect of the treatment.

::correlation

a measure of the extent to which two factors vary together, and thus of how well either factor predicts the other.

::correlation coefficient

a statistical index of the relationship between two things (from -1 to +1).

::dependent variable

the variable in which a researcher is interested in monitoring effects or outcomes

::double-blind procedure

an experimental procedure in which both the research participants and the research staff are ignorant (blind) about whether the research participants have received the treatment or a placebo. Commonly used in drug-evaluation studies.

::experiment

a research method in which an investigator manipulates one or more factors (independent variables) to observe the effect on some behavior or mental process (the dependent variable). By random assignment of participants, the experimenter aims to control other relevant factors.

::experimental control

the method of ensuring that the groups being studied are the same except for the manipulation or treatment under investigation

::experimental group

in an experiment, the group that is exposed to the treatment, that is, to one version of the independent variable.

::independent variable

the treatment variable manipulated in an experiment, or the causal variable believed to be responsible for particular effects or outcomes

::manipulation

the process of systematically varying an independent variable across different experimental conditions (sometimes referred to as the experimental treatment or intervention)

::naturalistic observation

observing and recording behavior in naturally occurring situations without trying to manipulate and control the situation.

::placebo [pluh-SEE-bo; Latin for “I shall please”] effect

experimental results caused by expectations alone; any effect on behavior caused by the administration of an inert substance or condition, which the recipient assumes is an active agent.

::population

all the cases in a group being studied, from which samples may be drawn. (Note: Except for national studies, this does not refer to a country’s whole population.)

::random assignment

assigning participants to experimental and control groups by chance, thus minimizing preexisting differences between those assigned to the different groups.

::random sample

a sample that fairly represents a population because each member has an equal chance of inclusion.

::treatment

the experimental manipulation of the independent variable

::Variable

A variable is simply something that changes or varies (is not constant).

::within-subjects design

a research design in which the same participants are exposed to different levels of the independent variable

2.11 CHECK YOUR PROGRESS

1. In which method of study of psychology, independent and dependent variable are important elements.
   (a) Introspection Method
   (b) Experimental Method
   (c) Observational Method
   (d) Case History Method
2. In _________ method of study in psychology, passive study and analysis of human behaviour is usually done.
   (a) Introspection Method
   (b) Experimental Method
   (c) Observational Method
   (d) Genetic Method
3. In the simplest experimental method, 'E' manipulates _________.
   (a) One Variable
   (b) Two Variables
   (c) Three Variables
   (d) Four Variables
4. The only way psychologists can establish cause-and-effect relationships through research is by
   (a) case studies
   (b) Naturalistic observation
   (c) Experiments
   (d) Correlational research

5. Random assignment is based on
   - (a) Chance
   - (b) Experimenter bias
   - (c) Participant choice
   - (d) The hypothesis in question

6. The change that an experimenter deliberately produces in a situation is called
   - (a) Experimental manipulation
   - (b) Randomization
   - (c) Replication
   - (d) Control group

2.12 ANSWERS TO CHECK YOUR PROGRESS

- (1) b
- (2) c
- (3) a
- (4) c
- (5) a
- (6) a

2.13 Model Questions

1. Explain the experimental method in detail.
2. What is the difference between experimental method and survey?
3. Explain correlational research.

LESSON 3
NERVOUS SYSTEM

INTRODUCTION

There is a great deal about the emergence of complex psychological processes from brain.In this unit, all aspects of behaviour and mental functioning can be better understood with some knowledge of the underlying biological processes. To start, let's consider the cellular foundations of the nervous system.

LEARNING OBJECTIVES

At the end of this lesson you will be able to understand

- the major parts of the nervous system and its principal components.
- the most important functions of these components.
- the parts of a nerve cell and how it functions.
- how nerve cells communicate with each other.

PLAN OF THE LESSON

3.1 INTRODUCTION

To LIVE is to take in information from the world and the body's tissues, to make decisions, and to send back information and orders to the body's tissues. All this happens through our body's speedy electrochemical communications network, our nervous system. The nervous system can be divided into two major regions: the central and peripheral nervous systems. The central nervous system (CNS) is the brain and spinal cord, and the peripheral nervous system (PNS) is everything else (Figure 3.1)

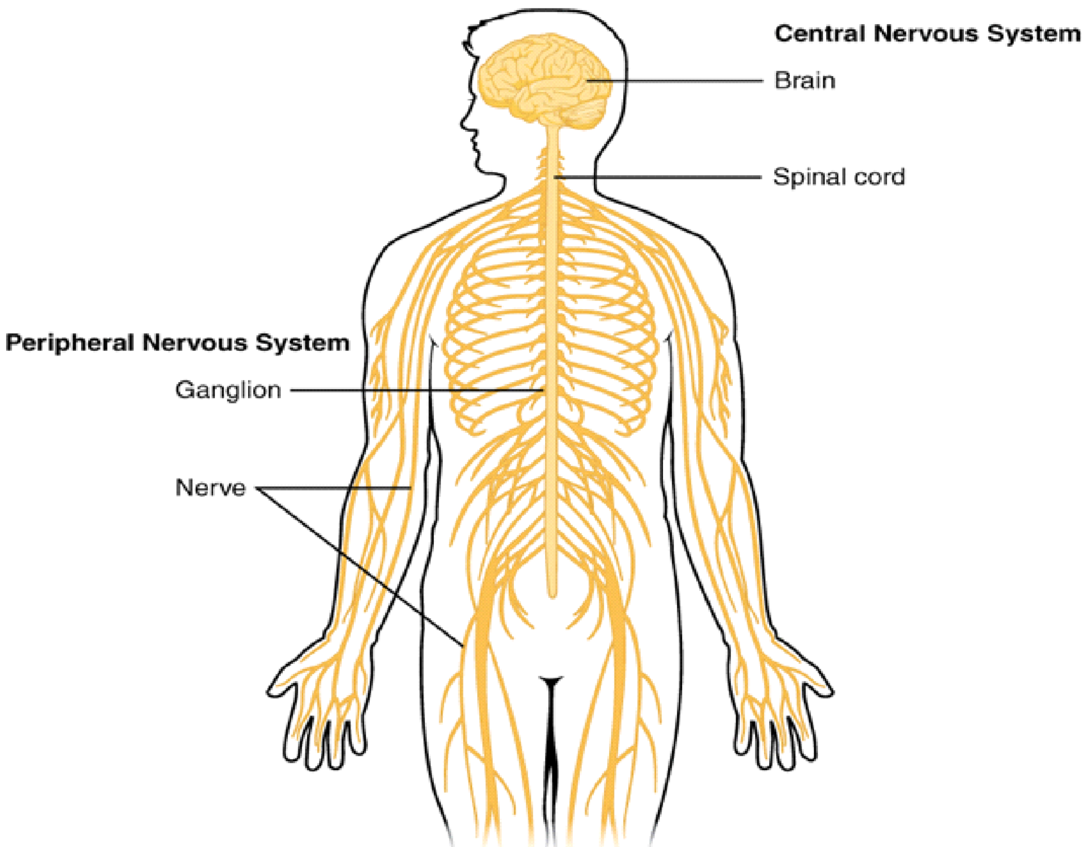


Figure 3.1

The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is too simple to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. The central nervous system (CNS), communicates with the body's sensory receptors, muscles, and glands via the peripheral nervous system (PNS).

The Major Divisions of the Nervous System	
Central Nervous System (CNS)	Peripheral Nervous System (PNS)
BrainNerves	Spinal cord Peripheral ganglia

TABLE 3.1

The brain has two primary functions: the control of behaviour and the regulation of the body's physiological processes. The brain cannot act alone – it needs to receive information from the body's sense receptors and it must be connected with the muscles and glands of the body if it is to affect behaviour and physiological processes. The spinal cord is a long, thin collection of nerve cells attached to the base of the brain and running the length of the spinal column. It contains circuits of nerve cells that control some simple reflexes, such as automatically pulling away from a painfully hot object. The central nervous system communicates with the rest of the body through the nerves – bundles of fibres that transmit information in and out of the central nervous system. The nerves, which are attached to the spinal cord and to the base of the brain, make up the peripheral nervous system.

3.2 THE STRUCTURE OF NEURONS

To describe the functional divisions of the nervous system, it is important to understand the structure of a neuron.

3.2.1 Glial cells – more than just glue

Neurons are the basic unit of the whole of the nervous system. Neurons operate alongside various other types of cells, whose activity can be essential to normal neuronal function. Even in the brain, only about 10 per cent of the cells are neurons. Most are glial cells, which fall into several different classes, each with its own function. There are astrocytes, oligodendrocytes (in the central nervous system), microglia and ependymal cells. (The word ending -cyte means 'cell'.)

Glia (or neuroglia), the other major components of the nervous system, do not transmit information over long distances as neurons do, although they do exchange chemicals with adjacent neurons.Glial cells were once thought of as the structural glue (that is what glia means in Greek) that holds the neurons in place, but their roles are proving to be far more complex.

There are several types of glia with different functions in the brain (Haydon, 2001). The star-shaped astrocytes wrap around the presynaptic terminals of a group of functionally related axons, synchronize the activity of the axons, enabling them to send messages by taking up chemicals released by axons and then releasing them back to axons.. Astrocytes also remove waste material created when neurons die and control the amount of blood fiow to each brain area . An additional function is that during periods of heightened activity in some brain area, astrocytes dilate the blood vessels to bring more nutrients into that area. Furthermore, astrocytes release chemicals that modify the activity of neighboring neurons.

Astrocytes do more than just support neurons. They are an important contributor to information processing. Microglia, very small cells, also remove waste material as well as viruses, fungi, and other microorganisms. In effect, they function like part of the immune system . Oligodendrocytes (OL-i-go-DEN-druh-sites) in the brain and spinal cord and Schwann cells in the periphery are specialized types of glia that build the myelin sheaths that surround and insulate certain vertebrate axons. Radial glia guide the migration of neurons and their axons and dendrites during embryonic development. When embryological development finishes, most radial glia differentiate into neurons,and a smaller number differentiate into astrocytes and oligodendrocytes .

3.2.2 Neurons:The three components of neurons

Neurons come in many shapes – or morphologies – which give them their different functions. For example, projection neurons have fibres that connect them to other parts of the nervous system. Even within this category, there are many different morphologies, but all projection neurons share some basic similarities. Generally neuron have three essential components (see figure 3.2). (1) The cell body, (2) Dendrites and (3) Axon

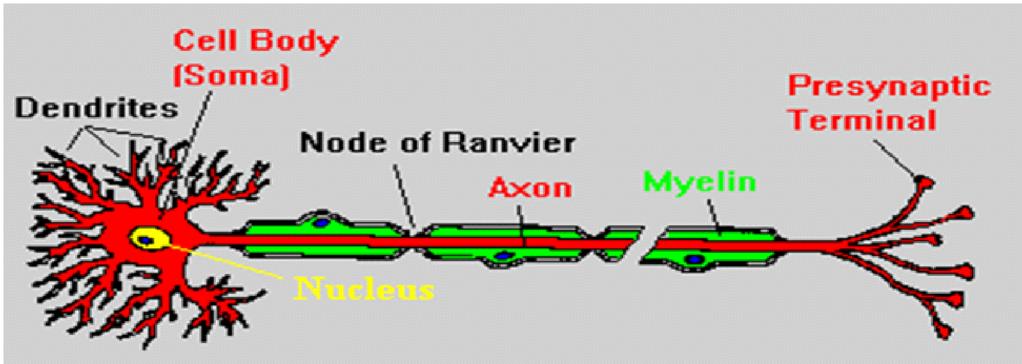


Figure 3.2

3.2.2.1 The cell body

The most prominent part of the neuron is the cell body or soma. The cell bodyor soma contains the nucleus, ribosomes, mitochondria, and other structures found in most cells. Much of the metabolic work of the neuron occurs here. Cell bodies of neurons range in diameter from 0.005 mm to 0.1 mm in mammals and up to a full millimeter in certain invertebrates. Like the dendrites, the cell body is covered with synapses on its surface in many neurons.

The cell body is filled with a watery liquid called cytoplasm and contains a number of organelles. The largest of these organelles is the nucleus, which contains the cell's chromosomes. Other organelles are responsible for converting nutrients into fuel for the cell, constructing proteins, and removing waste materials. The heart of the neuron is the cell body, where the cell's metabolic activities take place. Input from other neurons typically comes via the dendrites.

3.2.2.2 Dendrites

These can be a relatively simple cluster of fine, fibre-like extensions from the cell body, or highly complex branches like the twigs and leaves of a tree. Dendrites are branching fibers that get narrower near their ends. (The term dendrite comes from a Greek root word meaning "tree"; a dendrite is shaped like a tree.) The dendrite's surface is lined with specialized synaptic receptors, at which the dendrite receives information from other neurons.

The greater the surface area of a dendrite, the more information it can receive. Some dendrites branch widely and therefore have a large surface area. Some also contain dendritic spines, the short outgrowths that increase the surface area available for synapses. The shape of dendrites varies enormously from one neuron to another and can even vary from one time to another for a given neuron. The shape of the dendrite has much to do with how the dendrite combines different kinds of input. The output of the neuron is transmitted via its axon to the dendrites of other neurons, or other targets such as muscles.

3.2.2.3 Axon

The axon is a thin fiber of constant diameter, in most cases longer than the dendrites. (The term axon comes from a Greek word meaning “axis.”) The axon is the information sender of the neuron, conveying an impulse toward other neurons or an organ or muscle. Many vertebrate axons are covered with an insulating material called a myelin sheath with interruptions known as nodes of Ranvier (RAHN-vee-ay).

An axon has many branches, each of which swells at its tip, forming a presynaptic terminal, also known as an end bulb or bouton (French for “button”). At this point the axon releases chemicals that cross through the junction between one neuron and the next. A neuron can have any number of dendrites, but no more than one axon, which may have branches. In most cases, branches of the axon depart from its trunk far from the cell body, near the terminals.

Axons can be very long, reaching right down the spinal cord, or so short that it is difficult to tell them apart from the dendrites. Nerve cells with such short axons are called interneurons rather than projection neurons, because all their connections are local. Some neurons have just a single axon, although it may still make contact with a number of different target cells by branching out towards its end. Other cells have axons that are split into quite separate axon collaterals, each of which may go to an entirely different target structure.

3.2.3 Other terms associated with neurons

Neurons are also referred as afferent, efferent, and intrinsic. An afferent axon brings information into a structure; an efferent axon carries information away from a structure. Every sensory neuron is an afferent to the rest of the nervous system, and every motor neuron is an efferent from the nervous system. Within the nervous system, a given neuron is an efferent from one structure and an afferent to another. (You can remember that efferent starts wiThe as in exit; afferent starts with a as in admission.) For example, an axon that is efferent from the thalamus may be afferent to the cerebral cortex. If a cell’s dendrites and axon are entirely contained within a single structure, the cell is an interneuron or intrinsic neuron of that structure. For example, an intrinsic neuron of the thalamus has its axon and all its dendrites within the thalamus.

3.2.4 Variations Among Neurons

Neurons vary enormously in size, shape, and function. The shape of a given neuron determines its connections with other neurons and thereby determines its contribution to the nervous system. Neurons with wider branching connect with more neurons. Neurons are distinguished from other cells by their shape. The larger neurons have these components: dendrites, a soma (cell body), an axon, and presynaptic terminals. (The tiniest neurons lack axons, and some lack well-defined dendrites.)

A motor neuron has its soma in the spinal cord. It receives excitation from other neurons through its dendrites and conducts impulses along its axon to a muscle. A sensory neuron is specialized at one end to be highly sensitive to a particular type of stimulation, such as light, sound, or touch. The sensory neuron is a neuron conducting touch information from the skin to the spinal cord. Tiny branches lead directly from the receptors into the axon, and the cell's soma is located on a little stalk off the main trunk.

The function of a neuron relates to its shape. For example, the widely branching dendrites of the Purkinje cell of the cerebellum enable it to receive input from a huge number of axons. By contrast, certain cells in the retina have only short branches on their dendrites and therefore pool input from only a few sources.

3.3 Communication in the neuron: The Resting Potential of the Neuron

The membrane of a neuron maintains an electrical gradient, a difference in electrical charge between the inside and outside of the cell. This membrane which is covering all parts of a neuron is about 8 nanometers (nm) thick (just less than 0.00001 mm), composed of two layers (an inner layer and an outer layer) of phospholipid molecules (containing chains of fatty acids and a phosphate group). Embedded among the phospholipids are cylindrical protein molecules (see Figure 2.3). The structure of the membrane provides it with a good combination of fiexibility and firmness and retards the fiow of chemicals between the inside and the outside of the cell.

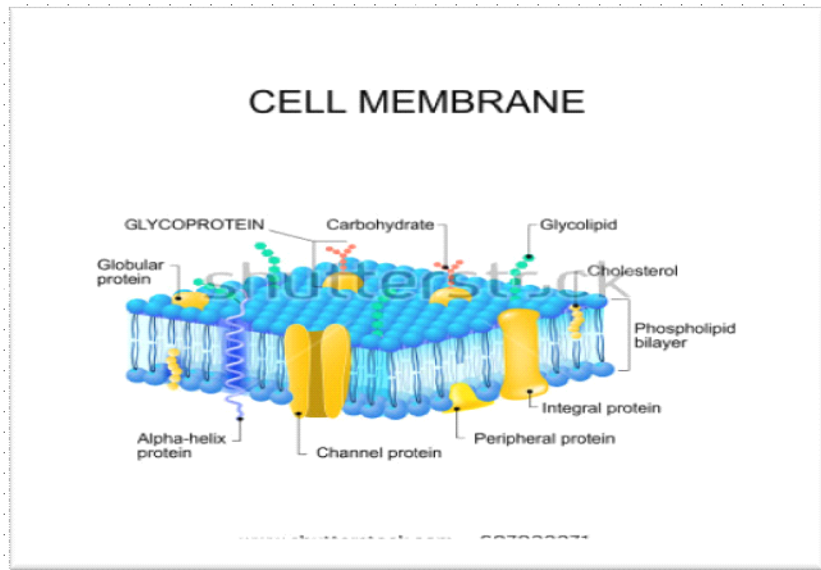


Figure 3.3

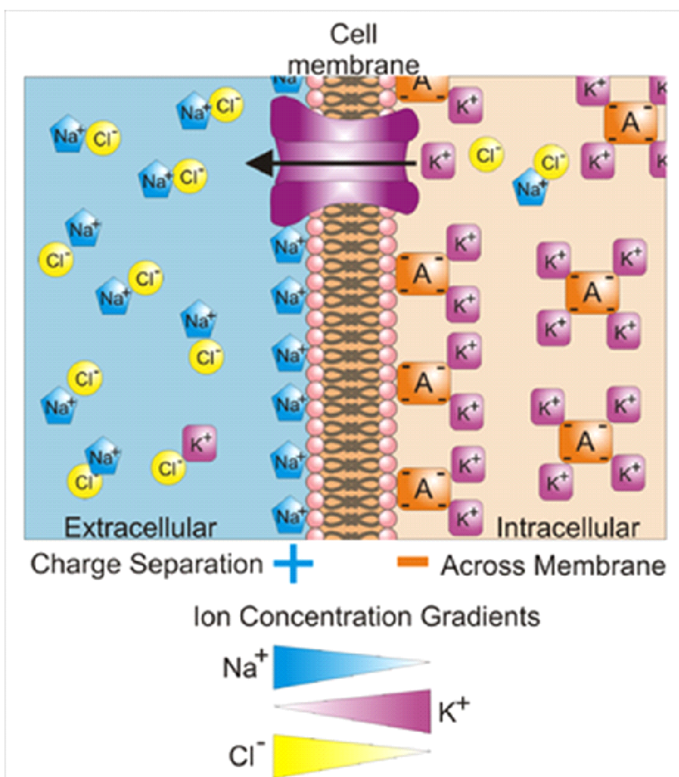


Figure 3.4

An electrical polarization, meaning a difference in electrical charge between two locations is maintained by the membrane in the absence of any outside disturbance. The neuron inside the membrane has a slightly negative electrical potential with respect to the outside, mainly because of negatively charged proteins inside the cell. This difference in voltage in a resting neuron is called the resting potential. The resting potential is mainly the result of negatively charged proteins inside the cell. A typical level electrical charge in a neuron during resting potential is –70 millivolts (mV), but it varies from one neuron to another.(Figure 3.4)

3.3.1 Forces Acting on Sodium and Potassium Ions

If the electrically charged ions could fiow freely across the membrane, the membrane would depolarize at once. But, since the membrane of neuron is selectively permeable; that is, only some chemicals can pass through it more freely than others. Most of the large or electrically charged ions and molecules cannot cross the membrane at all. Oxygen, carbon dioxide, urea, and water cross freely through channels that are always open. A few biologically important ions, such as sodium, potassium, calcium, and chloride, cross through membrane channels (or gates) that are sometimes open and sometimes closed.

During the resting potential the sodium channels remains closed, preventing almost all sodium fiow. Certain kinds of stimulation can open the sodium channels. Potassium channels are nearly but not entirely closed, when the membrane is at rest, allowing the potassium to fiow slowly. The sodium-potassium pump, a protein complex, repeatedly transports three sodium ions out of the cell while drawing two potassium ions into it. The sodium-potassium pump is an active transport requiring energy. As a result of the sodium-potassium pump, sodium ions are 10 times more concentrated outside the membrane than inside, and potassium ions are similarly more concentrated inside than outside.

The sodium-potassium pump is effective only because of the selective permeability of the membrane, which prevents the sodium ions that were pumped out of the neuron from leaking right back in again. As it is, the sodium ions that are pumped out stay out. However, some of the potassiumions pumped into the neuron do leak out, carrying a positive charge with them. That leakage increases the electrical gradient across the membrane.

When the neuron is at rest, two forces (the electrical gradient and the concentration gradient) act on sodium, both tending to push it into the cell. First, let us consider the electrical gradient. Sodium is positively charged and the inside of the cell is negatively charged. Opposite electrical charges attract, so the electrical gradient tends to pull sodium into the cell. Second, when we consider the concentration gradient, the difference in distribution of ions across the membrane. Sodium is more concentrated outside than inside, so just by the laws of probability, sodium is more likely to enter the cell than to leave it. (By analogy, imagine two rooms connected by a door. There are 100 cats are in room A and only 10 in room B. Cats are more likely to move from A to B than from B to A. The same principle applies to the movement of ions across a membrane.) Given that both the electrical gradient and the concentration gradient tend to move sodium ions into the cell, sodium would move rapidly if it could. However, the sodium channels are closed when the membrane is at rest, and almost no sodium fiows except for the sodium pushed out of the cell by the sodium-potassium pump.

Potassium is subject to competing forces. Potassium is positively charged and the inside of the cell is negatively charged, so the electrical gradient tends to pull potassium in. However, potassium is more concentrated inside the cell than outside, so the concentration gradient tends to drive it out. If the potassium channels were wide open, potassium would have a moderate net fiow out of the cell. That is, the electrical gradient and concentration gradient for potassium are almost in balance, but not quite. The sodium-potassium pump keeps pulling potassium in, so the two gradients cannot get completely in balance. The cell has negative ions, too. Negatively charged proteins inside the cell are responsible for the membrane's polarization. Chloride ions, being negatively charged, are mainly outside the cell. In most neurons, the concentration gradient and electrical gradient balance, so opening chloride channels produces little effect when the membrane is at rest. However, chloride fiow is important when the membrane's polarization changes, ions pumped into the neuron do leak out, carrying a positive charge with them. That leakage increases the electrical gradient across the membrane. (Figure 3.5)

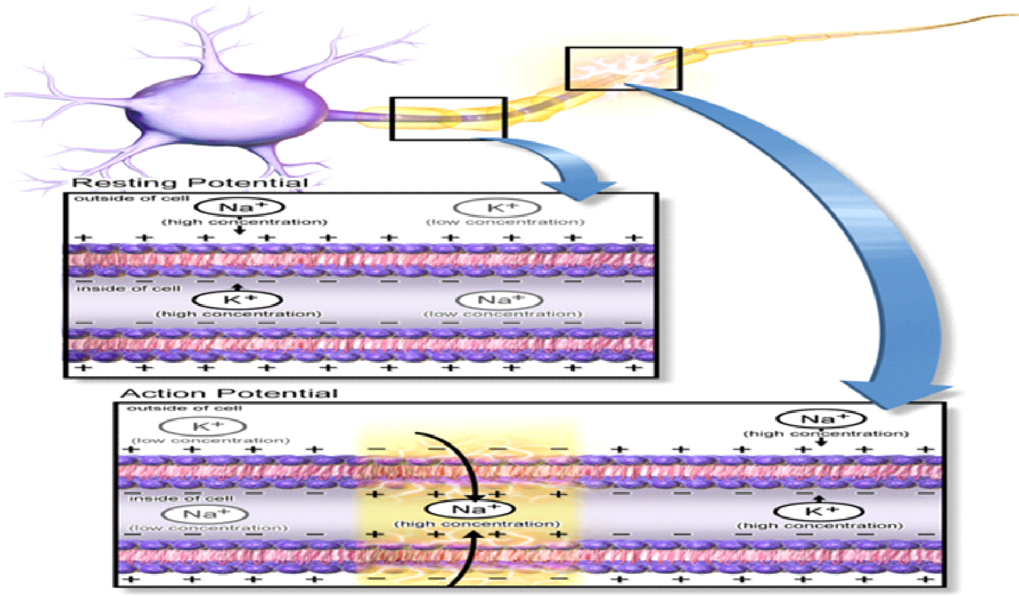


Figure 3.5

The resting potential prepares the neuron to respond rapidly. Excitation of the neuron opens channels that let sodium enter the cell explosively. Because the membrane did its work in advance by maintaining the concentration gradient for sodium, the cell is prepared to respond strongly and rapidly to a stimulus. The resting potential of a neuron can be compared to a poised bow and arrow: An archer who pulls the bow in advance and then waits, is ready to fire as soon as the appropriate moment comes. Evolution has applied the same strategy to the neuron.

3.4 The Action Potential

The resting potential remains stable until the neuron is stimulated. Ordinarily, stimulation of the neuron takes place at synapses. In the laboratory, it is also possible to stimulate a neuron by inserting an electrode into it and applying current. A neuron's electrical potential can be recorded with a microelectrode. When an axon's membrane is at rest, the recordings show a negative potential inside the axon. When negative charge is applied using another electrode, we can further increase the negative charge inside the neuron. This change is called hyperpolarization, which means increased polarization. As soon as the artificial stimulation ceases, the charge returns to its original resting level.

3.4.1 The Molecular Basis of the Action Potential

Both the electrical gradient and the concentration gradient tend to drive sodium ions into the neuron. If sodium ions could fiow freely across the membrane, they would enter rapidly. The membrane proteins that control sodium entry are voltage-gated channels, membrane channels whose permeability depends on the voltage difference across the membrane. At the resting potential, the channels are closed. As the membrane becomes depolarized, the sodium channels begin to open and sodium fiows more freely.

If the depolarization is less than the threshold, sodium crosses the membrane only slightly more than usual. When the potential across the membrane reaches threshold, the sodium channels open wide. Sodium ions rush into the neuron explosively until the electrical potential across the membrane passes beyond zero to a reversed polarity, as shown in the following diagram (3.1):

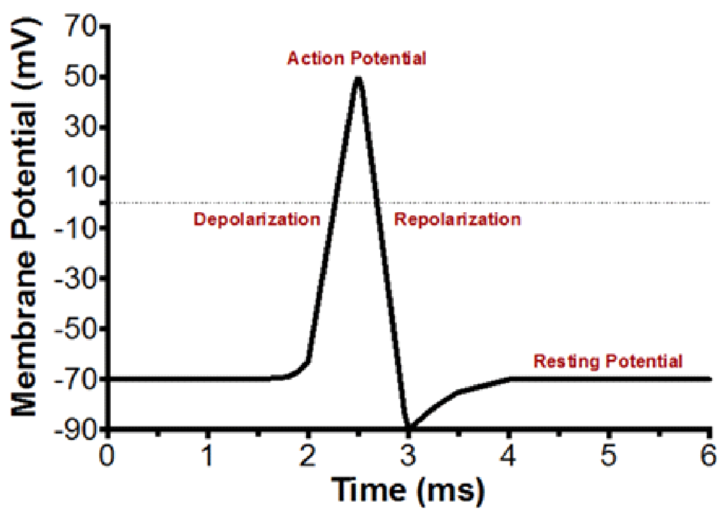


Diagram 3.1

Compared to the total number of sodium ions in and around the axon, fewer than 1% of them cross the membrane during an action potential. Even at the peak of the action potential, sodium ions continue to be far more concentrated outside the neuron than inside. Because of the persisting concentration gradient, sodium ions should still tend to diffuse into the cell. However, at the peak of the action potential, the sodium gates quickly close and resist reopening for about the next millisecond.

After the peak of the action potential, the voltage gated potassium channels open and brings the membrane back to its original state of polarization. When the potassium gates opens, potassium ions fiow out of the axon simply because they are much more concentrated inside than outside and they are no longer held inside by a negative charge. As they fiow out of the axon, they carry with them a positive charge. Because the potassium channels open wider than usual and remain open after the sodium channels close, enough potassium ions leave to drive the membrane beyond the normal resting level to a temporary hyperpolarization. Meanwhile, negatively charged chloride ions, which are more concentrated outside the membrane, are no longer repelled by a negative charge within the cell, so they tend to fiow inward.

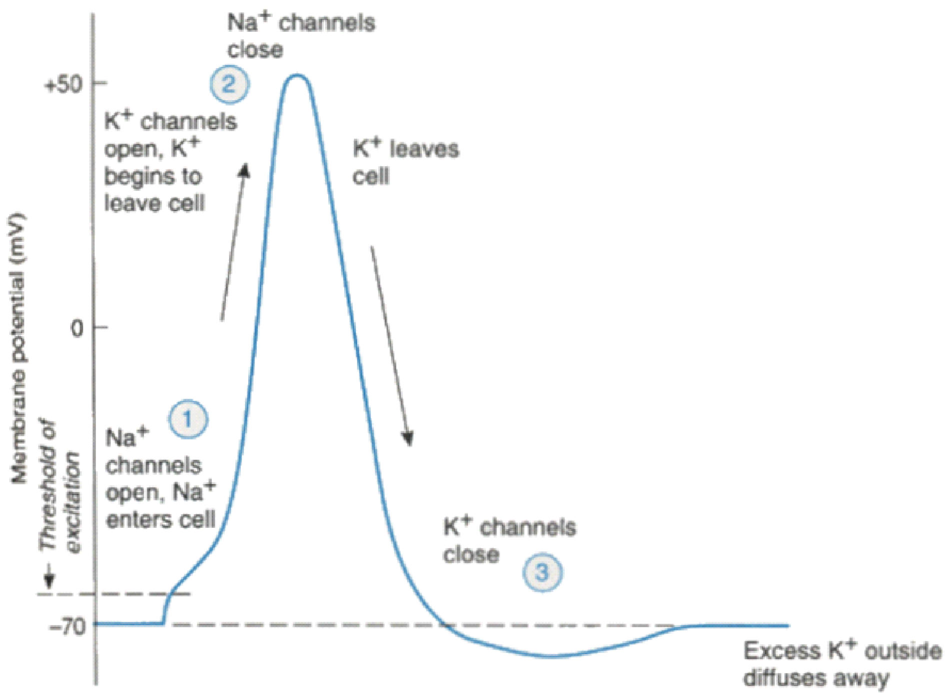


Diagram 3.2

Diagram 3.2 summarizes the key movements of ions during an action potential. At the end of this process, the membrane has returned to its resting potential, but the inside of the neuron has slightly more sodium ions and slightly fewer potassium ions than before. Eventually, the sodium-potassium pump restores the original distribution of ions, but that process takes time. Although the amplitude, velocity, and shape of action potentials are consistent over time for a given axon, they vary from one neuron to another.

The all-or-none law puts constraints on how an axon can send a message. To signal the difference between a weak stimulus and a strong stimulus, the axon can't send bigger or faster action potentials. All it can change is the timing. By analogy, suppose you agree to exchange coded messages with someone who can see your window when you fiick the lights on and off. The two of you might agree, for example, to indicate some kind of danger by the frequency of fiashes. (The more fiashes, the more danger.) Much of the brain's signaling follows this principle; more frequent action potentials signal a greater intensity of stimulus. You could also convey information by a rhythm. Flash-fiash . . . [long pause] . . . fiash-fiash might mean something different from Flash . . . [pause] . . . fiash . . . [pause] . . . fiash . . . [pause] . . . fiash. In some cases, the nervous system uses this kind of coding. For example, an axon might show one rhythm of responses for sweet tastes and a different rhythm for bitter tastes.

3.4.2 The Refractory Period

Immediately after an action potential, the cell is in a refractory period during which it resists the production of further action potentials. In the first part of this period, the absolute refractory period, the membrane cannot produce an action potential, regardless of the stimulation. During the second part, the relative refractory period, a stronger than usual stimulus is necessary to initiate an action potential.

The refractory period has two mechanisms: The sodium channels are closed, and potassium is fiowing out of the cell at a faster than usual rate. Most of the neurons that have been tested have an absolute refractory period of about 1 ms and a relative refractory period of another 2–4 ms. (For example in the toilet analogy, there is a short time right after you fiush a toilet when you cannot make it fiush again—an absolute refractory period. Then follows a period when it is possible but diffcult to fiush it again—a relative refractory period—before it returns to normal.)

3.4.3 The All-or-None Law

Action potentials occur only in axons and cell bodies. When the voltage across an axon membrane reaches a certain level of depolarization (the threshold), voltage-gated sodium channels open wide to let sodium enter rapidly, and the incoming sodium depolarizes the membrane still further. Dendrites can depolarize also, but they don't have voltage-gated sodium channels, so opening the channels a little, letting in a little sodium, doesn't cause them to open even more and let in still more sodium. Thus, dendrites don't have action potentials. If the dendrites depolarize the cell enough, its axon produces an action potential.

For a given neuron, all action potentials are approximately equal in amplitude (intensity) and velocity under normal circumstances. This is all-or-none law: The amplitude and velocity of an action potential are independent of the intensity of the stimulus that initiated it. By analogy, imagine fiushing a toilet: You have to make a press of at least a certain strength (the threshold), but pressing harder does not make the toilet fiush any faster or more vigorously.

3.4.4 Propagation of the Action Potential

Up to this point, we have seen how the action potential occurs at one point on the axon. Now let us see how it moves down the axon. It is important for axons to convey impulses without any loss of strength over distance. In a motor neuron, an action potential begins on the axon hillock, a swelling where the axon exits the soma. Each point along the membrane regenerates the action potential in much the same way that it was generated initially.

During the action potential, sodium ions enter a point on the axon. Temporarily, that location is positively charged in comparison with neighboring areas along the axon. The positive ions fiow down the axon and across the membrane. Other things being equal, the greater the diameter of the axon, the faster the ions fiow (because of decreased resistance). The positive charges now inside the membrane slightly depolarize the adjacent areas of the membrane,(as shown in Figure 3.6) causing the next area to reach its threshold and open the voltage-gated sodium channels. Therefore, the membrane regenerates the action potential at that point. In this manner, the action potential travels like a wave along the axon.

The term propagation of the action potential describes the transmission of an action potential down an axon. The propagation of an animal species is the production of off spring; in a sense, the action potential gives birth to a new action potential at each point along the axon. In this manner, the action potential can be just as strong at the end of the axon as it was at the beginning. The action potential is much slower than electrical conduction because it requires the diffusion of sodium ions at successive points along the axon.

Let’s examine Figure 3.6 for a moment. What is to prevent the electrical charge from fiowing in the direction opposite to that, in which the action potential is travelingfi Nothing. In fact, the electrical charge does fiow in both directions. In that case, what prevents an action potential near the center of an axon from reinvading the areas that it has just passedfi The answer is that the areas just passed are still in their refractory period.

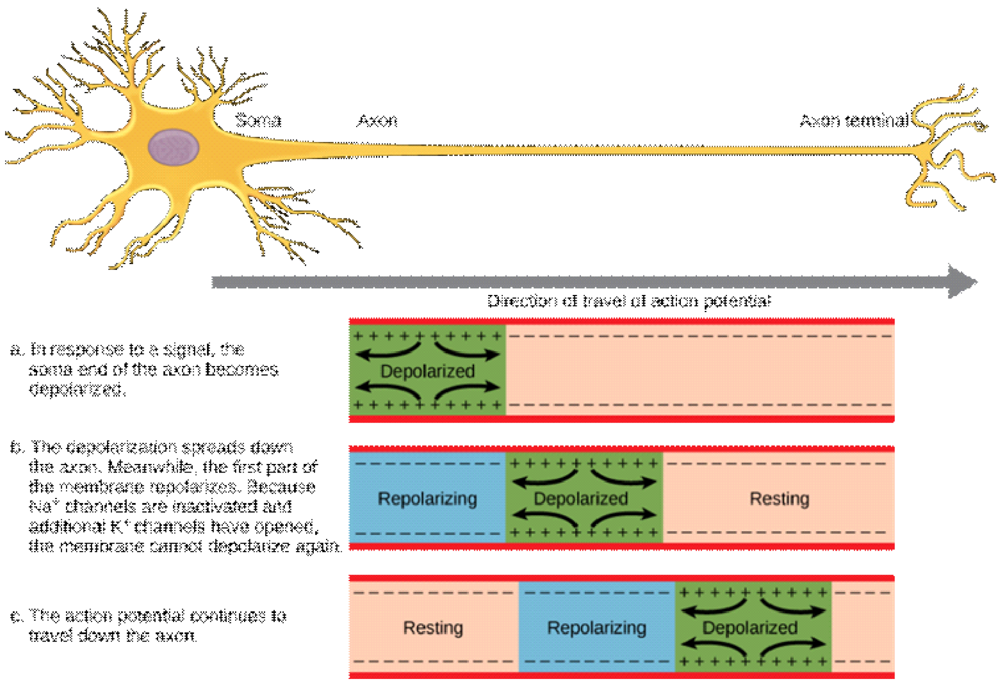


Figure 3.6

3.4.5 The Myelin Sheath and Saltatory Conduction

In the thinnest axons, action potentials travel at a velocity of less than 1 m/s. Increasing the diameter increases conduction velocity up to about 10 m/s. At that speed, an impulse along an axon to or from a giraffe's foot takes about half a second. To increase the speed up to about 100 m/s, vertebrate axons evolved a special mechanism: sheaths of myelin, an insulating material composed of fats and proteins. Consider the following analogy. Suppose my job is to take written messages over a distance of 3 kilometers (km) without using any mechanical device. Taking each message and running with it would be reliable but slow, like the propagation of an action potential along an unmyelinated axon. If I tied each message to a ball and threw it, I could increase the speed, but my throws would travel only a small fraction of the 3 km. The ideal compromise is to station people at moderate distances along the 3 km and throw the message-bearing ball from person to person until it reaches its destination. The principle behind myelinated axons, those covered with a myelin sheath, is the same.

Myelinated axons, found only in vertebrates, are covered with fats and proteins. The myelin sheath is interrupted periodically by short sections of axon called nodes of Ranvier

(Figure 3.7) Each node is only about 1 micrometer wide. Suppose an action potential starts at the axon hillock and propagates along the axon until it reaches the first myelin segment. The action potential cannot regenerate along the membrane between nodes because sodium channels are virtually absent between nodes.

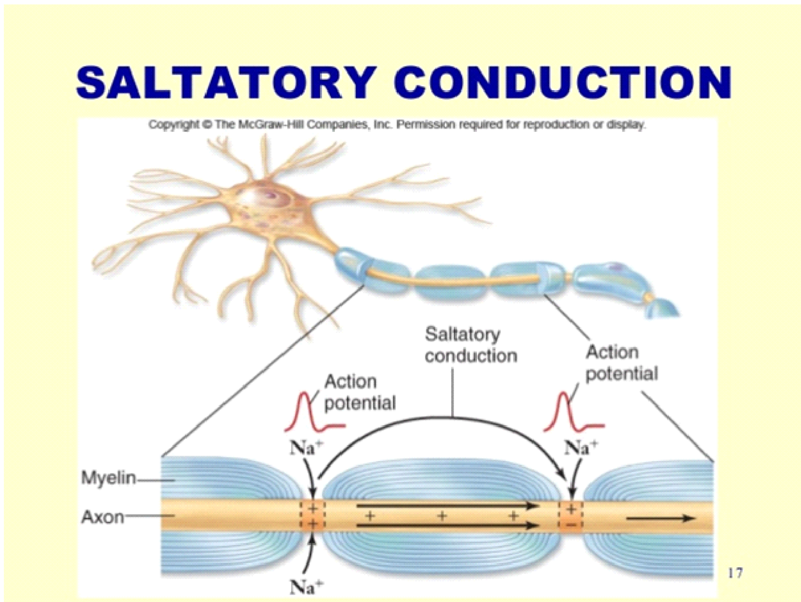


Figure 3.7

After an action potential occurs at a node, sodium ions enter the axon and diffuse within the axon, repelling positive ions that were already present and pushing a chain of positive ions along the axon to the next node, where they regenerate the action potential. This fiow of ions is considerably faster than the regeneration of an action potential at each point along the axon. The jumping of action potentials from node to node is referred to as saltatory conduction, from the Latin word saltare, meaning “to jump.”

In addition to providing rapid conduction of impulses, saltatory conduction conserves energy: Instead of admitting sodium ions at every point along the axon and then having to pump them out via the sodium-potassium pump, a myelinated axon admits sodium only at its nodes. Multiple sclerosis is one of several demyelinating diseases, in which the immune system attacks myelin sheaths. An axon that never had a myelin sheath conducts impulses, though at a relatively slow speed. An axon that has lost its myelin is not the same. When myelin forms along an axon, the axon loses its sodium channels under the myelin. If the axon loses myelin, it still lacks sodium channels in the areas previously covered with myelin, and most action potentials die out between one node and the next. People with multiple sclerosis suffer a variety of impairments, ranging from visual impairments to poor muscle coordination.

3.5 Graded Potentials

Neurons without axons exchange information only with their closest neighbors and are therefore known as local neurons. A local neuron receives information from other neurons and produces graded potentials, membrane potentials that vary in magnitude without following the all-or-none law. When a local neuron is stimulated, it depolarizes or hyperpolarizes in proportion to the intensity of the stimulus. The change in membrane potential is conducted to adjacent areas of the cell, in all directions, gradually decaying as it travels. Those various areas of the cell contact other neurons, which they excite or inhibit through synapses.

3.6 Communication with Other Cells: Synapses

Neurons communicate with other cells through synapses, by means of a process known as synaptic transmission. A synapse is the junction of a terminal button of one neuron and the membrane of another cell—another neuron or a cell in a muscle, a gland, or an internal organ. Let us first consider synapses between one neuron and another. The terminal button belongs to the presynaptic neuron—the neuron “before the synapse” that sends the message. When terminal buttons become active, they release a chemical called a neurotransmitter.

The neuron that receives the message (that detects the neurotransmitter) is called the postsynaptic neuron—the neuron “after the synapse.” A neuron receives messages from many terminal buttons, and in turn its terminal buttons form synapses with other neurons. There are two basic types of synapses: excitatory synapses and inhibitory synapses. Excitatory synapses do just what their name implies—when the axon fires, the terminal buttons release a neurotransmitter that excites the postsynaptic neurons with which they form synapses. The effect of this excitation is to increase the rate of firing of the axons of the postsynaptic neurons. Inhibitory synapses do just the opposite—when they are activated, they lower the rate at which these axons fire. The rate at which a particular axon fires is determined by the activity of all the synapses on the dendrites and soma of the cell. If the excitatory synapses are more active, the axon will fire at a high rate. If the inhibitory synapses are more active, it will fire at a low rate or perhaps not at all.

The neurotransmitter causes reactions in the postsynaptic neuron that either excite or inhibit it. These reactions are triggered by special sub microscopic protein molecules embedded in the postsynaptic membrane called neurotransmitter receptors. A molecule of a neurotransmitter binds with its receptor the way a particular key fits in a particular lock. After their release from a terminal button, molecules of a neurotransmitter diffuse across the synaptic cleft, bind with the receptors, and activate them. Once they are activated, the receptors produce excitatory or inhibitory effects on the postsynaptic neuron. They do so by opening ion channels.

Most ion channels found at excitatory synapses permit sodium ions to enter the postsynaptic membrane; most of those found at inhibitory synapses permit potassium ions to leave. The excitation or inhibition produced by a synapse is short-lived; the effects soon pass away, usually in a fraction of a second. At most synapses the effects are terminated by a process called reuptake. Molecules of the neurotransmitter are released and are quickly taken up again by the terminal button, so the neurotransmitter has only a short time to stimulate the postsynaptic receptors. The rate at which the terminal button takes back the neurotransmitter determines how prolonged the effects of the chemical on the postsynaptic neuron will be. The faster the neurotransmitter is taken back, the shorter its effects will be on the postsynaptic neuron.

3.6.1 A simple neural circuit

The ‘neural wiring diagram’ for a simpler reflexes that are triggered by certain kinds of sensory stimuli. For example, when your finger touches a painfully hot object, your hand withdraws. A simple withdrawal reflex, which is triggered by a noxious stimulus (such as contact with a hot object), requires three types of neuron. Sensory neurons detect the noxious stimulus and convey this information to the spinal cord. Interneurons, located entirely within the brain or spinal cord, receive the sensory information and in turn stimulate the motor neurons that cause the appropriate muscle to contract. The sequence is simple and straightforward. A noxious stimulus applied to the skin produces a burst of action potentials in the sensory neurons. Their axons fire, and their terminal buttons, located within the spinal cord, release an excitatory transmitter substance. The chemical stimulates the interneurons and causes them to fire. The interneurons excite the motor neurons, and these neurons cause the muscle to contract.

The next example adds a bit of complexity to the circuit. Imagine that you have removed a hot casserole dish from the oven. As you move over to the table to put it down, the heat begins to penetrate the rather thin oven gloves you are using. The pain caused by the hot dish triggers a withdrawal reflex that tends to make you drop it. And yet you manage to keep hold of it long enough to get to the table and put it down. The answer is that the activity of a neuron depends on the relative activity of the excitatory and inhibitory synapses on it. The pain from the hot casserole dish increases the activity of excitatory synapses on the motor neurons, which tends to cause the hand to open. However, this excitation is counteracted by inhibition from another source – the brain.

The brain contains neural circuits that recognize what a disaster it would be if you dropped the casserole dish on the floor. These neural circuits send information to the spinal cord that prevents the withdrawal reflex from making you drop the dish. An axon from a neuron in the brain reaches the spinal cord, where it forms a synapse with an inhibitory interneuron. When the neuron in the brain becomes active, it excites this inhibitory interneuron. The interneuron releases an inhibitory transmitter substance, which decreases the rate of firing of the motor neuron, preventing your hand from opening. This circuit provides an example of a contest between two competing tendencies: to drop the casserole dish and to hold onto it. Complex decisions about behaviour are made within the brain by much more complicated circuits of neurons, but the basic principles remain the same.

3.8 Conclusion

The cell body of a neuron is the site of synthesis and degradation of virtually all neuronal proteins and membranes. Axons are long processes specialized for the conduction of action potentials away from the neuronal cell body. Action potentials are sudden membrane depolarizations followed by a rapid repolarization. They originate at the axon hillock and move toward axon terminals, where the electric impulse is transmitted to other cells via an electric or chemical synapse Most neurons have multiple dendrites, which receive chemical signals from the axon termini of other neurons. When an action potential reaches a chemical synapse, a neurotransmitter is released into the synaptic cleft. Binding of the neurotransmitter to receptors on the postsynaptic cell changes the ion permeability and thus the electric potential of the postsynaptic plasma membrane. Neurons are organized into circuits. In a reflex arc, such as the knee-jerk reflex, interneurons connect multiple sensory and motor neurons, allowing one sensory neuron to affect multiple motor neurons. One muscle can be stimulated to contract while another is inhibited from contracting.

3.9 SUMMARY:

The nervous system is the basis of all that we refer to as psychological--thoughts, feelings, moods, behaviors. Nervous system consists of two major regions: the central nervous system consisting of brain and spinal cord and the peripheral nervous system. The most fundamental structure of the nervous system is a single cell called a neuron. The neurons are different from other cells of the body in that they are capable of carrying signals and relaying information. Although neurons play different roles and come in a variety of sizes and shapes, all can be described in terms of the same functional parts, including dendrites, axons, and axon terminals. Some neurons bring sensory information to the brain, others carry commands from the brain to muscles and glands, and still others serve communication functions entirely within the brain and spinal cord. A neuron's dendrites receive incoming information; its axon carries the information to other cells through axon terminals, which send a chemical messenger to other cells. The signals carried by the neurons take the form of electrical impulses, or action potentials, which involve the movement of electrically charged particles across the cell's membrane. These movements result in changes in the electrical balance across the membrane, carrying the impulses down the axon to the axon terminal, where, through synaptic transmission, the neuron sends messages to other cells. In synaptic transmission, minute quantities of chemical messengers called neurotransmitters flow across a tiny gap between cells, called the synapse. Upon reaching the cell that is receiving information, neurotransmitter molecules bind to special receptor sites and in that fashion affect the electrical balance of the receiving cell.

3.10 KEY WORDS

:: Absolute refractory period:

The period immediately following the firing of a nerve fiber when it cannot be stimulated no matter how great a stimulus is applied.

:: Action potential:

A rapid rise and subsequent fall in voltage or membrane potential across a cellular membrane with a characteristic pattern.

:: All-or-none Law:

The amplitude and velocity of an action potential are independent.

:: Axon:

Tube like long extension from the end of a neuron that carries messages to other cells through the neuron.

:: Concentration gradient:

The process of particles, which are sometimes called solutes, moving through a solution or gas from an area with a higher number of particles to an area with a lower number of particles.

:: Dendrites:

Cluster of fibers at one end of a neuron that receives messages from other neurons.

:: Depolarization:

Movement of a cell's membrane potential to a more positive value (i.e. movement closer to zero from resting membrane potential).

:: Electrical gradience :

Difference in charge across a membrane.

:: Glia:

The structural glue (that is what glia means in Greek) that holds the neurons in place

:: Hyper polarization:

Increased polarization

:: Myelin sheath:

axons protective coating, made of fat and protein. Its function is to prevent messages from short circulating by insulating the axons.

:: Polarization:

A difference in electrical charge between two locations, maintained by the membrane in the absence of any outside disturbance.

:: Refractory period:

Period immediately following stimulation during which a nerve or muscle is unresponsive to further stimulation.

:: Relative refractory period:

Is when the neuron is able to respond to a stimulus but needs a stronger than normal stimulus in order to do so and is longer in duration.

:: Resting potential:

The imbalance of electrical charge existing between the interior of electrically excitable neurons (nerve cells) and their surroundings. The resting potential of electrically excitable cells lies in the range of -60 to -95 millivolts (1 millivolt = 0.001 volt), with the inside of the cell negatively charged.

:: Saltatory conduction:

The propagation of action potentials along myelinated axons from one node of Ranvier to the next node, increasing the conduction velocity of action potentials.

:: Selective permeability:

Only some chemicals can pass through more freely than others.

:: Synapse:

The junction of a terminal button of one neuron and the membrane of another cell—another neuron or a cell in a muscle, a gland, or an internal organ.

:: Terminal buttons:

Small branches at the end of an axon that relay massages to other cells. Electrical messages travel through neuron beginning with detection of messages by General Psychology 43 dendrites, continue into the cell body (nucleus) and pass down the axon.

3.11 CHECK YOUR PROGRESS

1. The chief structural and functional units of the nervous system.________
2. The name of the neuron that conducts an impulse from a receptor organ to the CNS is ______________.
3 The neuron that transmits impulses from the CNS to an effector, such as amuscle or gland is called as ________
4. The name of the neuron that function as integrating centre, located between sensory neuron and a motor neuron is _________
5. The lipoprotein material that forms a sheath like covering around some nerve is known as________
6. ____________ is the fiber that conducts a nerve impulse away from a neuron cell body.
7. The name of the nerve fiber that transmits impulses toward a neuron cell body is __________
8. ____________________ is the portion of a nerve cell that includes a cytoplasmic mass and a nucleolus, and from which the nerve fibers extend.
9. Impulses travel much more rapidly along which neurons?
10. Which sheath of neuron is particularly good conductor of electric impulse?
11. Name the active transport mechanism that concentrates sodium ions on the outside of a plasma membrane and potassium ions on the inside of the membrane.
12. What is the measuring unit of resting membrane potential?
13. What is the normal resting membrane potential?
14. Name the type of nerve impulse conduction in which the impulse seems to jump from one neuro fibril node to the next.
15. Name the junction between the axon of one neuron and the dendrite of another neuron or effector cell.
16. Name the neuron carrying the action potential toward a synapse.
17. Name the chemical substance that the terminal end of an axon secretes that either stimulates or inhibits a muscle fiber contraction or an impulse in another neuron.

3.12 ANSWERS TO CHECK YOUR PROGRESS

1. Neurons
2. Interneuron
3. Motor neuron
4. Inter neuron
5. Myelin
6. Axon
7. Dendrite
8. Cell body
9. Myelinated neurons
10. Myelin sheath
11. Sodium Potassium pump.
12. Millivolts
13. -70mv
14. Saltatory conduction
15. Synapse
16. Presynaptic neuron
17. Neuro transmitter.

3.13 MODEL QUESTIONS:

1. Explain the molecular basis of resting potential.
2. Describe the different types of neurons.
3. Explain the structure of neuron.

LESSON - 4
NEUROTRANSMITTERS AND ITS FUNCTIONS

INTRODUCTION

The previous lesson explains how electrical signals are generated and propagated along the axon. It also covered how the action potential is communicated between the neurons. If we compare neurons to electrical circuits, the understanding of neuronal activity in its target is clear. Each wire in a circuit connects to the next wire in a circuit and current ?ows uninterrupted through all of them. But very few neurons are connected together in this way. Instead, communication between neurons usually relies on neurochemical transmission. This lesson explains the neurochemical transmission through neurotransmitters.

OBJECTIVES OF THE LESSON

At the end of this lesson you will be able to understand

- The common neurotransmitters.
- the effects of neurotransmitters in the body.
- the effect of altered concentrations of specific neurotransmitters upon the system.

PLAN OF THE LESSON

4.1 Definition of a Neurotransmitter

4.2 Process of neurotransmission

4.3 Difference between neurotransmission and other chemical signaling

4.4 Characteristics of neurotransmitters

4.5 Classification of neurotransmitters

4.6 Types of Neurotransmitters

4.7 Functions of neurotransmitters

4.8 Monoamines

4.9 Histamine

4.10 Drugs

4.11 Effect of neurotransmitter dysfunction

4.1 Definition of a Neurotransmitter

Neurotransmitters are types of hormones in the brain that transmit information from one neuron to another. They are made by amino acids. Neurotransmitters control major body functions including movement, emotional response, and the physical ability to experience pleasure and pain. They are produced in the terminal buttons (bulbs) of the neurons and stored in the synaptic vesicles. Their action is local when released into synapses to affect adjacent neurons, muscles, or glands. The action of these chemicals is due to the three-dimensional shape of the chemical molecules. Receptors at various sites only allow for particularly shaped molecules to trigger changes at the cellular membranes that then allow for channels in the membranes to open and allow ions to enter. This, in turn, alters the electrochemical charge of the cell relative to the surrounding environment, resulting in action potentials and neural transmission.

Neurotransmitters transmit the nerve impulse from the pre-synaptic neuron to the post-synaptic neuron through the synapse. Neurotransmitters are synthesized by the ribosome of the pre-synaptic neurons and stored in a synaptic vesicle in the cytoplasm of the pre-synaptic neuron. When a nerve impulse (action potential) stimulates the pre-synaptic neuron, it causes the opening of the calcium channels in the cell membrane of the pre-synaptic neurons. These calcium ions enter the cell and cause the synaptic vesicles to fuse with the pre-synaptic membrane and therefore releases the neurotransmitters into the synaptic cleft which is the space between two neurons.

In the post-synaptic cell membrane of the receiving neuron, there are many receptors for the neurotransmitters. These receptors are basically large protein molecules to which the neurotransmitters bind. Think of the neurotransmitters and the receptors as “locks and keys”. Certain keys fit into certain locks. It is the same with neurotransmitters and receptors.

When a neurotransmitter binds with a receptor, it either excites or inhibits the post-synaptic neurons. In the case of excitation, the neurotransmitter causes the post-synaptic neuron to generate an action potential and in the case of inhibition, the neurotransmitter prevents the post-synaptic neuron from generating an action potential.

Because neurotransmitters have two general effects on postsynaptic membranes—excitatory or inhibitory—it is expected that there would be two kinds of neurotransmitters. But in reality there are many different kinds—several dozen, at least. In the brain most synaptic communication is accomplished by two neurotransmitters: glutamate, which has excitatory effects, and GABA, which has inhibitory effects. (GABA stands for gamma-amino butyric acid.) Almost every neuron in the brain receives excitatory input from terminal buttons that secrete glutamate and inhibitory input from terminal buttons that secrete GABA.

The other neuro transmitters, in general, have modulating effects rather than information transmitting effects. That is, the release of neurotransmitters other than glutamate and GABA tends to activate or inhibit entire circuits of neurons that are involved in particular brain functions. These effects include facilitation of learning, control of wakefulness and vigilance, suppression of impulsive behaviors, and suppression or enhancement of anxiety.

4.2 Process of neurotransmission

To understand the effect of neurotransmitters, we must first understand what occurs in the process of neurotransmission. We will start with an oversimplified version for better understanding and then follow up with a more detailed explanation. A nerve impulse, which is an electrical signal, travels along the neural pathway until it reaches the end. At this point the electrical signal is converted to a chemical signal. This area, which converts the electrical signal into chemical signal, is called a synapse. The chemical signal is called a neurotransmitter. The nerve impulse then reaches the neuron on the other side, and once again becomes an electrical signal.

The arrival of a nerve impulse (or action potential) triggers the release of a neurotransmitter. This triggering occurs through an unusually rapid process of cellular secretion, also known as exocytosis. (Figure 4.1)

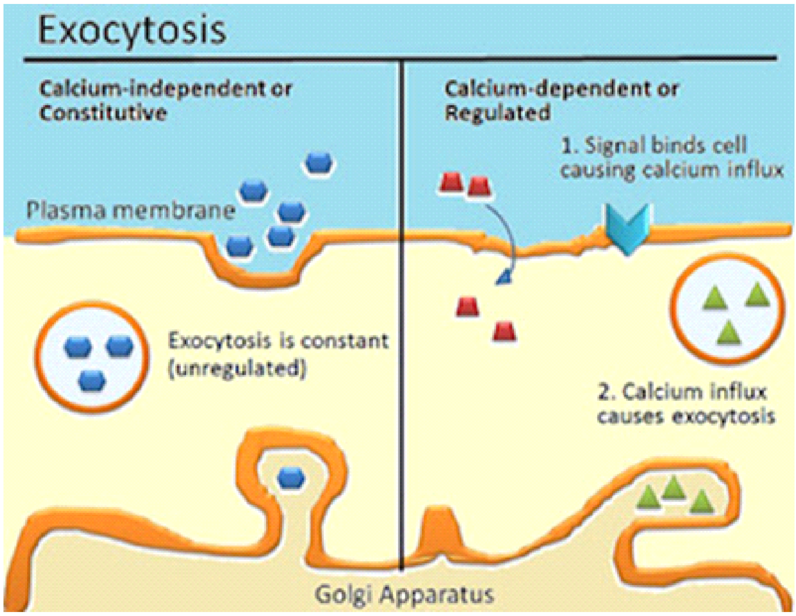


Figure 4.1

Within the presynaptic nerve terminal, vesicles containing neurotransmitter are anchored and ready at the synaptic membrane. Neurotransmitters are packaged into vesicles that cluster beneath the membrane on the presynaptic side of a synapse. When they are released into the synaptic cleft, they bind to receptors located in the membrane on the postsynaptic side of the synapse. The release of neurotransmitters is most commonly driven by arrival of an action potential at the synapse, but may also be driven by graded electrical potentials. Also, there is often a low level of "baseline" release even in the absence of electrical stimulation.

The arriving action potential produces an influx of calcium ions through voltage dependent, calcium-selective ion channels at the down stroke of the action potential (tail current). Calcium ions then trigger a biochemical flood which results in vesicles releasing their contents (neurotransmitters) in to the synaptic cleft within 180 microseconds of calcium entry. As calcium ions enter into the presynaptic neuron, they bind with the proteins found within the membranes of the synaptic vesicles that allow the vesicles to "anchor."

Triggered by the binding of the calcium ions, the synaptic vesicle proteins begin to move apart. This results in the creation of a fusion pore, which allows for the release of neurotransmitter into the synapse. The membrane added by this fusion is later retrieved by endocytosis and recycled for the formation of fresh neurotransmitter-filled vesicles. (Figure 4.2)

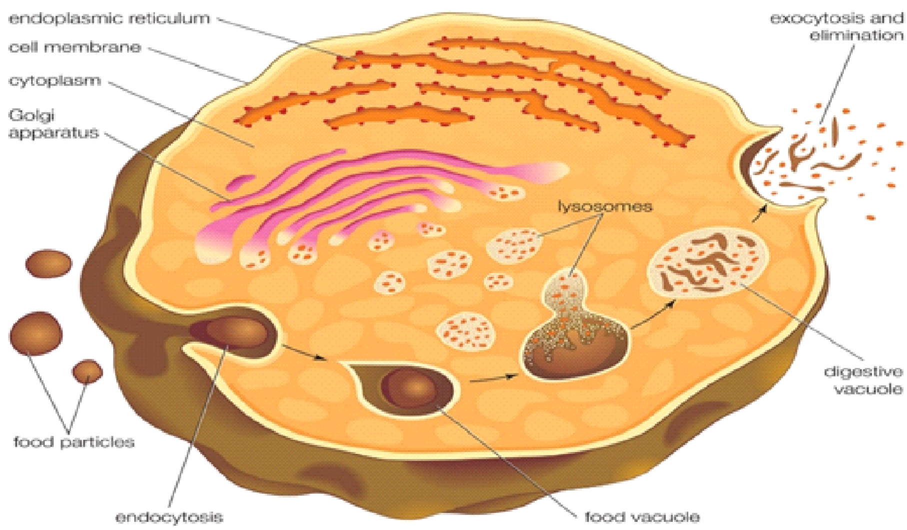


Figure 4.2

4.2.1 Receptor Binding

Receptors on the opposite side of the synaptic gap bind neurotransmitter molecules and respond by opening nearby ion channels in the postsynaptic cell membrane, causing ions to rush in or out and changing the local transmembrane potential of the cell. Generally the 'lock and key' hypothesis is used to illustrate the interaction between a neurotransmitter and its receptor. The key (the neurotransmitter) can only unlock (activate) a lock (the receptor) if it fits perfectly into the keyhole (neurotransmitter binding site) of the lock.

Receptors and auto receptors are sensitive to the neurotransmitter concentration in the synaptic cleft. Auto receptors regulate the release of the neurotransmitter from the presynaptic neuron – when these presynaptic receptors are fully occupied, neurotransmitter production is stopped. Almost every neurotransmitter can bind to more than one type of receptor, and each neurotransmitter can initiate different signals at the postsynaptic neuron. This all adds to the complexity of chemical signaling.

Binding of a neurotransmitter to its receptor on the postsynaptic membrane can activate channels in the postsynaptic neuron resulting in a change in the membrane potential. This initiates an excitatory or inhibitory postsynaptic potential that changes the excitability of the postsynaptic neuron and initiates an action potential. The resulting change in voltage is called a postsynaptic potential. In general, the result is excitatory, in the case of depolarizing currents, or inhibitory in the case of hyperpolarizing currents. Whether a synapse is excitatory or inhibitory depends on what type(s) of ion channel conduct the postsynaptic current display(s), which in turn is a function of the type of receptors and neurotransmitter employed at the synapse. (Figure 4.3)

► **Seven Processes in Neurotransmitter Action**

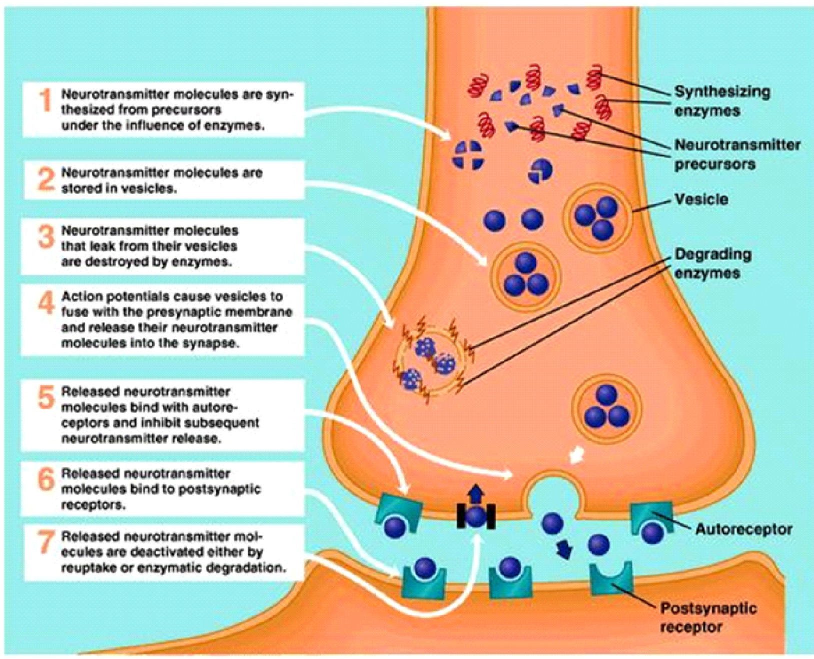


Figure 4.3

In this way, the electrical signal or impulse is transmitted down the neuronal pathway. Once the action potential is initiated, the transmitter must then be rapidly removed from the synaptic cleft, to enable the postsynaptic cell to engage in another cycle of signal generation. The release of a neurotransmitter from its nerve terminal is not only dependent upon the passage of an action potential, but also on the inter synaptic concentration of the transmitter. This is known as presynaptic inhibition.

At certain synapses, such as noradrenergic, GABAergic, dopaminergic and serotonergic synapses, the release of the neurotransmitter may be reduced by the presence of high concentrations of the transmitter in the synaptic cleft. The release of a neurotransmitter can also be affected by a variety of other neurotransmitters; for example, stimulation of serotonin receptors on noradrenergic terminals can lead to an enhanced release of noradrenaline. Such receptors are termed heteroreceptors. (Figure 4.4)

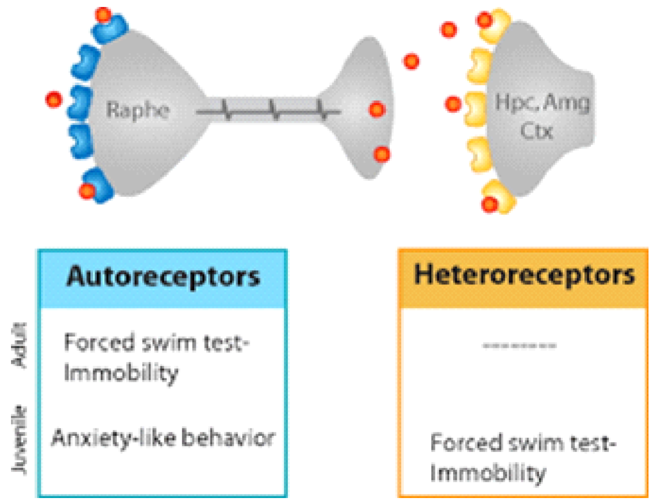


Figure 4.4

Neurons and synapses occur in specific patterns in the brain, giving rise to complex neuronal circuits. This results in the specialization of different regions of the brain for different functions and allows us to integrate information such as sound, vision, smell, taste and touch. Each neurotransmitter is made by a small number of neurons whose cell bodies are clustered in specific areas of the brain. For example, noradrenaline is synthesized mainly by neurons in the brainstem, specifically in the locus coeruleus, which is situated in the pons; the cell bodies of the dopamine neurons are clustered in a few brain regions, most importantly those deep within the midbrain. However, the axons of these neurons extend throughout the brain and influence almost the entire organ.

4.2.2 Termination

After a neurotransmitter molecule binds to a receptor molecule, it does not stay bound forever: sooner or later it is shaken loose by random temperature-related jiggling. Once the neurotransmitter breaks loose, it can either drift away, or bind again to another receptor molecule. The pool of neurotransmitter molecules undergoing this binding-loosening cycle steadily diminishes, however. Neurotransmitter molecules are typically removed in one of two ways, depending on the type of synapse: either they are taken up by the presynaptic cell (and then processed for re-release during a later action potential), or else they are broken down by special enzymes. The time course of these "clearing" processes varies greatly for different types of synapses, ranging from a few tenths of a millisecond for the fastest, to several seconds for the slowest.

Neurotransmitters must be broken down once it reaches the post-synaptic cell to prevent further excitatory or inhibitory signal transduction. For example, acetylcholine, (ACH) (an excitatory neurotransmitter), is broken down by acetyl cholinesterase (AchE). Choline is taken up and recycled by the pre-synaptic neuron to synthesize more ACH. Other neurotransmitters such as dopamine are able to diffuse away from their targeted synaptic junctions and are eliminated from the body via the kidneys, or destroyed in the liver. Each neurotransmitter has very specific degradation pathways at regulatory points, which may be the target of the body's own regulatory system or recreational drugs.

4.3 Difference between neurotransmission and other chemical signaling

There are many other signaling system of chemicals such as hormones, neurohormones, and paracrine signalling in the human body. However neurotransmitters have advantages in having a greater degree of amplification and control of the signal. It also lengthens the time of cellular integration from milliseconds to minutes and even hours. While hormones are mainly synthesized in gland, neurotransmitters are synthesized and released from neurons. Neurotransmitters are, as far as we know, only released in response to an electrical signal. There are many mechanisms that must exist to terminate the action of the neurotransmitters such as chemical deactivation, recapture (endocytosis), glial uptake and diffusion.

4.4 Characteristics of neurotransmitters

A chemical can be classified as a neurotransmitter if it meets the following conditions:

- There are precursors and/or synthesis enzymes located in the presynaptic side of the synapse.
- The chemical is present in the presynaptic element.
- It is available in sufficient quantity in the presynaptic neuron to affect the postsynaptic neuron;

- There are postsynaptic receptors and the chemical is able to bind to them.
- A biochemical mechanism for inactivation is present.

4.5 Classification of neurotransmitters

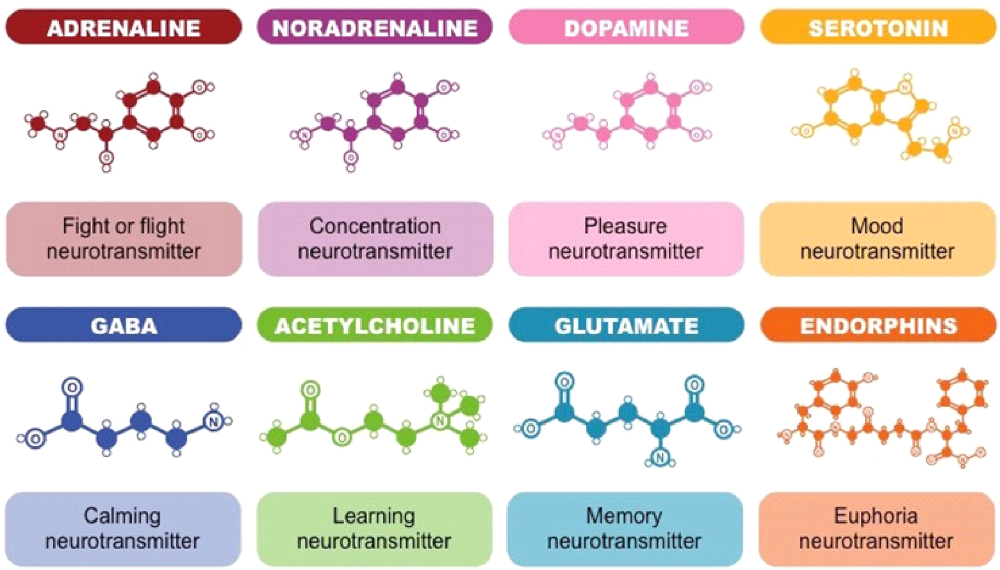
There are many different ways to classify neurotransmitters. Dividing them into amino acids, peptides, and monoamines is sufficient for some purposes. Approximately ten "small-molecule neurotransmitters" are known:

- Acetylcholine (ACh)
- Monoamines: norepinephrine (NE), dopamine (DA), serotonin (5-HT), melatonin
- Amino acids: glutamate, gamma aminobutyric acid (GABA), aspartate, glycine, histamine
- Purines: Adenosine, ATP, GTP, and their derivatives

In addition, over 50 neuroactive peptides have been found, and new ones are discovered on a regular basis. Many of these are "co-released" along with a small molecule transmitter, but in some cases a peptide is the primary transmitter at a synapse. Single ions, such as synaptically released zinc, are also considered neurotransmitters by some, as are a few gaseous molecules such as nitric oxide (NO) and carbon monoxide (CO). These are not neurotransmitters by the strict definition, however, because although they have all been shown experimentally to be released by presynaptic terminals in an activity-dependent way, they are not packaged into vesicles.

Not all neurotransmitters are equally important. By far the most prevalent transmitter is glutamate, which is used at well over 90% of the synapses in the human brain. The next most prevalent is GABA, which is used at more than 90% of the synapses that don't use glutamate. However, that even though other transmitters are used in far fewer synapses, they may be very important functionally: the great majority of psychoactive drugs exert their effects by altering the actions of some neurotransmitter system, and the great majority of these act through transmitters other than glutamate or GABA. Addictive drugs such as cocaine, amphetamine, and heroin, for example, exert their effects primarily on the dopamine system.

4.6 Types of Neurotransmitters



Neurotransmitters can be broadly classified into two categories; excitatory and inhibitory. Some neurotransmitters can serve both functions. Some neurotransmitters are commonly described as "excitatory" or "inhibitory". It is important to understand what these terms mean. The only thing that a neurotransmitter does directly is to activate one or more types of receptors. The effect on the postsynaptic cell depends entirely on the properties of the receptors. It so happens that for some neurotransmitters (for example, glutamate), the most important receptors all have excitatory effects: that is, they increase the probability that the target cell will fire an action potential. For other neurotransmitters (such as GABA), the most important receptors all have inhibitory effects.

There are, however, other important neurotransmitters, such as acetylcholine, for which both excitatory and inhibitory receptors exist; and there are some types of receptors that activate complex metabolic pathways in the postsynaptic cell to produce effects that cannot appropriately be called either excitatory or inhibitory.

4.6.1 Excitatory neurotransmitters

Excitatory neurotransmitters are the nervous system's "on switches", increasing the likelihood that an excitatory signal is sent. They act like a car’s accelerator, revving up the engine. Excitatory transmitters regulate many of the body’s most basic functions including: thought processes, the body’s fight or flight response, motor movement and higher thinking. Physiologically, the excitatory transmitters act as the body's natural stimulants, generally serving to promote alertness, energy, and activity. Common excitatory neurotransmitters are

- Dopamine
- Histamine
- Norepinephrine
- Epinephrine
- Glutamate
- Acetylcholine

4.6.2 Inhibitory neurotransmitters

Without a functioning inhibitory system to put on the brakes, things can get out of control. Inhibitory neurotransmitters are the nervous system's "off switches", decreasing the likelihood that an excitatory signal is sent. Excitation in the brain must be balanced with inhibition. Too much excitation can lead to restlessness, irritability, insomnia, and even seizures. Inhibitory transmitters regulate the activity of the excitatory neurotransmitters, much like the brakes on a car. The inhibitory system slows things down. Physiologically, the inhibitory transmitters act as the body's natural tranquilizers, generally serving to induce sleep, promote calmness, and decrease aggression. Most common inhibitory neurotransmitters are :

- GABA
- Dopamine
- Serotonin
- Acetylcholine
- Taurine

4.7 Functions of neurotransmitters

As many as 200 neurotransmitters are postulated, but we will discuss only a few of the better known and most prominent in detail. The most familiar neurotransmitters, which are thought to play a role in mood regulation, are serotonin, norepinephrine, dopamine, acetylcholine, and GABA.

4.7.1 Acetylcholine:

Acetylcholine is distinguished as the transmitter at the neuromuscular junction connecting motor nerves to muscles. Acetylcholine release can be excitatory or inhibitory depending on the type of tissue and the nature of the receptor with which it interacts. It plays numerous roles in the nervous system. Its primary action is to stimulate the skeletal muscular system. It is the neurotransmitter used to cause voluntary muscle contraction or relaxation in the muscles. In the brain, acetylcholine is involved in learning and memory.

Acetylcholine is a small molecule transmitter that is also found in the hippocampus and prefrontal cortex. The hippocampus is responsible for memory and memory retrieval. The paralytic arrow-poison curare acts by blocking transmission of signals at the (motor nerve to muscle) synapses. Blocking acetylcholine results in muscle paralysis, including the diaphragm. Insecticides, and nerve gases also have their effects by way of blocking normal acetylcholine functioning.

Acetylcholine also operates in many regions of the brain, but using different types of receptors. Alzheimer's disease is associated with a lack of acetylcholine in certain regions of the brain. The chemical compound acetylcholine (often abbreviated ACh) is a neurotransmitter in both the peripheral nervous system (PNS) and central nervous system (CNS) in many organisms including humans. Acetylcholine is one of many neurotransmitters in the autonomic nervous system (ANS) and the only neurotransmitter used in the somatic nervous system. It is also the neurotransmitter in all autonomic ganglia.

Because all muscular movement is accomplished by the release of acetylcholine, it is not surprise to learn that the immune systems of people with myasthenia gravis attack acetylcholine receptors. The axons and terminal buttons of acetyl cholinergic neurons are distributed widely throughout the brain.

Two drugs, botulinum toxin and the venom of the black widow spider, affect the release of acetylcholine. Botulinum toxin, produced by a bacterium that can grow in improperly canned food, prevents the release of ACh. The drug is an extremely potent poison; someone once calculated that a teaspoonful of pure botulinum toxin could kill the world's entire human population. Extremely dilute solutions of this drug, usually referred to as botox, can be injected into people's facial muscles to stop muscular contractions that are causing wrinkles. Black widow spider venom has the opposite effect: It stimulates the release of ACh.

4.7.1.1 Functions

Acetylcholine has functions both in the peripheral nervous system (PNS) and in the central nervous system (CNS) as a neuromodulator. In the PNS, acetylcholine activates muscles, and is a major neurotransmitter in the autonomic nervous system. In the CNS, acetylcholine and the associated neurons form a neurotransmitter system, the cholinergic system, which tends to cause excitatory actions.

In PNS When acetylcholine binds to acetylcholine receptors on skeletal muscle fibers, it opens ligand gated sodium channels in the cell membrane. Sodium ions then enter the muscle cell, stimulating muscle contraction. In CNS In the central nervous system, ACh has a variety of effects as a neuromodulator, e.g., for plasticity and excitability. Other effects are arousal and reward. Damage to the cholinergic system in the brain has been suggested to play a role in the memory deficits associated with Alzheimer's Disease.

The disease myasthenia gravis, characterized by muscle weakness and fatigue, occurs when the body inappropriately produces antibodies against acetylcholine nicotinic receptors, and thus inhibits proper acetylcholine signal transmission. Over time, the motor end plate is destroyed. Drugs that competitively inhibit acetylcholinesterase (e.g., neostigmine, physostigmine, or primarily mestinon) are effective in treating this disorder. They allow endogenously-released acetylcholine more time to interact with its respective receptor before being inactivated by acetylcholinesterase in the gap junction. Blocking, hindering or mimicking the action of acetylcholine has many uses in medicine. Drugs acting on the acetylcholine system are either agonists to the receptors, stimulating the system, or antagonists, inhibiting it.

4.7.2 Enkephalins/Endorphins

Endorphins are endogenous opioid polypeptide compounds. They are produced by the pituitary gland and the hypothalamus in vertebrates during strenuous exercise, excitement, and orgasm, and they resemble the opiates in their abilities to produce analgesia and a sense of well-being. Endorphins work as "natural fever relievers", whose effects may be enhanced by other medications. The term "endorphin" implies a pharmacological activity (analogous to the activity of the corticosteroid category of biochemicals) as opposed to a specific chemical formulation. It consists of two parts: endo- and -orphin; these are short forms of the words endogenous and morphine, intended to mean "a morphine like substance originating from within the body."

When a nerve impulse reaches the spinal cord, endorphins are released which prevent nerve cells from releasing more pain signals. Endorphins are released during long, continuous workouts, when the level of intensity is between moderate and high, and breathing is difficult. This also corresponds with the time that muscles use up their stored glycogen. Workouts that are most likely to produce endorphins include running, swimming, cross country skiing, long distance rowing, bicycling, weight lifting, aerobics, or playing a sport such as soccer, basketball, rugby, lacrosse, or American football. Endorphins may be released during low levels of pain and physical stimulation when it lasts over 30 minutes.

4.7.2.1 Functions

[1] Controls and regulates the perception of pain (somatosensory cortex of parietal lobes, somatic nervous system).

[2] Can generate euphoria (hypothalamus). Overall, these chemicals allow the body to continue functioning despite being at or beyond the normal thresholds of endurance or pain. Opiate drugs are very similar chemically and mimic these effects.

4.7.3 Epinephrine(Adrenaline)

Epinephrine, also known as adrenaline, is an excitatory neurotransmitter. It is derived from norepinephrine and is secreted along with norepinephrine in response to fear or anger. This reaction, referred to as the “fight or flight” response, prepares the body for strenuous activity. Epinephrine regulates attentiveness, arousal, cognition, sexual arousal, and mental focus. It is also responsible for regulating the metabolism. Epinephrine is used medicinally as a stimulant in cardiac arrest, as a vasoconstrictor in shock, as a bronchodilator and antispasmodic in bronchial asthma, and anaphylaxis.

4.7.3.1 Functions

[1] Arousal, excitation, anxiety, fear, and rage (hypothalamus, autonomic nervous system).

[2] Readiness for stress, combat, or flight (autonomic nervous system - sympathetic branch).

4.7.3.2 High levels

Epinephrine levels that are too high can result in restlessness, anxiety, sleep problems, acute stress, and ADHD. Excess amounts of epinephrine can also raise the blood pressure, increase the heart rate, cause irritability and insomnia.

4.7.3.3 Low levels

Low levels of epinephrine can also contribute to weight gain, fatigue, lack of focus, decreased sexual arousal, and poor concentration. Stress tends to deplete our store of adrenalin (epinephrine), while exercise tends to increase it.

4.8 Monoamines

This is a class of neurotransmitters, which includes serotonin, norepinephrine, GABA, glutamate, and dopamine. The monoamine hypothesis holds that mood disorders are caused by depletion in the levels of one or more of these neurotransmitters.

4.8.1 Norepinephrine (Noradrenaline)

When the noradrenaline is activated, the system plays major roles in the brain. Noradrenaline is released from the neurons, and acts on adrenergic receptors. It is an excitatory neurotransmitter that is important for attention and focus. Norepinephrine is synthesized from dopamine and is strongly associated with bringing our nervous systems into the “fight or flight” state. Norepinephrine triggers the release of hormones from the limbic section of the brain that signal other stress hormones to act in a crisis. It can raise blood pressure and increase heart rate. It can elevate the metabolic rate, body temperature and stimulate the smooth bronchial muscles to assist breathing. It is also important for forming memories.

4.8.1.1 Functions

[1] Calming effects, relaxation, routine bodily functioning (autonomic nervous system - parasympathetic branch).

[2] Excesses in the brain are implicated in mania.

[3] Lack of sufficient usable norepinephrine in the brain implicated in depression. (Dopamine is oxidized by an enzyme to produce norepinephrine.) Most major tranquilizers (reserpine, chlorpromazine) decrease usable amounts of norepinephrine and dopamine. Antidepressants (MOA inhibitors, tricyclics such as imipramine) increase usable amounts of norepinephrine and dopamine.

4.8.1.2 High levels

Elevated norepinephrine activity seems to be a contributor to anxiety. In addition, brain norepinephrine turnover is increased in conditions of stress. Increased levels of norepinephrine will lead to alertness and mood elevation and increased sexual interest. However, high amounts raise blood pressure; increase heart rate, and cause anxiety, fear, panic, stress, hyperactivity, an overwhelming sense of dread, irritability, and insomnia.

4.8.1.3 Low levels

Low levels of norepinephrine are linked to lack of energy, focus, and motivation. Insufficient norepinephrine levels also contribute to depression, loss of alertness, and poor memory.

4.8.2 Dopamine

Dopamine can act as both an excitatory or inhibitory neurotransmitter and functions as the brain's "feel good" neurotransmitter. It is part of the brain's reward system and creates feelings of satisfaction or pleasure when we do things we enjoy, such as eating or having sex. Drugs like cocaine, nicotine, opiates, heroin, and alcohol increase the levels of dopamine. Eating foods that taste good and having sex also stimulate an increase in dopamine levels. For this reason, many surmise that a deficient level of dopamine in the brain may be behind peoples' tendencies to use drugs, drink alcohol, smoke cigarettes, be promiscuous, gamble or overeat.

Dopamine's functions are diverse, affecting memory, motor control, and pleasure. It allows us to be alert and motivated and to feel satisfied. Dopamine is associated with positive stress states such as being in love, exercising, listening to music, and sex. Once produced, dopamine can, in turn, convert into the brain chemicals norepinephrine and epinephrine. Dopamine can play a lot of different roles in the brain, depending on the location. In the frontal cortex, dopamine acts as a traffic officer by controlling the flow of information to other areas of the brain. It also plays a role in attention, problem-solving, and memory.

4.8.2.1 Functions

[1] Initiation of muscle movement (substantia nigra, caudate nucleus, cerebellum)

[2] Muscle control related to posture, gait, regulation of opposing muscle groups (cerebellum) Excess of usable dopamine affects this function in the form of rigidity such as the catatonia sometimes found in schizophrenia.

[3] Reflexive responses (cerebellum) Lack of usable dopamine affects these first three functions by causing an inability to control starting and stopping of movements, tremors, and motor/speech tics such as those found in Parkinson's patients and cases of tardive dyskinesia.

[4] Ability to sort/filter sensory inputs and information (frontal and temporal lobes)

[5] Ability to focus attention/concentrate (frontal lobes) Excess of usable dopamine affects the fourth and fifth functions in the form of hallucinations (especially auditory) and delusions found in schizophrenia.

[6] Regulation of impulsivity (frontal lobes, hypothalamus, amygdala)

[7] Ability to experience pleasure (reward/punishment centers in hypothalamus)

Excess of usable dopamine affects the sixth and seventh functions by producing behavioral or emotional outbursts and inappropriate affect as found in schizophrenia. Lack or excess may be due to actual amounts or improper regulation by way of other substances such as serotonin. Nicotine, amphetamine, cocaine, and related drugs mimic dopamine at receptors and produce enhancement of functions 5, 6, and 7. Prolonged abuse of these drugs results in fourth and fifth functions being affected in much the same way as in Schizophrenia. Prolonged use also increases number of dopamine receptors, and by way of this the amount of dopamine or drug needed to activate these functions/systems is elevated (tolerance). Discontinuing use of drugs results in anhedonia as body cannot supply enough dopamine to activate the additional receptors in brain pleasure centers of hypothalamus, so relapse common. The amino acid tyrosine is oxidized to produce L-Dopa, which is then transformed by an enzyme to produce dopamine.

4.8.2.2 High levels

However, too much of a good thing can be bad. An increased level of dopamine in the frontal lobe of the brain contributes to the incoherent and disrupted thought processes that are characteristic of schizophrenia. Excessive levels of dopamine cause our thinking to become excited, energized, then suspicious and paranoid, as we are hyper stimulated by our environment. With low levels of dopamine, we lose the ability to focus. When dopamine levels are too high, our focus becomes narrowed and intense. High dopamine levels have been observed in patients with poor gastrointestinal function, autism, mood swings, aggression, psychosis, anxiety, hyperactivity, and children with attention disorders.

4.8.2.3 Low levels

Too little dopamine in the motor areas of the brain are responsible for Parkinson's disease, which involves uncontrollable muscle tremors. A decline in dopamine levels in the thinking areas of the brain is linked to cognitive problems (learning and memory deficits), poor concentration, difficulty initiating or completing tasks, impaired ability to “lock onto” tasks, activities, or conversations, lack of energy, lack of motivation, inability to “feel alive”, addictions, cravings, compulsions, a loss of satisfaction in activities which previously pleased you, and slowed motor movements.

Dopamine can be supplied as a medication that acts on the sympathetic nervous system, producing effects such as increased heart rate and blood pressure. However, because dopamine cannot cross the blood-brain barrier, dopamine given as a drug does not directly affect the central nervous system. To increase the amount of dopamine in the brains of patients with diseases such as Parkinson's disease and dopa responsive dystonia, L-DOPA (levodopa), which is the precursor of dopamine, can be given because it can cross the blood-brain barrier.

4.8.3 Serotonin

Serotonin is an inhibitory neurotransmitter involved in the regulation of mood, anxiety, libido, compulsivity, headaches, aggression, body temperature, eating disorders, social anxiety, phobias, sleep, appetite, memory and learning, cardiovascular function, muscle contraction, and endocrine regulation. Other brain neurotransmitters, such as dopamine and norepinephrine, also influence mood and arousal. However, serotonin generally has different effects. Serotonin plays a major role in sleep and mood regulation. Proper amounts of circulating serotonin promote relaxation. Stress reduces our serotonin levels as our body uses up serotonin in an attempt to calm itself. Serotonin is chemically related to the amino acid tryptophan, as well as the neurotransmitters norepinephrine and dopamine. All known hallucinogens believed to simulate the structural characteristics of either serotonin, norepinephrine, and/or dopamine.

Serotonin (5-hydroxytryptamine, or 5-HT) is a monoamine neurotransmitter synthesized in serotonergic neurons in the central nervous system (CNS) and enterochromaffin cells in the gastrointestinal tract of animals including humans. In the central nervous system, serotonin plays an important role as a neurotransmitter in the modulation of anger, aggression, body temperature, mood, sleep, sexuality, appetite, and metabolism, as well as stimulating vomiting. Serotonin has broad activities in the brain, and genetic variation in serotonin receptors and the serotonin transporter, which facilitates reuptake of serotonin into presynapses, have been implicated in neurological diseases.

In addition, serotonin is also a peripheral signal mediator. It is found extensively in the human gastrointestinal tract. In the blood, the major storage site is platelets, which collect serotonin for use in mediating post-injury vasoconstriction. Recent research suggests that serotonin plays an important role in liver regeneration and acts as a mitogen (induces cell division) throughout the body. Defective signaling of serotonin in the brain may be the root cause of sudden infant death syndrome (SIDS).

4.8.3.1 Functions

[1] Regulates sleep/wake cycle (reticular formation)

[2] Regulates overall mood (frontal and temporal lobes)

[3] Responsible for sleep disorders such as insomnia or excess sleep.

[4] Implicated in mood disorders such as chronic depression and bipolar disorder, as well as a number of other conditions. This is most likely due to an overall function designed to modulate the effects of the other neuro-chemicals across a wide range of locations and systems.

Serotonergic action is terminated primarily via uptake of 5-HT from the synapse. This is through the specific monoamine transporter for 5-HT, 5-HT reuptake transporter, on the presynaptic neuron. Various agents can inhibit 5-HT reuptake including MDMA (ecstasy), amphetamine, cocaine, dextromethorphan (an antitussive), tricyclic antidepressants (TCAs) and selective serotonin reuptake inhibitors (SSRIs).Several classes of drugs target the 5-HT system including some antidepressants, antipsychotics, anxiolytics, antiemetics, and antimigraine drugs as well as the psychedelic drugs and empathogens. If neurons that make serotonin — serotonergic neurons — are abnormal in infants, there is a risk of sudden infant death syndrome (SIDS).

4.8.3.2 Low levels

Low levels of serotonin can result in depressed mood, anxiety, panic attacks , low energy, migraines, sleeping problems, obsessions or compulsions, feeling tense and irritable, craving sweets or loss of appetite, impaired memory and concentration, angry or aggressive behavior, slowed muscle movement, slowed speech, altered sleep patterns, and having a reduced interest in sex.

4.8.3.3 High levels

Excess amounts of serotonin cause sedation, a decrease in sexual drive, a sense of well-being, bliss, and of being one with the universe. However, if serotonin levels become too high they can result in Serotonin Syndrome, which can be fatal. Serotonin Syndrome produces violent trembling, profuse sweating, insomnia, nausea, teeth chattering, chilling, shivering, aggressiveness, over-confidence, agitation, and malignant hyperthermia. Emergency medical treatment is required, utilizing medications that neutralize or block the action of serotonin.

4.8.3.4 Factors affecting serotonin production

Hormones and estrogen levels can affect serotonin levels and this may explain why some women have pre-menstrual and menopausal mood problems. Moreover, daily stress can greatly reduce serotonin supplies. While exercise and exposure to light may increase or stimulate serotonin levels, antidepressants can aid the brain to replenish its own supply.

4.8.4 Glutamate

Glutamate is the most important excitatory neurotransmitter in the brain. It is also the major excitatory neurotransmitter in the spinal cord. With the exception of neurons that detect painful stimuli, all sensory organs transmit information to the brain through axons whose terminals release glutamate. One type of glutamate receptor (the NMDA receptor) plays a critical role in the effects of environmental stimulation on the developing brain and is also responsible for many of the changes in synaptic connections that are responsible for learning. This receptor is partially deactivated by alcohol, which accounts for the fact that binge drinkers often have no memory for what happened while they were drunk.

In addition, researchers believe that the effect of alcohol on this receptor is responsible for the dangerous convulsions that can be caused by sudden withdrawal from heavy, long-term alcohol abuse. When this receptor is suppressed for a long time, a compensatory mechanism makes it become more sensitive to glutamate. If the person suddenly stops taking alcohol, a rebound effect causes glutamate to have such a strong effect that the normal balance of excitation and inhibition in the brain is disrupted.

4.8.4.1 High levels

Excessive levels of glutamate are toxic to neurons and have been implicated in the development of neurological disorders such as amyotrophic lateral sclerosis and Huntington's chorea, peripheral neuropathies, chronic pain, schizophrenia, stroke, and Parkinson's disease.

4.8.4.2 Low levels

Insufficient levels of glutamate may play a role in impaired memory and learning.

4.8.5 GABA

GABA is the abbreviation for Gamma-aminobutyric acid. GABA is the major inhibitory neurotransmitter in the central nervous system and plays a major role in regulating anxiety and reducing stress. GABA has a calming effect on the brain and helps the brain filter out “background noise”. It improves mental focus while calming the nerves. GABA acts like a brake to the excitatory neurotransmitters, which can cause anxiety if the system is overstimulated. Many sedative/ tranquilizing drugs act by enhancing the effects of GABA. Correspondingly glycine is the inhibitory transmitter in the spinal cord.

Some drugs depress behavior, causing relaxation, sedation, or even loss of consciousness. Most of these drugs act on a particular type of GABA receptor (the GABAA receptor), increasing its sensitivity to the neurotransmitter. Barbiturates act this way. In low doses, barbiturates have a calming effect. In progressively higher doses, they produce difficulty in walking and talking, unconsciousness, coma, and death. Barbiturates are abused by people who want to achieve the relaxing, calming effect of the drugs, especially to counteract the anxiety and irritability that can be produced by stimulants. A dose of a barbiturate sufficient to cause relaxation is not much lower than a fatal dose; thus, these drugs do not have much of a safety factor. Physicians rarely prescribe barbiturates. By far the most commonly used depressant drug is ethyl alcohol, the active ingredient in alcoholic beverages. This drug also acts on the GABAA receptor. The effects of alcohol and barbiturates are additive: A moderate dose of alcohol plus a moderate dose of barbiturates can be fatal.

Many antianxiety drugs are members of a family known as the benzodiazepines, which include the well-known tranquilizer Valium (diazepam). These drugs, too, act on GABA receptors on neurons in various parts of the brain, including a region that is involved in fear and anxiety. Benzodiazepines are much safer than barbiturates—a lethal dose is more than a hundred times higher than a therapeutic dose. They are sometimes used to treat people who are afflicted by periodic attacks of severe anxiety. In addition, some benzodiazepines serve as sleep medications. These drugs also are used to treat the convulsions caused by sudden withdrawal from heavy, long-term alcohol abuse.

4.8.5.1 Functions

The primary function of GABA is to prevent over stimulation. GABA is used at the great majority of fast inhibitory synapses in virtually every part of the brain.

It regulates norepinephrine, adrenaline, dopamine, and serotonin and is a significant mood modulator.

4.8.5.2 High levels

Excessive GABA levels result in excessive relaxation and sedation, to the point that normal reactions are impaired.

4.8.5.3 Low levels

Insufficient GABA results in the brain being over stimulated. People with too little GABA tend to suffer from anxiety disorders and may have a predisposition to alcoholism. Low levels of GABA are associated with bipolar disorder, mania, poor impulse control, epilepsy, and seizure disorders. Since proper GABA functioning is required to induce relaxation, analgesia, and sleep, dysfunction of the GABA system is implicated in the patho physiology of several neuropsychiatric disorders, including anxiety and depression.

4.8.5.4 Taurine

Taurine is an inhibitory neurotransmitter involved in neuromodulatory and neuro protective actions. Supplementing with taurine can increase GABA function. By helping GABA function, taurine is an important neuro modulator for prevention of anxiety. The relevance of GABA support is to prevent overstimulation due to high levels of excitatory amino acids, such as norepinephrine and epinephrine. Therefore, taurine and GABA constitute an important protective mechanism against excessive excitatory neurotransmitters.

4.9 Histamine

Histamine is a biogenic amine involved in local immune responses as well as regulating physiological function in the gut and acting as a neurotransmitter. Histamine plays an important role in chemotaxis of white blood cells. Most histamine in the body is generated in granules in mast cells or in white blood cells called basophils. Mast cells are especially numerous at sites of potential injury - the nose, mouth, and feet; internal body surfaces; and blood vessels. Non-mast cell histamine is found in several tissues, including the brain, where it functions as a neurotransmitter. Another important site of histamine storage and release is the enterochromaffin-like (ECL) cell of the stomach.. Histamine helps control the sleep-wake cycle and promotes the release of epinephrine and norepinephrine.

4.9.1 High levels

High histamine levels have been linked to obsessive-compulsive tendencies, depression, and headaches.

4.9.2 Low levels

Low histamine levels can contribute to paranoia, low libido, fatigue, and medication sensitivities.

4.10 Drugs

The major neurotransmitter systems are the noradrenaline (norepinephrine) system, the dopamine system, the serotonin system and the cholinergic system. Most other neurotransmitters, on the other hand, e.g. glutamate, GABA and glycine, are used very generally throughout the central nervous system. Drugs targeting the neurotransmitter of such systems affects the whole system; this fact explains the mode of action of many drugs.

Drugs differ from hormones in that they are not produced inside the body but are introduced from outside. However, like hormones, drugs are carried by the blood and taken up in target tissues of the body including the nervous system. Once in the bloodstream drugs can have widespread effects and like hormones can affect synaptic transmission. Drugs often have molecular structures sufficiently close enough to those of neurotransmitters to allow them to bind with the post-synaptic receptors. Some drugs mimic the neurotransmitter and a false input is registered. Others simply block the receptor so the real neurotransmitter cannot bind, thereby rendering it inert. Also some drugs prevent the reuptake of neurotransmitter molecules causing them to repeatedly activate the receptors.

Cocaine, for example, blocks the reentering of dopamine back into the presynaptic neuron, leaving these neurotransmitters in the synaptic gap longer. Since the dopamine is in the synapse longer, the neurotransmitter rapidly hit the receptors on the postsynaptic neuron cell, and therefore causing happiness. Excess intake of cocaine can lead to physical addiction. The physical addiction of cocaine is when the neurotransmitters stay in the synapse so long , the body removes some receptors from the postsynaptic neuron. After the effects of the drug wear off, the person usually feels unhappy, because now the neurotransmitters are less likely to hit the receptor since the body removed many of them during the drug intake.

Prozac is a selective serotonin reuptake inhibitor (SSRI), hence potentiating the effect of naturally released serotonin. In neuroscience, neuromodulation is the process in which several classes of neurotransmitters in the nervous system regulate diverse populations of neurons (one neuron uses different neurotransmitters to connect to several neurons), as opposed to direct synaptic transmission in which one presynaptic neuron directly influences a postsynaptic partner (one neuron reaching one other neuron), neuromodulatory transmitters secreted by a small group of neurons diffuse through large areas of the nervous system, having an effect on multiple neurons. Examples of neuromodulators include dopamine, serotonin, acetylcholine, histamine and others. A neuromodulator is a relatively new concept in the field and it can be conceptualized as a neurotransmitter that is not reabsorbed by the pre-synaptic neuron or broken down into a metabolite. Such neuromodulators end up spending a significant amount of time in the CSF (cerebrospinal fluid) and influencing (or modulating) the overall activity level of the brain. For this reason, some neurotransmitters are also considered as neuromodulators. Examples of neuromodulators in this category are serotonin and acetylcholine.

4.11 Effect of neurotransmitter dysfunction

4.11.1 Depression

There are many known causes of depression, with one of them being the amount of serotonin in the brain. Decreases in the production of serotonin in the brain can lead to feelings of depression. In some cases, low serotonin levels can actually lead to “suicidal thoughts”. Some studies link lower levels of norepinephrine to depression. These studies suggest that the low levels of serotonin are actually triggering the norepinephrine levels to be low, causing a depressed mood.

4.11.2 Parkinson's Disease

Parkinson's Disease (PD) is a neurodegenerative disorder that affects the neurons responsible for movement in the body. Since dopamine is responsible for transmitting information about movement, the death of these neurons can cause symptoms such as tremor, stiffness, or balance issues. The body tries to compensate for the lack of dopamine by releasing more glutamate, which is a neurotransmitter that has a role in learning and memory. However, glutamate is an excitatory neurotransmitter, and having too much glutamate can lead to the overexcitement and eventual death of neurons. Treatments for PD include L-Dopa, which is a precursor to dopamine that can cross the blood-brain barrier and relieve movement problems.

4.11.3 Schizophrenia

Schizophrenia is a disabling disorder that impacts how a person thinks, feels, and acts. Research shows that some imbalances in dopamine might play a role. The "dopamine hypothesis" states that having too much dopamine in the brain can cause schizophrenia. This idea led to antipsychotic medications that aim to lower the amount of dopamine released in the brain and reduce the symptoms of schizophrenia. But there are other small changes in the brain that may contribute to schizophrenia. For example, the ventricles, or areas of the brain filled with cerebrospinal fluid (CSF), are larger in patients with schizophrenia. However, these differences are not significant enough to generalize for all people with schizophrenia.

4.12 Conclusion

Neurotransmitters have many roles within the body that extend beyond the central nervous system. Understanding how the neurotransmission systems of the body operate, leads to greater understanding regarding the effects of drugs and medications upon the body and the manifestations of impaired neuro regulation.

4.13 SUMMARY

Neurotransmitters are chemicals that are released from nerve cells to other target cells to communicate information. Neurons can communicate using both electrical and chemical methods. Tiny packages called vesicles are hidden within the synaptic terminal of each neuron. These vesicles contain the neurotransmitters that are released when stimulated by an electrical impulse, called an action potential. Once these packages are given a signal to open, they travel to the cell’s membrane and release the neurotransmitters into the synapse. The synapse is a gap between the dendrites of one neuron and the axon terminal of another neuron.

Neurotransmitters interact with receptors on the dendrites of the other neuron, much like how a lock and key work. The neurotransmitters have specific shapes that fit into a receptor that can accommodate that shape. Once the neurotransmitter and the receptor are connected, the neurotransmitter sends information to the next neuron to either fire an action potential, or to inhibit firing. If the neuron gets the signal to fire, then the whole process starts over again.

When the neurotransmitters are balanced, it helps us to lead healthy and balanced lives. But sometimes the environment or our genes can trigger imbalances in these essential chemicals, causing illnesses such as depression, Parkinson’s disease, and schizophrenia to arise.

4.14 KEY WORDS

:: Amino acids

Organic compounds containing amine (-NH2) and carboxyl (-COOH) functional groups, along with a side chain (R group) specific to each amino acid

:: Endorphins

Endogenous opioid polypeptide compounds.

:: Excitatory neurotransmitters

The nervous system's "on switches", increasing the likelihood that an excitatory signal is sent.

:: Exocytosis

Rapid process of cellular secretion.

:: Inhibitory neurotransmitters

The nervous system's "off switches", decreasing the likelihood that an excitatory signal is sent.

:: Monoamines

A compound having a single amine group in its molecule

:: Nerve impulse

An electrical signal

:: Neurotransmitters

Types of hormones in the brain that transmit information from one neuron to another.

:: Peptides

A compound consisting of two or more amino acids linked in a chain, the carboxyl group of each acid being joined to the amino group of the next by a bond of the type -OC-NH-.

:: Receptor binding

A technique in which a labeled compound, a ligand, which binds to a receptor is used to detect that receptor.

4.15 CHECK YOUR PROGRESS

1. Which neurotransmitter has 5 different receptors for it?

   (a) Acetylcholine

   (b) Dopamine

   (c) Serotonin

   (d) Glutamate

2. Which neurotransmitter is also called 5-hydroxytryptamine, or 5-HT for short?

   (a) Dopamine

   (b) GABA

   (c) Epinephrine

   (d) Serotonin

3. Which of the following neurotransmitters are inhibitory?

   (a) GABA

   (b) Acetylcholine

(c) Epinephrine

(d) Norepinephrine

4. The area in which neurotransmitters are released from one cell to communicate with the other is called the _____

(a) Dendrites

(b) Axon

(c) Synapse

(d) Myelin sheath

5. When there is a neurochemical imbalance causing an issue or illness, scientists can develop drugs that help to balance it. What is a major consideration when developing drugs that influence brain chemistry?

(a) Blood brain barrier

(b) Nature of neurotransmitter (inhibitory, excitatory)

(c) Type of neurotransmitter

(d) Location of the neurotransmitter in the brain

4.16 ANSWERS TO CHECK YOUR PROGRESS

1. (b)
2. (d)
3. (a)
4. (c)
5. (a)

4.17 MODEL QUESTIONS

1. Identify the common neurotransmitters.
2. Explain the effects of neurotransmitters in the body.
3. What are the effect of altered concentrations of specific neurotransmitters upon the system.

LESSON 5

THE SPINAL CORD, BRAIN AND THEIR FUNCTIONS

INTRODUCTION

The previous lesson was focusing on the types of neurotransmitters and how they transmit information. And also it was covering the effects of excess/lack of a particular neurotransmitter. The whole neurotransmission is the function of central nervous system and it is necessary to understand the structure and functions of CNS. This lesson teaches about the structure and functions of the central nervous system.

OBJECTIVES OF THE LESSON

At the end of this lesson you will be able to understand

- the anatomical and functional divisions of the central nervous system
- the basic structure of the spinal cord
- the basic structure of brain
- the basic functions of the central nervous system

PLAN OF THE LESSON

5.1 THE CENTRAL NERVOUS SYSTEM

The complete network of all nerve cells in the human body is divided into two systems: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is composed of the brain and spinal cord and provides the command and integrating centre of the nervous system. Not only does the CNS contain all the major command centres vital for the maintenance of life, but its higher regions are crucially involved in decision making (that is, detecting sensory events, analyzing this information and deciding how to respond).

The central nervous system (CNS), consisting of brain and spinal cord, is the integrative control centre of the body. In particular, the brain exerts executive control over the peripheral nervous system and endocrine glands, and is the organ of movement, emotion, thought and consciousness. An important prerequisite for understanding how the brain produces behaviour is having a good understanding of its anatomy. This includes knowing where the main brain regions are sited and the ways in which they are connected.

The problem of understanding the structure of brain lies in trying to visualize the shape of brain structures and their pathways. The brain is simply too complex. One simple way to remember the main anatomical terms used to convey direction in the brain is to imagine a fish. Its front end, or head, is anterior (sometimes called rostral), and its tail-fin is posterior (sometimes called caudal). The fish also has a dorsal fin on its upper surface – and one on its underside called the ventral fin. In addition, the fish has lateral fins on its sides – while the term medial would be used to describe parts of the body towards the midline. Two other terms that are useful to know, particularly in regards to neural pathways, are ipsilateral (referring to structures on the same side of the body), and contralateral (referring to structures on the opposite side of the body).

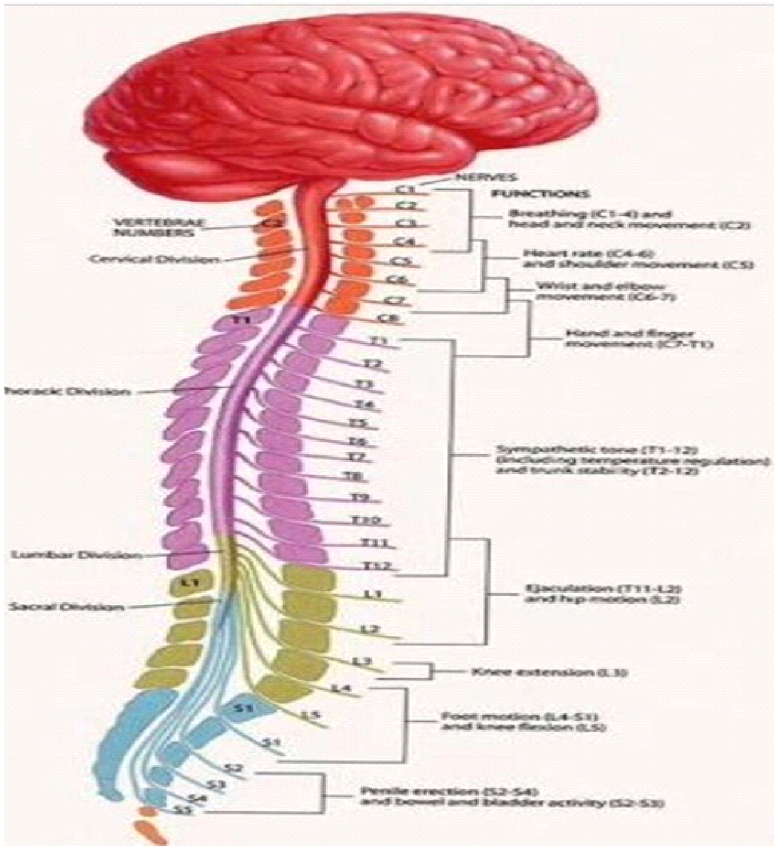


Figure 5.1

5.2 Spinal cord

The spinal cord is an extension of the medulla in the brain, about the size of a large pencil, that forms a cylinder of nervous tissue that runs down the back. The spinal cord in an adult is at about 17 1/4 inches long, is about as wide as thumb, and is just as thin as a straw at the base. It is enclosed and protected by meninges, three layers of membrane just like those surrounding the brain. The spinal nerves come out from the spaces between the bony arches in pairs. They are named for the area of the vertebral column from which they come. These areas include:

- Cervical or neck
- Thoracic or chest

- Lumbar or abdomen
- Sacral or pelvis
- Coccygeal or tailbone

From top to bottom, these segments comprise eight cervical vertebrae, twelve thoracic, five lumbar, five sacral and one coccygeal. The end of the spinal cord is called the cauda equine because it looks like a horse's tail with its cascade of nerves.

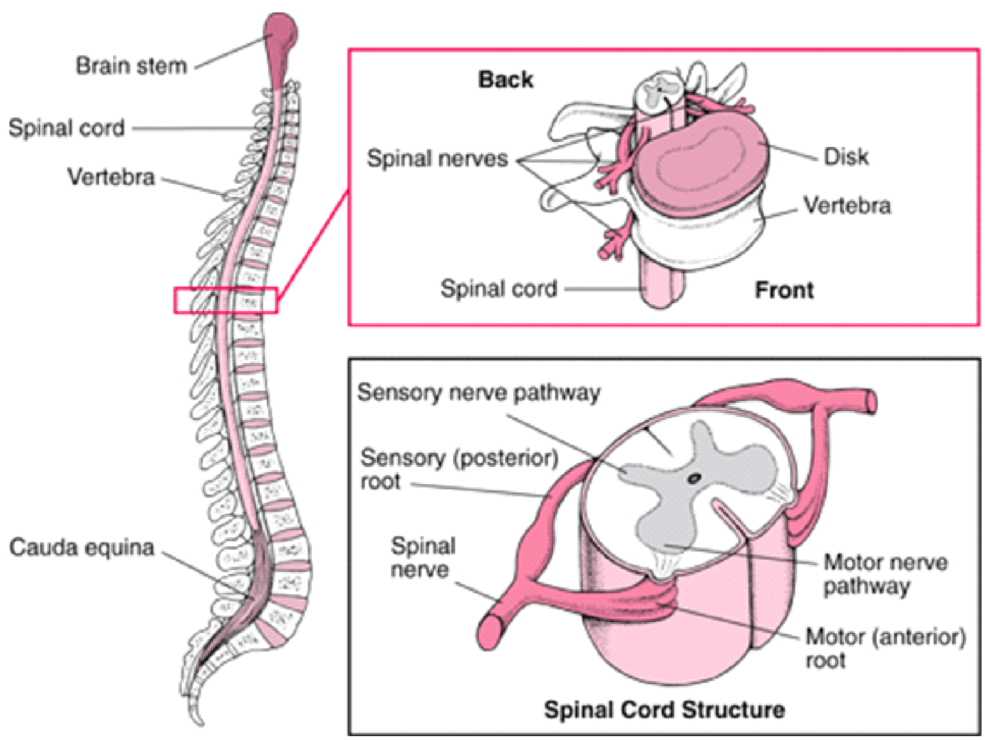


Figure 5.2

The most striking visual feature of the spinal cord is its grey matter (comprising cell bodies) and white matter (comprising myelinated axons). Forming a butterfly shape in the centre of the spinal cord is the grey matter, and this is packed tightly with the cell bodies of various neurons. These include the motor neurons that send their fibres out to innervate the muscles of the body, and a large number of interneurons that are confined to the grey matter.

Interneurons are important because they are located in pathways between sensory fibres going into the spinal cord, and motor fibres going out, which allow complex reflexes to take place. Furthermore, interneurons allow communication to take place between different segments or regions of the spinal cord.

In contrast, the white matter which surrounds the grey material is composed mainly of long myelinated axons that form the ascending and descending pathways of the spinal cord. More precisely, the ascending pathways arise from cell bodies that receive sensory input in the grey matter, and descending axons derive from the brain and pass into the grey matter where they form synapses with motor neurons.

The posterior column conveys touch and pressure information to the thalamus, and the corticospinal tract which passes information all the way from the motor regions of the cerebral cortex. Axons enter or leave the grey matter of spinal cord in spaces between the vertebrae, via spinal nerves which are ganglia containing large numbers of nerve fibres. There are 31 pairs of spinal nerves along the entire length of the spinal cord, and each one serves either the right or left side of the body (Figure 5,3).

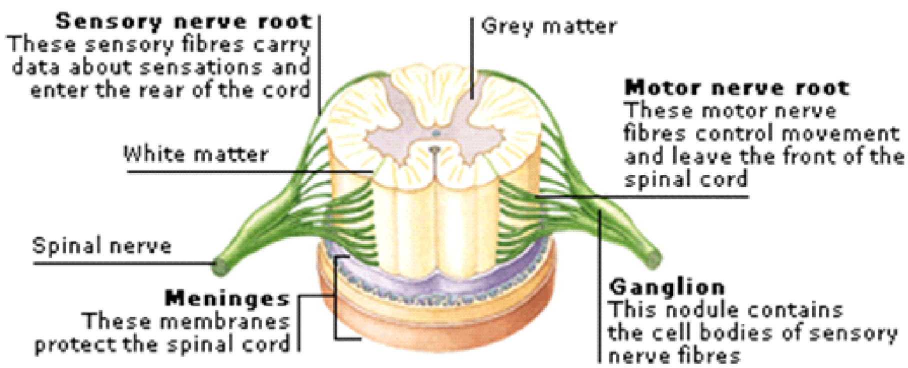


Figure 5.3

5.2.1 Functions

The spinal cord serves many functions: it helps humans maintain an erect posture, and also provides the point of attachment for muscles of the back. However, by far its most important function is to distribute motor neurons to their targets (for examples, muscles and glands), and to convey internal and external sensory information to the brain. Moreover, the spinal cord is also capable of producing certain types of behaviour by itself, including simple spinal reflexes such as the knee jerk response, or more complex patterns of automated rhythmical activity, including the postural components of walking.

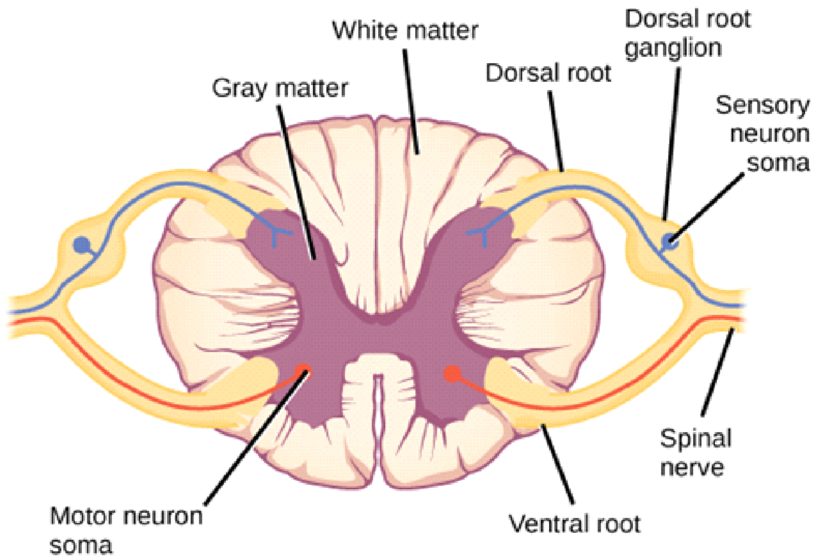


Figure 5.4

Closer examination of these nerves shows that they comprise two branches as they enter or leave the spinal cord (Figure 5.4). The dorsal root of each spinal nerve provides the pathway that relays sensory information into the spinal cord (the cell bodies of these neurons are actually located in the root itself), whereas the ventral root provides the motor pathway that controls the muscles of the body. The spinal cord also contains cerebrospinal fluid which is connected with the brain's ventricles. Samples of this spinal fluid can be a very useful diagnostic tool in determining various brain disorders.

5.3 Structure of Brain

As the spinal cord enters the brain it enlarges and forms the brainstem (Figure 5.5)

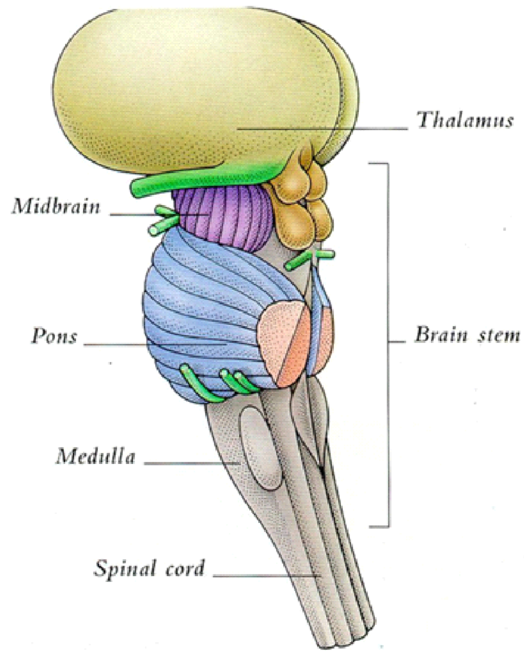


Figure 5.5

5.3.1 Brain stem

The oldest part of the brainstem is the medulla oblongata ('long marrow') and this directly controls many functions essential for life, including breathing, heart rate, salivation and vomiting. It also contains a profusion of ascending and descending nerve pathways that connect the spinal cord with the rest of the brain. If the brain is cut above the medulla, basic heart rate and breathing can be maintained, but damage to the medulla itself is inevitably fatal.

The next region is the pons (from the Latin for 'bridge') which appears as a significant enlargement of the medulla. This area also contains many nuclei (sometimes called the pontine nuclei) although its increased size is largely due to the many ascending and descending fibre tracts that cross from one side of the brain to the other at this point, including the pyramidal tracts. Two important structures often regarded as pontine nuclei (although they also extend into the midbrain) are the locus coeruleus and dorsal raphe. These are, respectively, the origin of noradrenergic and serotonergic-containing fibres in the forebrain. The pons also includes an area known as the tegmentum, which includes many motor nuclei and secondary sensory cell groups, as well as the beginning of the reticular formation, a tubular net-like mass of grey tissue which is involved in arousal. The pons also serves as the main junction between the cerebellum ('little brain') and the rest of the brain.

The brainstem (medulla and pons) is also the most important part of the brain giving rise to the cranial nerves, which were first discovered by Galen in the first century AD. There are twelve pairs of cranial nerves directly connecting the brain with bodily structures, and eight of these originate or terminate in the brainstem: four from the medulla (hypoglossal, spinal accessory, vagus and glossopharyngeal), and four from the pons (auditory, facial, abducens and trigeminal) (Figure 5.6).

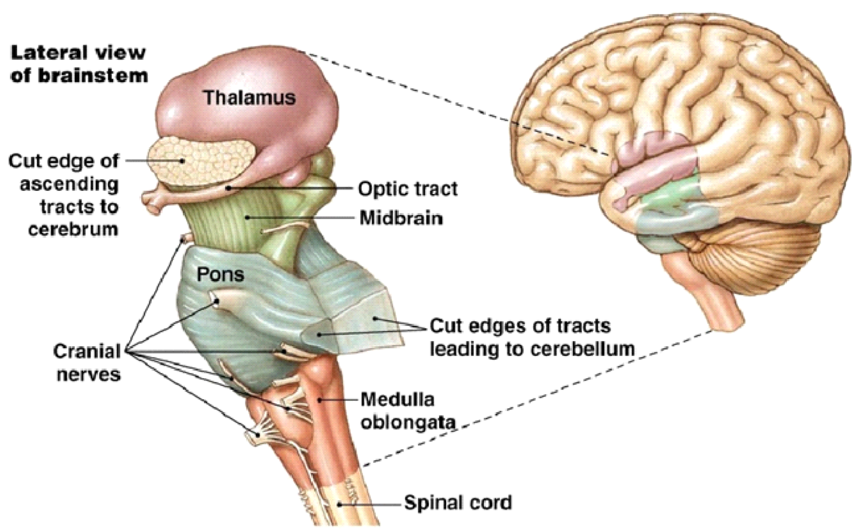


Figure 5.6

Cranial nerves are complex to understand as they can be sensory, motor or mixed (relaying both sensory and motor input), and may convey both sympathetic and parasympathetic fibres of the autonomic nervous system. In general, the cranial nerves of the brainstem are concerned with the senses of taste, hearing and balance, along with specialized motor activities, including chewing, swallowing, breathing, eye movements and facial expression.

The vagus nerve (derived from the Latin vagus meaning 'wandering') which has the most extensive distribution of any cranial nerve in the body) is somewhat different as it projects fibres to a variety of organs in the abdomen and thorax, including heart, lungs and digestive system. A consideration of the cranial nerves provide an interesting insight into the functions of the brainstem.

5.3.2 Mid brain

The midbrain (sometimes called the mesencephalon) is the name given to the region that forms the top part of the brainstem (Figure). It is generally divided into two areas: the tegmentum which is continuous with the pontine regions below it, and the tectum (meaning 'roof') which sits above it. The tegmentum contains several nuclei with important motor functions linked to basal ganglia function, including the red nucleus and substantia nigra.

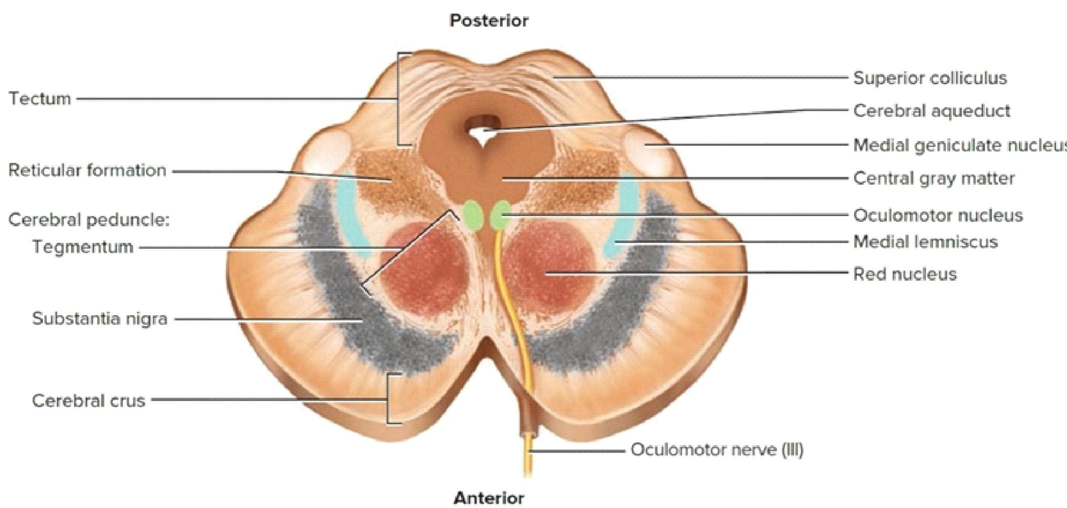


Figure 5.7

In addition, there are more diffuse areas of the tegmentum, including the periaqueductal grey area situated around the cerebral aqueduct (the passage connecting the third and fourth ventricles), and the ventral tegmental area which acts as an interesting crossroads – receiving descending input from the medial forebrain bundle, and returning information back to the forebrain (most notably striatum, limbic system and frontal cortex) via its dopaminergic pathways.

The tectum is actually the most recently evolved part of the brain, and it contains two pairs of nuclei called colliculi (derived from the Latin meaning 'small hills'), which protrude from its upper surface. These are the superior colliculi which are involved in visual processing and reflexes such as blinking and orientation, and inferior colliculi that serves a similar function for auditory processing. This part of the brain also gives rise to two more cranial nerves: the oculomotor controlling the muscles of the eyeball, and the trochlear involved in eye movement.

Also coursing through the centre of the brainstem and into the midbrain is the reticular activating system (RAS). This contains the ascending projections of the reticular formation, along with other areas of the brainstem, which passes to many areas of the forebrain, including the thalamus.

The RAS serves many essential functions, including the various stages of wakefulness and sleep. It also controls the level of electrical activity that governs states of arousal in the cerebral cortex (via its effect on the thalamus) which can be measured by using an electroencephalograph (EEG). The fibres making up the RAS are particularly complex and use a number of neurotransmitters, including noradrenaline, serotonin and acetylcholine.

5.3.3 Forebrain

Up to this point, the brain can be likened to a neural tube that has evolved and enlarged from the spinal cord. In fact, this is basically what happens during embryonic development. At first, the brain and spinal cord of every vertebrate animal appears as a tube which is only one cell thick. As it develops it begins to show three bulbous swellings called the primary brain vesicles. These can actually be observed in the human embryo by the fifth week of gestation. From bottom to top these are called the hindbrain (technically called the rhombencephalon) which becomes the brainstem; the mesencephalon which becomes the midbrain, and the forebrain.

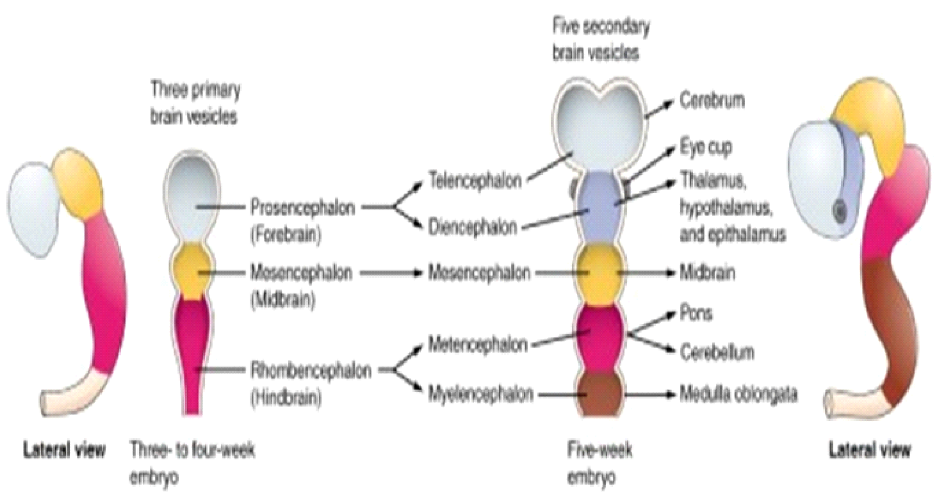


Figure 5.8

If we observe further development, we will see the forebrain 'mushroom out' so that it not only covers and surrounds much of the older 'tubular' brain but also adds greater complexity with the addition of many new structures. In fact, the forebrain will develop into two main regions: the diencephalon (literally 'between-brain'), and telencephalon ('endbrain'). The most important structures of the diencephalon are the thalamus and the hypothalamus.

5.3.3.1 Thalamus

The thalamus (from the Greek for 'inner chamber') consists of a symmetrical pair of egg-shaped structures that are separated medially by the third ventricle, and bounded laterally by a band of white fibres called the internal capsule that acts as the main communication link between the cerebral cortex and lower regions of the brain and spinal cord. The thalamus contains a bewildering number of different nuclei but are generally divided into anterior, medial, lateral and ventral groups.

Anatomically, the hypothalamus is very complex, with many different groups of nuclei, although it can be simplified by viewing it as having three zones. These are the preoptic area at the front, the medial zone which contains the majority of nuclei, and lateral nuclei which contain many of axons leaving the hypothalamus. In addition, the mammallary bodies are found at the back of the hypothalamus.

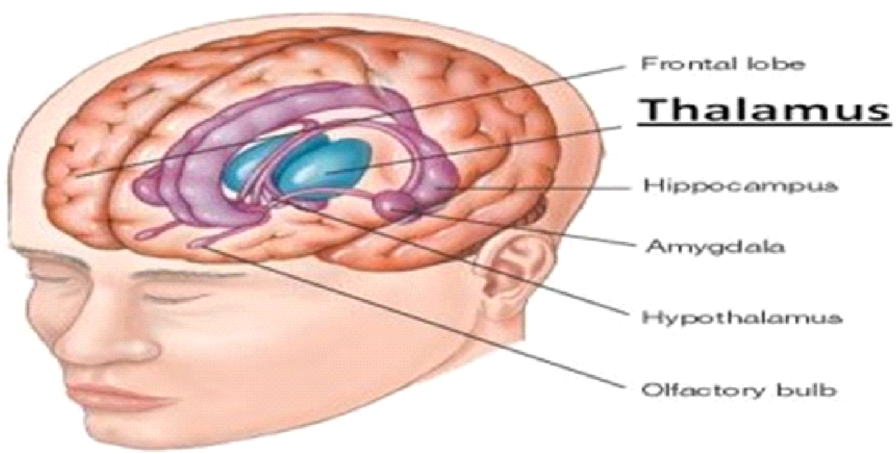


Figure 5.9

The thalamus has nerve connections with the cerebral cortex and hippocampus. In addition, connections with the spinal cord allow the thalamus to receive sensory information from the peripheral nervous system and various regions of the body. This information is then sent to the appropriate area of the brain for processing. It sends visual information to the visual cortex of the occipital lobes and auditory signals are sent to the auditory cortex of the temporal lobes

In general, the main function of the thalamus is to act as a relay station for information destined for the cerebral cortex. In this respect, its nuclei may either project to very precise locations (for example, the lateral geniculate bodies which project to the visual cortex), or have very diffuse ones that go to widespread areas of the cerebral cortex (for example, the intralaminar nuclei). The former are normally associated with a single sensory modality or motor system, whereas the latter appear to be involved in arousal.

5.3.3.2 Hypothalamus

Located just underneath the thalamus is a small structure making up only 0.15 per cent of the human brain called the hypothalamus (hypo meaning 'below'). Though it is small in size (it is roughly the size of a small grape), it plays a critical role in the maintenance of life as it controls both the autonomic and endocrine systems. In fact, destruction of the hypothalamus produce death in human.

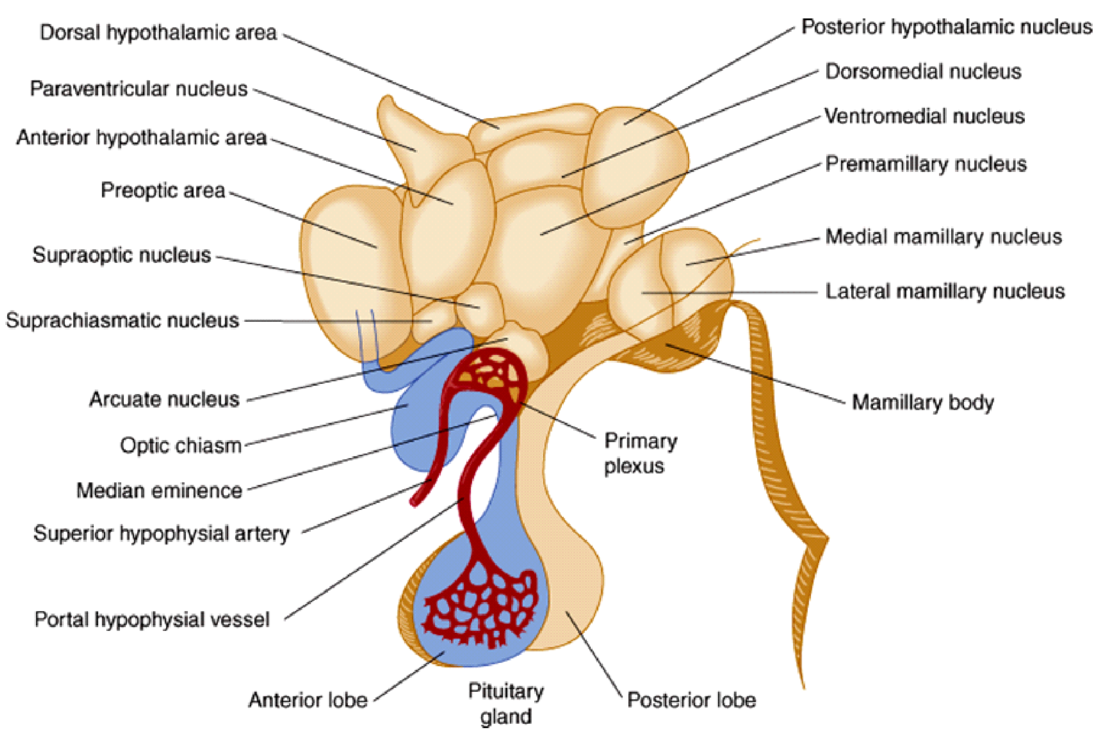


Figure 5.10

One of the most important functions of the hypothalamus is the co-ordination of homeostasis, that is, the ability of the body to maintain a constant internal environment despite continual exposure to various changes and external fluctuations. In addition, the hypothalamus has been described as the interface between our conscious brain, with its emotions and feeling, and the autonomic 'vegetative' processes of the body. The hypothalamus is also regarded as an integral part of the limbic system.

5.3.3.3 Limbic system

The word limbus comes from the Latin for 'border'; in 1878 Paul Broca applied the name to an area of the brain that surrounded the thalamus and striatum and appeared to separate the older brainstem from more recent cerebral cortex.

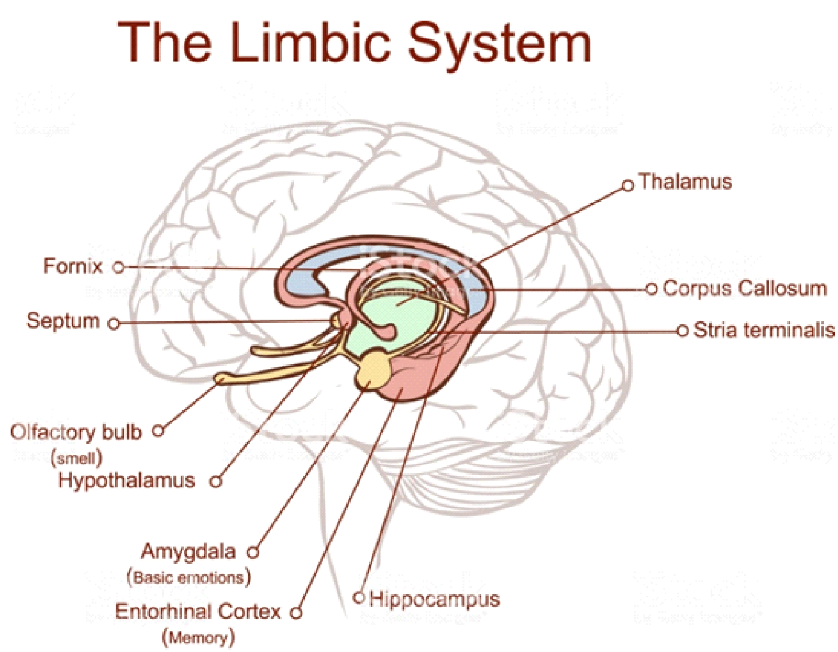


Figure 5.11

The limbic system plays a major role in producing drives, motivation and emotions. It also plays an important part in determining human behaviour – not least because it has been shown to be involved in producing the feelings of pleasure, anxiety and fear. The anatomy of the limbic system is complex and difficult to visualize. One of the most conspicuous structures of the limbic system is the hippocampus which is found in the medial aspects of the temporal lobe (Figure 5.11).

Partly surrounding the hippocampus is phylogenetically ‘old’ cortex, including the entorhinal cortex (which provides the perforant pathway into the hippocampus), Para hippocampal cortex and pyriform cortex. Another striking feature of the limbic system is the fornix, which is a massive (in humans it contains over 1 million fibres) long arching pathway that connects the hippocampus with the mammillary bodies and hypothalamus. The pathways are known to ascend from this part of the diencephalon via the anterior thalamus to the cingulate cortex.

The cingulate cortex wraps itself around the upper part of the corpus callosum, and contains a large bundle of fibres called the cingulum, which projects back to the hippocampus. Another important structure found in the limbic system is the amygdala which lies anterior to the hippocampus. This structure also has two descending pathways to the hypothalamus (the ventral amygdalofugal pathway and stria terminalis) and a pathway that projects to the prefrontal cortex via the mediodorsal nuclei of the thalamus.

5.3.3.4 Basal ganglia

The set of structures seen on the sideways of the thalamus comprise basal ganglia (literally meaning ‘basal nuclei’) (see Figure). The three main structures of the basal ganglia are the caudate nucleus (which also has a tail that curls over the top of the thalamus); the putamen which is separated from the caudate by the fibres of the internal capsule; and the globus pallidus (pale globe) which lies medial to the putamen. The caudate nucleus and putamen are also referred to as the corpus striatum – a term invented by Thomas Willis in 1664 who noted that this structure had a very distinct striated appearance of white and grey bands.

Two other structures generally regarded as important components of the basal ganglia are the substantia nigra which innervates the corpus striatum with dopaminergic neurons, and the subthalamic nucleus which has reciprocal connections with the globus pallidus. Traditionally, the basal ganglia have been considered as important structures of the extrapyramidal motor system (that is, the motor system of the brain whose output fibres do not cross in the pyramidal regions of the medulla).

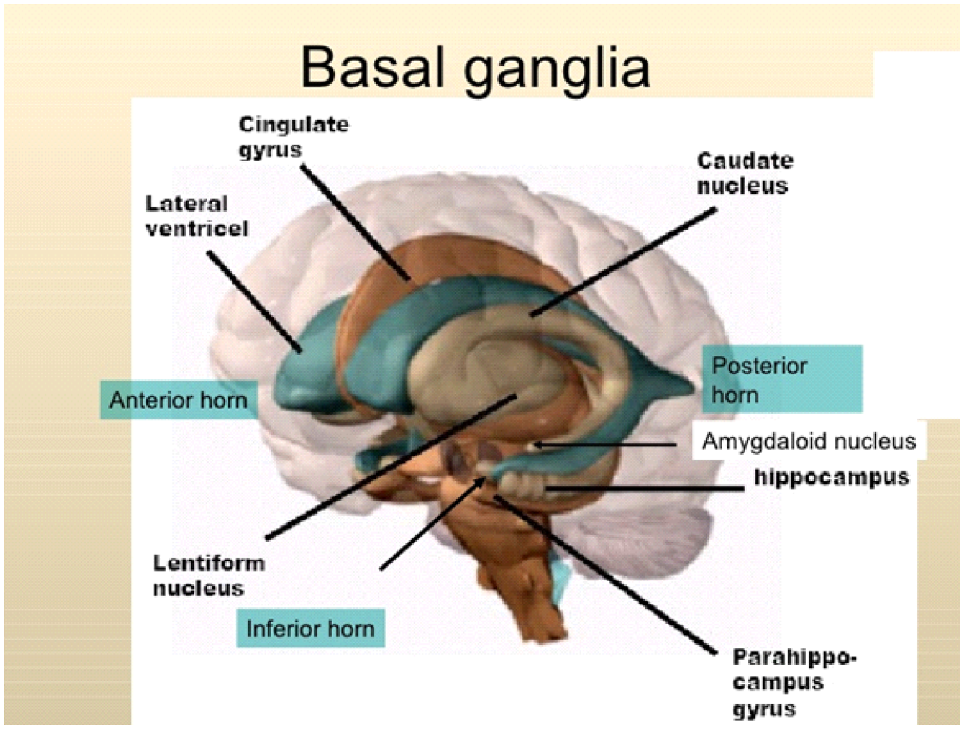


Figure 5.12

The most important functions of the basal ganglia can be discerned by examining the main symptoms of Parkinson's disease (rigidity, tremor and 'slow' movement) that are resulting from degeneration of the nigral–striatal pathway. Thus, the basal ganglia would appear to be involved in the co-ordination of motor activity, allowing it be automated (i.e. undertaken without 'thinking'), smooth and fluent. Although the nigral–striatal pathway is a significant projection to the corpus striatum, the largest projection actually derives from motor areas of the cerebral cortex which innervate the corpus striatum with fibres using the neurotransmitter glutamate.

In turn, the output fibres of both caudate and putamen project to, or pass through, the globus pallidus. From here, a major pathway travels back to the cerebral cortex via the ventral nuclei of the thalamus, with a smaller projection also going to the substantia nigra. The caudate nucleus, putamen and globus pallidus also have ventromedial extensions which extend deeper into the brain. In doing this, they appear to take on a more important role in emotional functions.

5.3.3.5 Cerebral cortex

The most striking feature of the human brain is undoubtedly the two symmetrical wrinkled cerebral hemispheres that form the cerebral cortex. This is truly remarkable structure which has been estimated to contain some 100,000 km of axons, and many millions of synapses. The cerebral cortex has a deceptive appearance: it is only around 2–3 mm thick, but is highly folded (not unlike a piece of paper that has been screwed up) which allows its large area to fit inside the small confines of the skull. In fact, if the cerebral cortex was flattened out its total surface area would be about 75 cm2 (2.5 ft2).

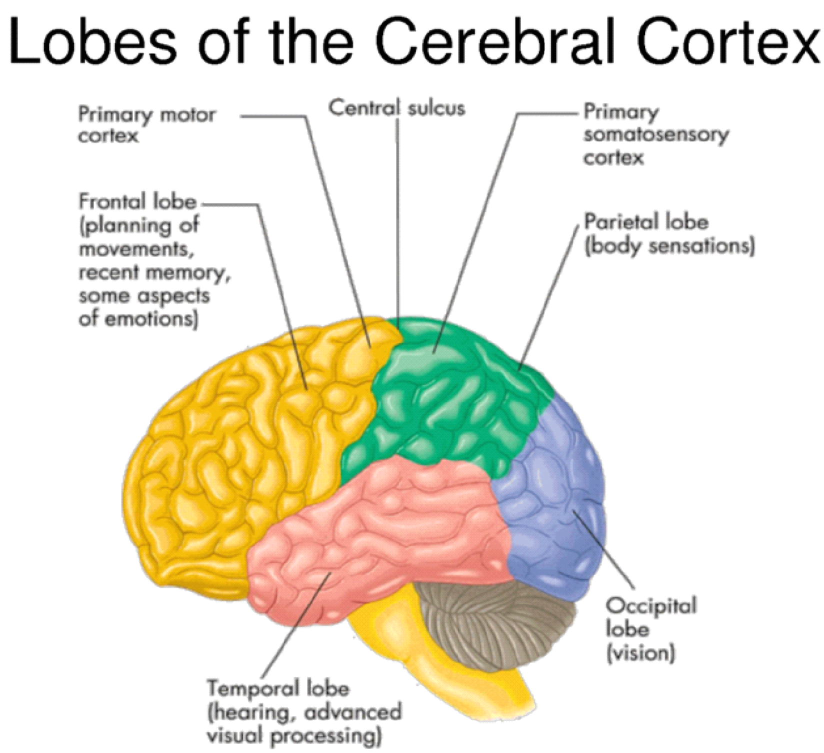


Figure 5.13

Because of this, about two-thirds of the cortex is hidden from view in fissures (or sulci) which are the gaps between the surface ridges (or gyri). The main fissures also make good surface landmarks to distinguish different regions of the cerebral cortex (Figure 5.13) For example, all the cortex anterior to the central fissure (sometimes called the Rolandic fissure) comprises the frontal lobe, whereas the tissue posterior to it forms the parietal lobe. Another sulcus called the parietal–occipital fissure separates the parietal lobe from the occipital lobe which is located at the back of the cerebral cortex.

The other main region of the cerebral cortex is the temporal lobe which is separated from the frontal and parietal lobes by the lateral fissure (sometimes called the Sylvian fissure). When examined under a high-powered microscope it can be seen that about 90 per cent of the cerebral cortex is made up of six layers (this is sometimes called neocortex) which is anatomically more complex than the more primitive three-layered cortex (archicortex) found mainly in parts of the limbic system.

In 1909, Brodmann divided the cerebral cortex into 52 different regions based on anatomical differences (now known as Brodmann's areas) and showed that this cortical organization was similar in all mammals. These anatomical differences reflect different functions that are undertaken by the cerebral cortex.

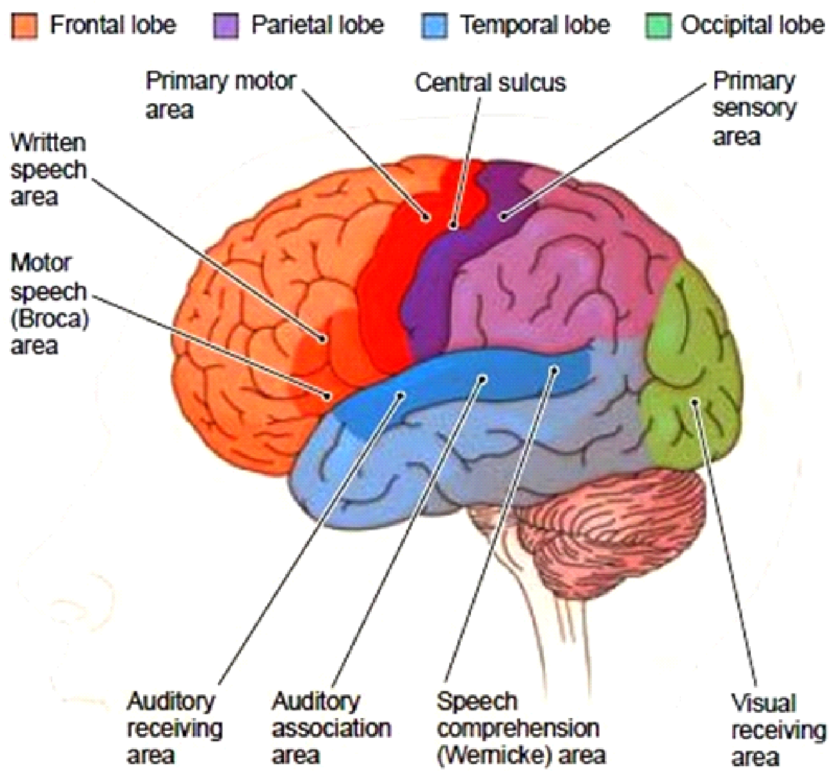


Figure 5.14

The functions served by the cerebral cortex are extremely varied. For example, the cerebral cortex contains the primary sensory areas that are specialized for receiving visual, auditory and somatosensory (touch) input. This information is relayed to the cortex by specific nuclei in the thalamus. In addition, the cerebral cortex contains a number of motor areas, including the primary motor cortex, located in the precentral gyrus of the frontal cortex, which controls voluntary movement.

The cerebral cortex also has a number of areas that are highly specialized for understanding and producing language. Despite this, most of the cerebral cortex in humans is actually made up of association areas – regions that are involved in the integration of many types of information. These regions are involved in many higher functions of the brain – and in abilities that underpin our ability to plan and see the consequences of our actions and to engage in various forms of abstract thought. It is also interesting to note that the right and left hemispheres also tend to show different types of cognition: the left being dominant for language and the right being dominant for spatial processing. The two cerebral hemispheres communicate with each other by a huge fibre bundle called the corpus callosum which contains around 300 million axons.

5.4 Functions of major Brain areas

The brain is comprised of a number of different regions, each with specialized functions. The brain's central core, includes the brain stem and the midbrain, and is quite different than the cerebral cortex that envelops it. The central core is relatively simple, older and its activity is largely unconscious. In contrast, the cortex is highly developed and capable of the deliberation and associations necessary for complex thinking and problem solving. In humans, its size and function has increased rapidly. While the older portions of the brain remain relatively static.

5.4.1 THE BRAIN STEM

The brain stem seems to be inherited almost "as is" from the reptilian brain. It consists of structures such as the medulla (controlling breathing, heart rate, and digestion) and the cerebellum (which coordinates sensory input with muscle movement).

5.4.2 THE MIDBRAIN

The Midbrain includes features that appear intimately connected to human emotion and to the formation of long-term memory via neural connections to the lobes of the neocortex. The structures contained here also link the lower brain stem to the thalamus — for information relay from the senses, to the brain, and back out to muscles — and to the limbic system. The limbic system, essentially alike in all mammals, lies above the brain stem and under the cortex. It consists of a number of interrelated structures. The limbic system is linked to hormones, drives, temperature control, and emotion. One part is dedicated to memory formation, thus explaining the strong link between emotion and long term memory.

The limbic system includes these parts:

- The hypothalamus is instrumental in regulating drives and actions. Neurons affecting heart rate and respiration are concentrated here. These direct most of the physical changes that accompany strong emotions, such as the “flight or fight” response.
- The amygdala appears connected to aggressive behavior.
- The hippocampus plays a crucial role in processing various forms of information to form long-term memories. Damage to the hippocampus will produce global retrograde amnesia. One very important feature of the midbrain and limbic system is the reticular activating system (RAS). It is this area that keeps us awake and aware of the world. The RAS acts as a master switch that alerts the brain to incoming data — and to the urgency of the message.

5.4.3 THE FOREBRAIN OR NEOCORTEX

The forebrain, which appears as a mere bump in the brain of a frog, balloons out into the cerebrum of higher life forms and covers the brain stem like the head of a mushroom. This, the newest part of the human brain, is also called the neocortex, or cerebral cortex. The structure of the neocortex is very complicated and most of the higher level functions associated with human thought are enabled in this region. We now turn to some specific parts of the cortex. The areas of the cerebral cortex is divided based on the structure and function of cells. For convenience, these areas are grouped into four lobes named for the skull bones that lie over them: occipital, parietal, temporal, and frontal.

5.4.3.1 Frontal Lobes

The frontal lobes occupy the front part of the brain. It contains the primary motor cortex and the prefrontal cortex, extending from the central sulcus to the anterior limit of the brain. The posterior portion of the frontal lobe just anterior to the central sulcus, the precentral gyrus, is specialized for the control of fine movements, such as moving one finger at a time. Separate areas are responsible for different parts of the body, mostly on the contra lateral (opposite) side but also with slight control of the ipsilateral (same) side. The most anterior portion of the frontal lobe is the prefrontal cortex. In general, the larger a species' cerebral cortex, the higher the percentage of it is devoted to the prefrontal cortex. The dendrites in the prefrontal cortex have up to 16 times as many dendritic as neurons in other cortical areas. As aresult, the prefrontal cortex integrates an enormous amount of information.

The functions of frontal lobes are associated with making decisions, planning, and voluntary muscle movement. Speech, smell, and emotions are processed here as well. The frontal lobes control our responses and reactions to input from the rest of the system. The saying "Get your brain in gear" refers to activity in the frontal lobes.

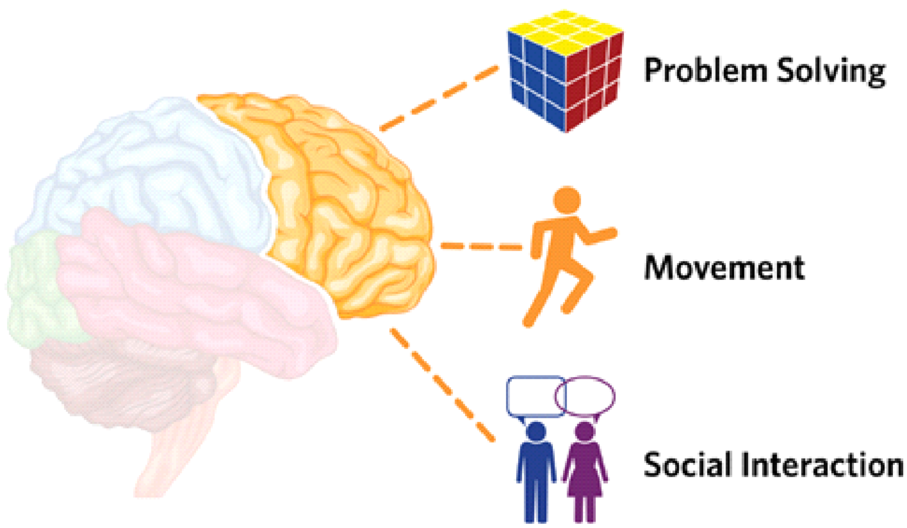


Figure 5.15

5.4.3.2 Parietal Lobes

The parietal lobe lies between the occipital lobe and the central sulcus, which is one of the deepest grooves in the surface of the cortex. The area just posterior to the central sulcus, the postcentral gyrus, or primary somatosensory cortex, is the main target for touch sensations and information from muscle-stretch receptors and joint receptors. The postcentral gyrus includes four bands of cells parallel to the central sulcus. Separate areas along each band receive simultaneous information from different parts of the body. Two of the bands receive mostly light-touch information, one receives deep-pressure information, and one receives a combination of both.

The parietal lobes are most closely associated with our sense of touch. They contain a detailed map of the whole body's surface. More neurons are dedicated to some regions of surface area than others. For example, the fingers have many more nerve endings than the toes, and therefore they have more associated areas in the brain for processing. Information about touch and body location is important not only for its own sake but also for interpreting visual and auditory information. For example, if you see something in the upper left portion of the visual field, your brain needs to know which direction your eyes are turned, the position of your head, and the tilt of your body before it can determine the location of the object that you see and therefore your direction if you want to approach or avoid it. The parietal lobe monitors all the information about eye, head, and body positions and passes it on to brain areas that control movement.

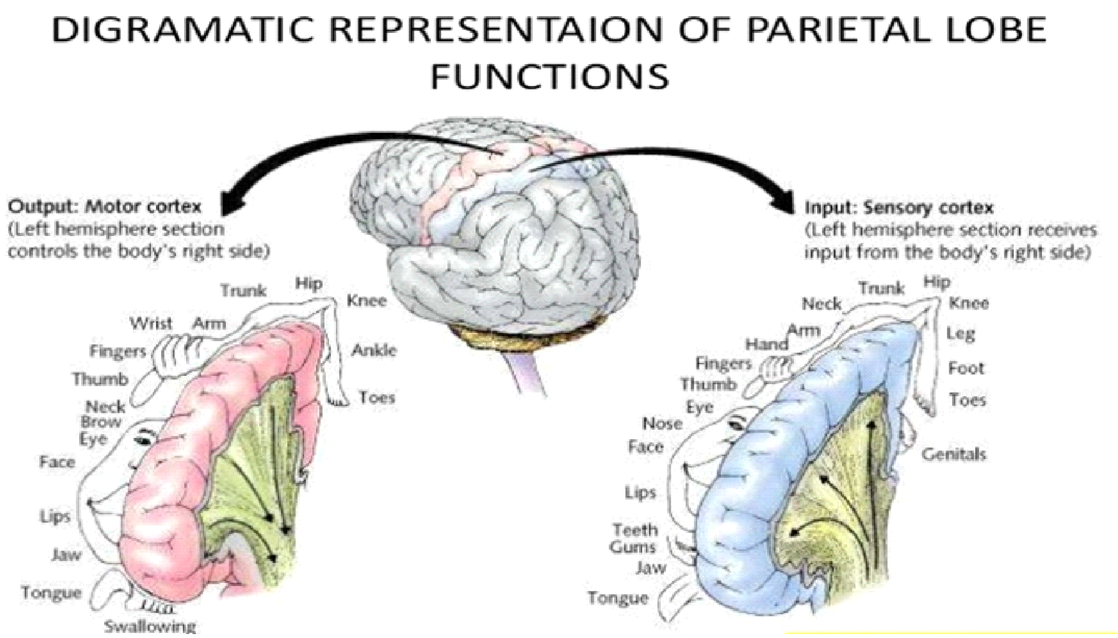


Figure 5.16

The parietal lobe of the right hemisphere appears to be especially important for perceiving spatial relationships. The recognition of relationships between objects in space is important to activities such as drawing, finding your way, construction, and mechanical or civil engineering. It is essential not only for spatial information but also numerical information.

5.4.3.3 Temporal Lobes

The temporal lobes are concerned with emotions, and also contain the primary auditory cortex, which processes soundThe temporal lobe is the lateral portion of each hemisphere, near the temples. It is the primary cortical target for auditory information. The human temporallobe—in most cases, the left temporal lobe—is essential for understanding spoken language. The temporal lobe also contributes to complex aspects of vision, including perception of movement and recognition of faces. A tumor in the temporal lobe may give rise to elaborate auditory or visual hallucinations, whereas a tumor in the occipital lobe ordinarily evokes only simple sensations, such as flashes of light.

The temporal lobes also play a part in emotional and motivational behaviors. Temporal lobe damage can lead to a set of behaviors known as the Klüver-Bucy syndrome (named for the investigators who first described it). Previously wild and aggressive monkeys fail to display normal fears and anxieties after temporal lobe damage (Klüver & Bucy, 1939). They put almost anything they find into their mouths and attempt to pick up snakes and lighted matches (which intact monkeys consistently avoid). Interpreting this behavior is difficult. For example, a monkey might handle a snake because it is no longer afraid (an emotional change) or because it no longer recognizes what a snake is (a cognitive change).

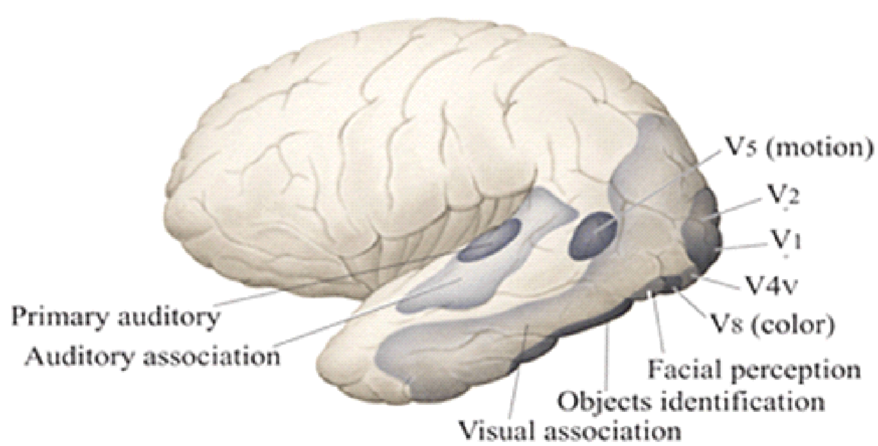


Figure 5.17

5.4.4.4 Occipital Lobes

The occipital lobes are the primary visual cortex. This area at the back of the brain, just above the cerebellum, processes stimuli from our eyes, via the optic nerve, and associates that information with other sensory input and memories. The posterior pole of the occipital lobe is known as the primary visual cortex, or striate cortex, because of its striped appearance in cross-section. Destruction of any part of the striate cortex causes cortical blindness in the related part of the visual field. For example, extensive damage to the striate cortex of the right hemisphere causes blindness in the left visual field (the left side of the world from the viewer's perspective).

A person with cortical blindness has normal eyes, normal pupillary reflexes, and some eye movements but no pattern perception or visual imagery. People who suffer eye damage become blind, but if they have an intact occipital cortex and previous visual experience, they can still imagine visual scenes and can still have visual dreamsRecall that areas crucial to long-term memory also reside at the back of the brain. These association areas interpret sensory data by relating it to existing knowledge, and are essential to memory formation.. The occipital lobe, located at the posterior (caudal) end ofthe cortex, is the main target for visual information.

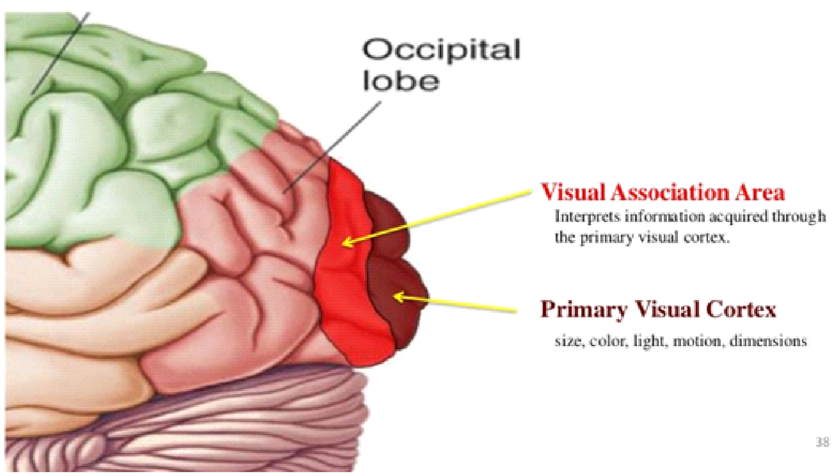


Figure 5.18

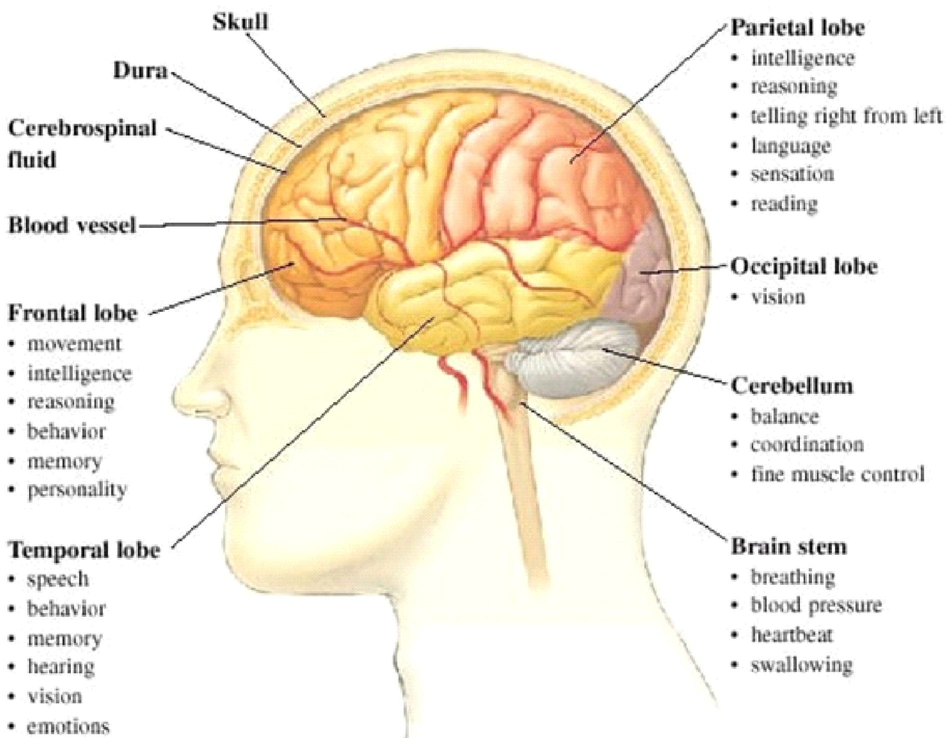


Figure 5.19

5.4.4.5 Sensory Cortex and Motor Cortex

Regions called the sensory cortex and the motor cortex are sandwiched between the frontal and parietal lobes, right at the top of the head. These areas specialize in the control of movement and in receiving information from the body's primary sensory systems (vision, smell, taste, touch, and sound).

Thus the frontal lobe of the neocortex appears to be responsible for planning, decision-making, and risk-taking while the back of the brain stores memories. The middle section is focused on experiencing the present moment, since it houses the primary sensory and motor cortex. It is busily processing information from our five senses and sending control signals back out to our muscles.

5.5 Conclusion

The human brain is a very complex and interesting organ in the human body. The brain has three basic units that are all responsible for its own distinct functional role of the body; brain and spinal cord are the two main structures of the central nervous system, the three units of the brain are the hindbrain, midbrain, and the forebrain. With each region of the brain, there are specific ones that have their main roles that help guide cognitive functions. The brain helps humans to organize, retrieve, make sense out of the information we process every day with the use of the various regions of our brain that work together as well as independently. Knowledge of the brain functions gives a better understanding for how humans are so much alike, yet can behave, and react to similar stimuli in completely different ways.

5.6 SUMMARY

The main divisions of the vertebrate nervous system are the central nervous system and the peripheral nervous system. Each segment of the spinal cord has a sensory nerve on each side and a motor nerve on each side. Spinal pathways convey information to the brain. The central nervous system consists of the spinal cord, the hindbrain, the midbrain, and the forebrain. The hindbrain consists of the medulla, pons, and cerebellum. The medulla and pons control breathing, heart rate, and other vital functions through the cranial nerves. The cerebellum contributes to movement and timing short intervals. The cerebral cortex receives its sensory information (except for olfaction) from the thalamus. The subcortical areas of the forebrain include the thalamus, hypothalamus, pituitary gland, basal ganglia, and hippocampus. Although brain size varies among mammalian species, the overall organization is similar.

The occipital lobe of the cortex is primarily responsible for vision. Damage to part of the occipital lobe leads to blindness in part of the visual field. The parietal lobe processes body sensations. The postcentral gyrus contains four separate representations of the body. The temporal lobe contributes to hearing, complex aspects of vision, and processing of emotional information. The frontal lobe includes the precentral gyrus, which controls fi ne movements. It also includes the prefrontal cortex, which contributes to memories of current and recent stimuli, planning of movements, and regulation of emotional expressions. The prefrontal cortex is important for working memory and for planning actions that depend on the context.

5.7 KEY WORDS

::autonomic nervous system

controls the heart, the intestines, and other organs.

::basal ganglia

a group of subcortical structures lateral to the thalamus, include three major structures: the caudate nucleus, the putamen, and the globus pallidus

::brainstem

The medulla and pons, the midbrain, and certain central structures of the forebrain constitute the brainstem

::central nervous system (CNS)

the brain and the spinal cord

::cerebellum

a large hindbrain structure with many deep folds.

::cranial nerves

control sensations from the head, muscle movements in the head, and much of the parasympathetic output to the organs

::dorsal

toward the back

::dorsal root ganglia

clusters of neurons outside the spinal cord

::forebrain

the most anterior and most prominent part of the mammalian brain.

::gray matter

dense package with cell bodies and dendrites.

::hindbrain

the posterior part of the brain, consists of the medulla, the pons, and the cerebellum.

::hippocampus

a large structure between the thalamus and the cerebral cortex.

::hypothalamus

a small area near the base of the brain just ventral to the thalamus

::inferior colliculus

midbrain nucleus of the auditory pathway and receives input from several peripheral brainstem nuclei in the auditory pathway, as well as inputs from the auditory cortex.

::limbic system

A number of interlinked structures, forming a border around the brainstem.

::medulla

a cone-shaped neuronal mass responsible for autonomic (involuntary) functions ranging from vomiting to sneezing.

::midbrain

the middle of the brain

::peripheral nervous system (PNS)

the nerves and ganglia outside the brain and spinal cord.

::Pituitary gland

an endocrine (hormone-producing) gland attached to the base of the hypothalamus

::pons

Part of the midbrain lying inferior to the midbrain, superior to the medulla oblongata and anterior to the cerebellum.

::spinal cord

a long, thin, tubular bundle of nervous tissue and support cells that extends from the medulla oblongata in the brainstem to the lumbar region of the vertebral column.

::substantia nigra

structure in the midbrain

::superior colliculus

a paired structure of the mammalian midbrain.

::tectum

The roof of the midbrain

::tegmentum

the intermediate level of the midbrain.

::thalamus

a pair of structures (left and right) in the center of the forebrain

::cerebral cortex

The most prominent part of the mammalian brain , consisting of the cellular layers on the outer surface of the cerebral hemispheres.

::corpus callosum

a thick band of nerve fibers that divides the cerebral cortex lobes into left and right hemispheres.

::frontal lobe

the part of the brain that controls important cognitive skills in humans, such as emotional expression, problem solving, memory, language, judgment, and sexual behaviors.

::Klüver-Bucy syndrome

a neuro-behavioral syndrome associated with bilateral lesions in the anterior temporal horn or amygdala.

::occipital lobe

located in the back portion of the brain behind the parietal and temporal lobes, and is primarily responsible for processing visual information .

::parietal lobe

positioned above the temporal lobe and behind the frontal lobe and central sulcus

::postcentral gyrus

gyrus in the lateral parietal lobe of the human brain and is the location of the primary somatosensory cortex.

::precentral gyrus

the primary motor cortex, is a very important structure involved in executing voluntary motor movements.

::temporal lobe

the lateral portion of each cerebral hemisphere, near the temples

5.8 CHECK YOUR PROGRESS

1. The central nervous system (CNS) contains
   (a) Brain and cranial nerves
   (b) Spinal cord and spinal nerves
   (c) Brain and spinal cord
   (d) Cranial and spinal nerves

2. What is the greatest evolutionary change in the human brain?
   (a) Overall size
   (b) Overall weight
   (c) Enlargement of the cerebrum
   (d) Elongation of the brainstem

3. What is the role of the corpus collosum?
   (a) Center of the executive functions
   (b) Connects the two hemispheres of the brain
   (c) Coordination of motor movements
   (d) Determines handedness in humans

4. Which part of the brain controls balance and coordinates movements?
   (a) Medulla
   (b) Thalamus
   (c) Hypothalamus
   (d) Cerebellum

5. Lobe controlling vision is
   (a) Occipital
   (b) Frontal
   (c) Temporal
   (d) Parietal

6. Lobe controlling auditory and hearing function is
   (a) Occipital
   (b) Parietal
   (c) Temporal
   (d) Frontal

5.9 ANSWERS TO CHECK YOUR PROGRESS

1. (c)
2. (c)
3. (b)
4. (d)
5. (a)
6. (c)

5.10 MODEL QUESTIONS

1. Explain the anatomical and functional divisions of the central nervous system
2. Trace out the basic structure of the spinal cord
3. What are the basic structure of brain?
4. Explain the basic functions of the central nervous system.

LESSON 6
SENSORY ORGANS

INTRODUCTION

In the completed lessons, how the communication of information inside the human body takes place and the structures involved for this communication to happen, were dealt in detail. In order to communicate, the information about the world has to have a way to get into the brain, where it can be used to determine actions and responses. The way into the brain is through the sensory organs and the process of sensation. This lesson deals with the sensory organs.

LEARNING OBJECTIVES

At the end of this unit you will be able to understand

- the characteristics of sensory modalities
- the nature of sense organs
- he structure of sense organs

PLAN OF THE LESSON

6.1 Sensation

6.2 Nature and Varieties of Stimulus

6.3 Sensory Receptors

6.4 Sensory Threshold

6.5 Habituation and Sensory adaptation

6.6 The Structure of the Eye

6.7 The Structure of the Ear

6.8 Chemical Senses

6.9 The Sense of Scents: Olfaction

6.10 Somesthetic Senses

6.11 Conclusion

6.1 Sensation

Our picture of the world around us depends on an elaborate sensory system that processes incoming information. In other words, we experience the world through a series of “filters” that we call our senses .Sensation is very basic. Sensation involves all those processes that are necessary for the basic detection that something exists in the world. For example, a sensory process might be detecting the loudness of a sound or the type of taste in a food.

Sensation and Perception

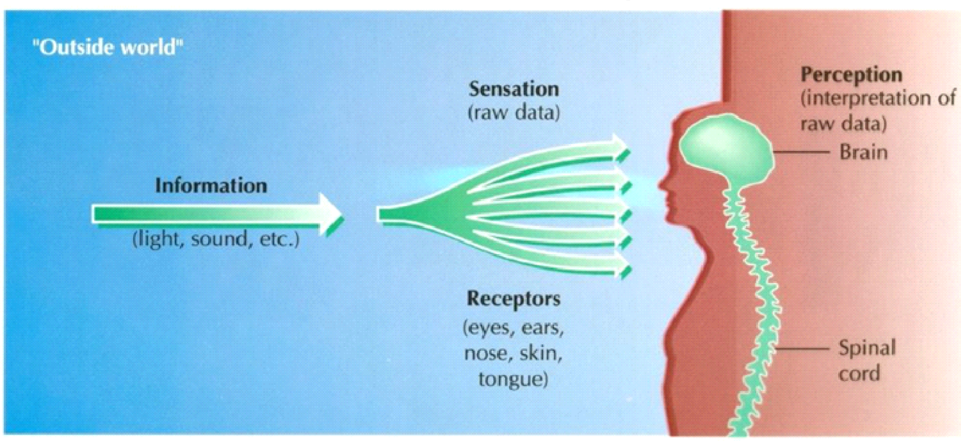


Figure 6.1

sensation is defined as the simple process by which a stimulated receptor (such as the eyes or ears) creates a pattern of neural messages that represent the stimulus in the brain, giving rise to our initial experience of the stimulus. Sensation occurs when special receptors in the sense organs—the eyes, ears, nose, skin, and taste buds—are activated, allowing various forms of outside stimuli to become neural signals in the brain. (This process of converting outside stimuli, such as light, into neural activity is called transduction.) Sensation is the process whereby a physical stimulus produces physiological reactions that eventually lead to a subjective, psychological experience (Figure 6.1). Sensation is the raw, unanalysed experience, before perceptual processes interpret the evoked experience. All of our sensory systems require receptors. These are unique neural structures that react to particular forms of physical stimulation.

6.2 Nature and Varieties of Stimulus

The external environment that surrounds us contains a wide variety of stimuli. Some of them can be seen (e.g., a house), while some can be heard only (e.g., music). There are several others that we can smell (e.g., fragrance of a flower) or taste (e.g., sweets). There are still others that we can experience by touching (e.g., softness of a cloth). All these stimuli provide us with various kinds of information.

We have very specialized sense organs to deal with these different stimuli. As human beings we are bestowed with a set of seven sense organs. These sense organs are also known as sensory receptors or information gathering systems, because they receive or gather information from a variety of sources. Five of these sense organs collect information from the external world. These are eyes, ears, nose, tongue, and skin. While our eyes are primarily responsible for vision, ears for hearing, nose for smell, and tongue for taste, skin is responsible for the experiences of touch, warmth, cold, and pain. Specialised receptors of warmth, cold, and pain are found inside our skin. Besides these five external sense organs, we have also got two deep senses. They are called kinesthetic and vestibular systems. They provide us with important information about our body position and movement of body parts related to each other. With these seven sense organs, we register ten different variety of stimuli.

6.3 Sensory Receptors

The sensory receptors are specialized forms of neurons, the cells that make up the nervous system. (Table 6.1)

Instead of receiving neurotransmitters from other cells, these receptor cells are stimulated by different kinds of energy—for example, the receptors in the eyes are stimulated by light, whereas the receptors in the ears are activated by vibrations. Touch receptors are stimulated by pressure or temperature, and the receptors for taste and smell are triggered by chemical substances. The different types of sensory receptors are (a) Mechanoreceptors, (b) Chemoreceptors, (c) Electromagnetic receptors and (d) Photoreceptors.(Diagram 6.1)

Sense	Stimulus	Sense Organ	Receptor	Sensation
Sight	Light waves	Eye	Rods and cones of retina	Colors, patterns, textures, motion, depth in space
Hearing	Sound waves	Ear	Hair cells located in inner ear	Noises, tones
Skin sensations	External contact	Skin	Nerve endings in skin	Touch, pain, warmth, cold
Smell	Volatile substances	Nose	Hair cells of olfactory membrane	Odors (musky, flowery, burnt, minty)
Taste	Soluble substances	Tongue	Taste buds of tongue	Flavors (sweet, sour, salty, bitter)
Vestibular sense	Mechanical and gravitational forces	Inner ear	Hair cells of semicircular canals and vestibule	Spatial movement, gravitational pull
Kinesthesis	Body movement	Muscles, tendons,	Nerve fibers in muscles, tendons, and joints	Movement and position of body parts

Table 6.1

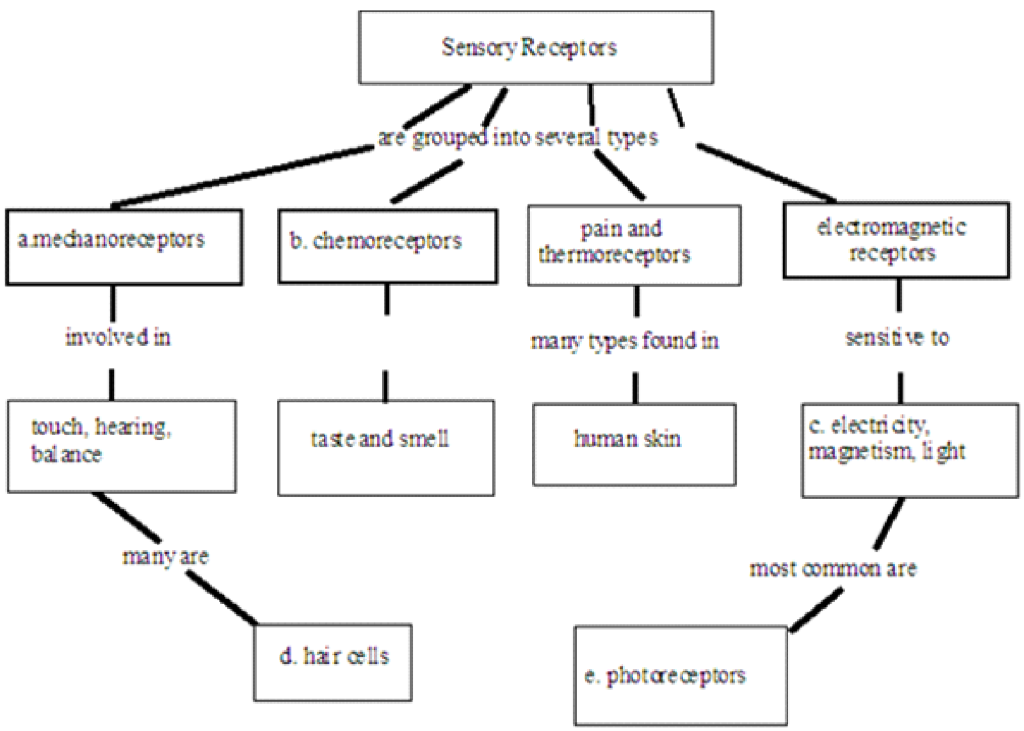


Diagram 6-.1

6.4 Sensory Threshold

Before we move on to a discussion of sense organs, it is important to understand that our sense organs function with certain limitations. For example, our eyes cannot see things which are very dim or very bright. Similarly our ears cannot hear very faint or very loud sounds. The same is true for other sense organs also. As human beings, we function within a limited range of stimulation. For being noticed by a sensory receptor, a stimulus has to be of an optimal intensity or magnitude. The relationship between stimuli and the sensations they evoke has been studied in a discipline, called psychophysics.

A stimulus has to carry a minimum value or weight in order to be noticed. The minimum value of a stimulus required to activate a given sensory system is called absolute threshold or absolute limen (AL). For example, adding a granule of sugar to a glass of water, sweetness in that water may not be experienced. Addition of a second granule to water may also not make it taste sweet. But if sugar granules are added one after another continuously, there will come a point when you will experience the sweetness in the water. The minimum number of sugar granules required to say that the water is sweet will be the absolute threshold of sweetness. Absolute threshold is not a fixed point; instead it varies considerably across individuals and situations depending on the people's organic conditions and their motivational states. Hence, it has to be assessed on the basis of a number of trials. The number of sugar granules that may produce the experience of "sweetness" in water on 50 per cent of occasions will be called the AL of sweetness. If more number of sugar granules are added, the chances are greater that the water will be reported more often as sweet than plain.

As it is not possible for us to notice all stimuli, it is also not possible to differentiate between all stimuli. In order to notice two stimuli as different from each other, there has to be some minimum difference between the value of those stimuli. Ernst Weber (1795–1878) did studies trying to determine the smallest difference between two weights that could be detected. His research led to the formulation known as Weber's law of just noticeable differences (**jnd**, or the difference threshold).

A **jnd** is the smallest difference between two stimuli that is detectable 50 percent of the time, and Weber's law simply means that whatever the difference between stimuli might be, it is always a constant. If to notice a difference the amount of sugar a person would need to add to a cup of coffee that is already sweetened with 5 teaspoons is 1 teaspoon, then the percentage of change needed to detect a just noticeable difference is one-fifth, or 20 percent. So if the coffee has 10 teaspoons of sugar in it, the person would have to add another 20 percent, or 2 teaspoons, to be able to taste the difference half of the time. The smallest difference in the value of two stimuli that is necessary to notice them as different is called **difference threshold** or **difference limen** (DL). The understanding of sensations is not possible without understanding the AL and DL of different types of stimuli (for example, visual, auditory).

Stimuli that are below the level of conscious awareness are called subliminal stimuli. (The word limin means “threshold,” so sublimin means “below the threshold.”) These stimuli are just strong enough to activate the sensory receptors but not strong enough for people to be consciously aware of them. Many people believe that these stimuli act upon the unconscious mind, influencing behavior in a process called subliminal perception. There is a growing body of evidence that we process some stimuli without conscious awareness, especially stimuli that are fearful or threatening.

6.5 Habituation and Sensory adaptation

From previous lessons it was learned that the lower centers of the brain filters the sensory stimulation and “ignore” or prevent conscious attention to stimuli that do not change. The brain is only interested in changes in information. That’s why people don’t really “hear” the noise of the air conditioner unless it suddenly cuts off or the noise made in some classrooms unless it gets very quiet. Although they actually are hearing it, they aren’t paying attention to it. This is called habituation, and it is the way the brain deals with unchanging information from the environment.

Sometimes the odor of the garbage can be felt in the kitchen when you first come home, but after a while the smell seems to go away. Though it is similar to habituation, this is called sensory adaptation. Sensory adaptation is another process by which constant, unchanging information from the sensory receptors is effectively ignored.

In habituation, the sensory receptors are still responding to stimulation but the lower centers of the brain are not sending the signals from those receptors to the cortex. The process of sensory adaptation differs because the receptor cells themselves become less responsive to an unchanging stimulus—garbage odors included—and the receptors no longer send signals to the brain. For example, when we eat, the food that we put in our mouth tastes strong at first, but as we keep eating the same thing, the taste does fade somewhat.

Smell, taste, and touch are all subject to sensory adaptation. You might think, then, that if you stare at something long enough, it would also disappear, but the eyes are a little different. Even though the sensory receptors in the back of the eyes adapt to and become less responsive to a constant visual stimulus, under ordinary circumstances the eyes are never entirely still. There's a constant movement of the eyes, tiny little vibrations called "micro saccades" or "saccadic movements" that people don't consciously notice. These movements keep the eyes from adapting to what they see.

6.6 The Structure of the Eye

The surface of the eye is covered in a clear membrane called the cornea. The cornea not only protects the eye but also is the structure that focuses most of the light coming into the eye. The cornea has a fixed curvature, like a camera that has no option to adjust the focus. The next visual layer is a clear, watery fluid called the aqueous humor. This fluid is continually replenished and supplies nourishment to the eye.

The light from the visual image then enters the interior of the eye through a hole, called the pupil, in a round muscle called the iris (the colored part of the eye). The iris can change the size of the pupil, letting more or less light into the eye. That also helps focus the image; people try to do the same thing by squinting. Behind the iris, suspended by muscles, is another clear structure called the lens. After the lens, there is a large, open space filled with a clear, jelly-like fluid called the vitreous humor. This fluid, like the aqueous humor, also nourishes the eye and gives it shape.

6.6.1 Retina, rods, cones and blind spot

The final stop for light within the eye is the retina, a light sensitive area at the back of the eye containing three layers: ganglion cells, bipolar cells, and the rods and cones, special cells (photoreceptors) that respond to the various light waves. There is a "hole" in the retina—the place where all the axons of those ganglion cells leave the retina to become the optic nerve. There are no rods or cones here, so this is referred to as the blind spot.

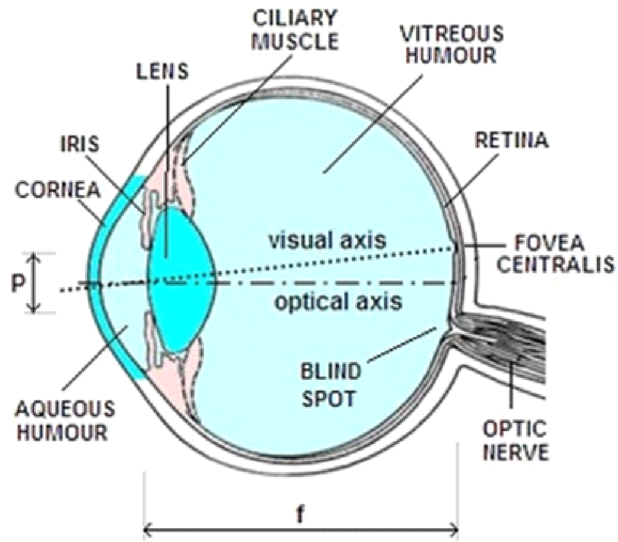


Figure 6.2

6.7 The Structure of the Ear

The properties of sound are indeed similar to those of light, as both senses rely on waves. But the similarity ends there, as the physical properties of sound are different from those of light. The ear is a series of structures, each of which plays a part in the sense of hearing.

6.7.1 The Outer Ear

The pinna is the visible, external part of the ear that serves as a kind of concentrator, funnelling the sound waves from the outside into the structure of the ear. The pinna is also the entrance to the auditory canal (or ear canal), the short tunnel that runs down to the tympanic membrane, or eardrum. When sound waves hit the eardrum, they cause three tiny bones in the middle ear to vibrate.

6.7.2 The Middle Ear

The three tiny bones in the middle ear are known as the hammer (malleus), anvil (incus), and stirrup (stapes), each name stemming from the shape of the respective bone. The vibration of these three bones amplifies the vibrations from the eardrum. The stirrup, the last bone in the chain, causes a membrane covering the opening of the inner ear to vibrate.

6.7.3 The Inner Ear

This membrane is called the oval window, and its vibrations set off another chain reaction within the inner ear.

6.7.3.1 Cochlea

The inner ear is a snail-shaped structure called the cochlea, which is filled with fluid. When the oval window vibrates, it causes the fluid in the cochlea to vibrate. This fluid surrounds a membrane running through the middle of the cochlea called the basilar membrane.

6.7.3.2 Basilar Membrane and the Organ of Corti

The basilar membrane is the resting place of the organ of Corti, which contains the receptor cells for the sense of hearing. When the basilar membrane vibrates, it vibrates the organ of Corti, causing it to brush against a membrane above it. On the organ of Corti are special cells called hair cells, which are the receptors for sound. When these auditory receptors or hair cells are bent up against the other membrane, it causes them to send a neural message through the auditory nerve and into the brain, where the auditory cortex will interpret the sounds (the transformation of the vibrations of sound into neural messages is transduction). The louder the sound in the outside world, the stronger the vibrations that stimulate more of those hair cells—which the brain interprets as loudness.

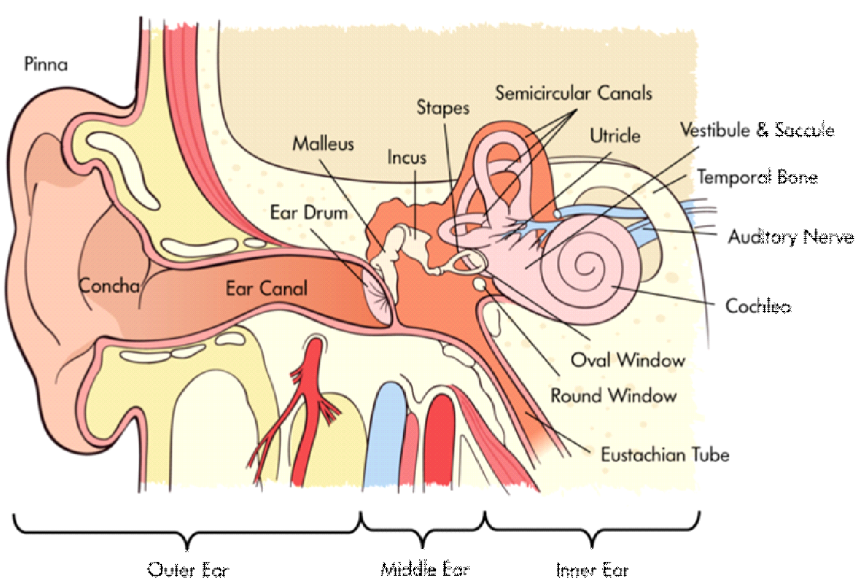


Figure 6.3

6.8 Chemical Senses

The sense of taste (taste in food, not taste in clothing or friends) and the sense of smell are very closely related. Have you ever noticed that when your nose is all stopped up, your sense of taste is affected, too? That's because the sense of taste is really a combination of taste and smell. Without the input from the nose, there are actually only four, and possibly five, kinds of taste sensors in the mouth.

6.8.1 Gustation

Taste buds are the common name for the taste receptor cells, special kinds of neurons found in the mouth that are responsible for the sense of taste, or gustation. Most taste buds are located on the tongue, but there are a few on the roof of the mouth, the cheeks, and under the tongue as well. The sensitivity for various tastes in people depends on how many taste buds they have; some people have only around 500, whereas others have 20 times that number. The latter are called "supertasters" and need far less seasoning in their food than those with fewer taste buds. The little bumps seen on the tongue are called papillae, and the taste buds line the walls of these papillae.

Each taste bud has about 20 receptors that are very similar to the receptor sites on receiving neurons at the synapse. In fact, the receptors on taste buds work exactly like receptor sites on neurons—they receive molecules of various substances that fit into the receptor like a key into a lock. Taste is often called a chemical sense because it works with the molecules of foods people eat in the same way the neural receptors work with neurotransmitters. When the molecules (dissolved in saliva) fit into the receptors, a signal is fired to the brain, which then interprets the taste sensation.

In general, the taste receptors has such a workout that they have to be replaced every 10 to 14 days. And when the tongue is burned, the damaged cells no longer work. As time goes on, those cells get replaced and the taste sense comes back.

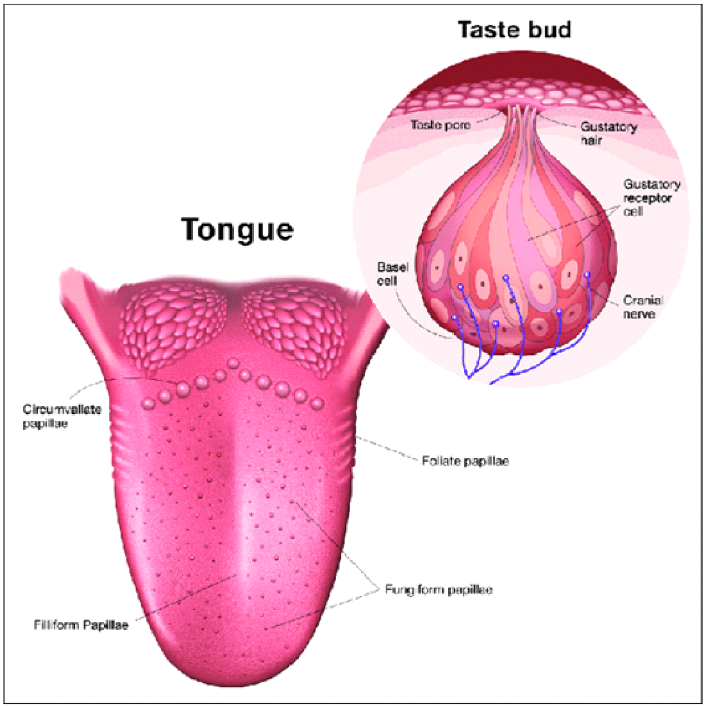


Figure 6.4

6.8.2 The Five Basic Tastes

In 1916 a German psychologist named Hans Henning proposed that there are four primary tastes: sweet, sour, salty, and bitter. Lindemann (1996) supported the idea that there is a fifth kind of taste receptor that detects a pleasant "brothy" taste associated with foods like chicken soup, tuna, kelp, cheese, and soy products, among others. Lindemann proposed that this fifth taste be called umami, a Japanese word first coined in 1908 to describe the taste. Dr. Ikeda identified that glutamate is the substance which helps in the sensation of umami. Glutamate is present in human breast milk and is the reason that the seasoning MSG—monosodium glutamate—adds a pleasant flavor to foods.

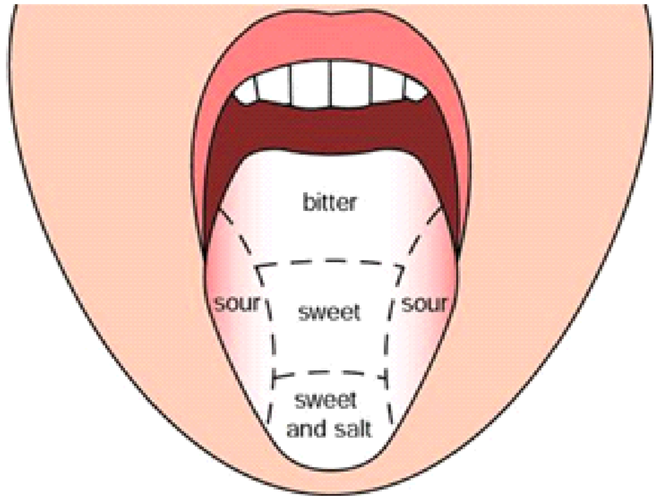


Figure 6.5

The five taste sensations work together, along with the sense of smell and the texture, temperature, and “heat” of foods, to produce thousands of taste sensations. Although researchers used to believe that certain tastes were located on certain places on the tongue (Figure 6.5), it is now known that all of the taste sensations are processed all over the tongue. Just as individuals and groups can vary on their food preferences, they can also vary on level of perceived sweetness. For example, obese individuals have been found to experience less sweetness than individuals who are not obese; foods that are both sweet and high in fat tend to be especially attractive to individuals who are obese.

6.9 The Sense of Scents: Olfaction

Like the sense of taste, the sense of smell is a chemical sense. The ability to smell odors is called olfaction, or the olfactory sense. The outer part of the nose serves the same purpose for odors that the pinna and ear canal serve for sounds: Both are merely ways to collect the sensory information and get it to the part of the body that will translate it into neural signals.

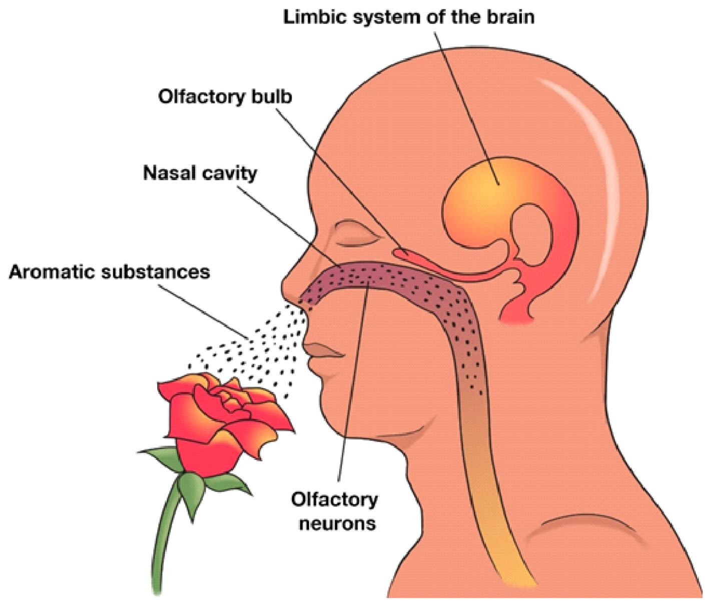


Figure 6.6

The part of the olfactory system that transduces odors—turns odors into signals the brain can understand—is located at the top of the nasal passages. This area of olfactory receptor cells is only about an inch square in each cavity yet contains about 10 million olfactory receptors.

6.9.1 Olfactory Receptor Cells

The olfactory receptor cells each have about a half dozen to a dozen little “hairs,” called cilia, that project into the cavity. Like taste buds, there are receptor sites on these hair cells that send signals to the brain when stimulated by the molecules of substances that are in the air moving past them. When a person is sniffing something, the sniffing serves to move molecules of whatever the person is trying to smell into the nose and into the nasal cavities.

Olfactory receptors are like taste buds in another way, too. Olfactory receptors also have to be replaced as they naturally die off, about every 5 to 8 weeks. Unlike the taste buds, there are way more than five types of olfactory receptors—in fact, there are at least 1,000 of them. Signals from the olfactory receptors in the nasal cavity do not follow the same path as the signals from all the other senses. Vision, hearing, taste, and touch all pass through the thalamus and then on to the area of the cortex that processes that particular sensory information. But the sense of smell has its own special place in the brain—the olfactory bulbs, which are actually part of the brain.

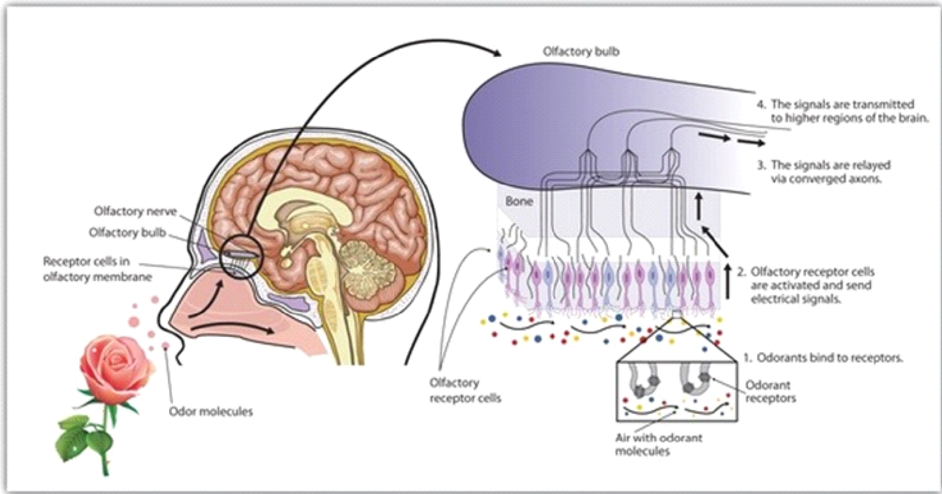


Figure 6.7

6.10 Somesthetic Senses

The sense of touch is really several sensations, originating in several different places in—and on—the body. It's really more accurate to refer to these as the body senses, or somesthetic senses. The first part of that word, soma, means "body,". The second part, esthetic, means "feeling," hence, the name. There are three somesthetic sense systems, the skin senses (having to do with touch, pressure, temperature, and pain), the kinesthetic sense (having to do with the location of body parts in relation to each other), and the vestibular senses (having to do with movement and body position).

6.10 Conclusion

The sense-organs were the necessary material basis of perception. The classic five senses are sight, smell, hearing, taste, and touch. The organs that do these things are the eyes, nose, ears, tongue, and skin. The sense organs -eyes, ears, tongue, skin, and nose - help to protect the body. The human sense organs contain receptors that relay information through sensory neurons to the appropriate places within the nervous system. Each sense organ contains different receptors.

6.11 SUMMARY

Sensation is the activation of receptors located in the eyes, ears, skin, nasal cavities, and tongue. Sensory receptors are specialized forms of neurons that are activated by different stimuli such as light and sound. A just noticeable difference is the point at which a stimulus is detectable half the time it is present. Weber's law of just noticeable differences states that the just noticeable difference between two stimuli is always a constant. Absolute thresholds are the smallest amount of energy needed for conscious detection of a stimulus at least half the time it is present. Subliminal stimuli are stimuli presented just below the level of conscious awareness. Habituation occurs when the brain ignores a constant stimulus. Sensory adaptation occurs when the sensory receptors stop responding to a constant stimulus.

Light enters the eye and is focused through the cornea, passes through the aqueous humor, and then through the hole in the iris muscle called the pupil. The lens also focuses the light on the retina, where it passes through ganglion and bipolar cells to stimulate the rods and cones. Sound has three aspects: pitch (frequency), loudness, and timbre (purity). Sound enters the ear through the visible outer structure, or pinna, and travels to the eardrum and then to the small bones of the middle ear. The bone called the stirrup rests on the oval window, causing the cochlea and basilar membrane to vibrate with sound.. The organ of Corti on the basilar membrane contains the auditory receptors, which send signals to the brain about sound qualities as they vibrate. Gustation is the sense of taste. Taste buds in the tongue receive molecules of substances, which fit into receptor sites. The five basic types of taste are sweet, sour, salty, bitter, and umami (brothy). Olfaction is the sense of smell. The olfactory receptors in the upper part of the nasal passages receive molecules of substances and create neural signals that then go to the olfactory bulbs under the frontal lobes.

6.12 KEY WORDS:

::Absolute threshold

The lowest level of stimulation that a person can consciously detect 50 percent of the time the stimulation is present.

::Blind spot

Area in the retina where the axons of the three layers of retinal cells exit the eye to form the optic nerve, insensitive to light.

::Cones

Visual sensory receptors found at the back of the retina, responsible for color vision and sharpness of vision.

::Gustation

The sensation of a taste

::Habituation

Tendency of the brain to stop attending to constant, unchanging information.

::Just noticeable difference (jnd or the difference threshold)

The smallest difference between two stimuli that is detectable 50 percent of the time.

::Kinesthetic sense

Sense of the location of body parts in relation to the ground and each other.

::Olfaction (olfactory sense)

The sensation of smell.

::Olfactory bulbs

Areas of the brain located just above the sinus cavity and just below the frontal lobes that receive information from the olfactory receptor cells.

::Rods

Visual sensory receptors found at the back of the retina, responsible for noncolor sensitivity to low levels of light

::Sensation

The process that occurs when special receptors in the sense organs are activated, allowing various forms of outside stimuli to become neural signals in the brain.

::Sensory adaptation

Tendency of sensory receptor cells to become less responsive to a stimulus that is unchanging.

::Skin senses

The sensations of touch, pressure, temperature, and pain

::Somesthetic senses

The body senses consisting of the skin senses, the kinesthetic sense, and the vestibular senses.

::Vestibular senses

The sensations of movement, balance, and body position.

::Visual accommodation

The change in the thickness of the lens as the eye focuses on objects that are far away or close.

6.13 CHECK YOUR PROGRESS

1. You find that you have to add 1 teaspoon of sugar to a cup of coffee that already has 5 teaspoons of sugar in it to notice the difference in sweetness. If you have a cup of coffee with 10 teaspoons of sugar in it, how many teaspoons would you have to add to notice the difference in sweetness at least half the time?

   a. 1

   b. 2

   c. 4

   d. 5

2. The process by which the brain stops attending to constant, unchanging information is called:

   a. adaptation

   b. sensation

   c. habituation

   d. accommodation

3. The thin membrane stretched over the opening to the inner ear is the __________.
   a. pinna
   b. oval window
   c. tympanic membrane
   d. cochlea

4. The sense of taste is closely related to the sense of __________.
   a. sight
   b. hearing
   c. smell
   d. touch

5. The "bumps" on the tongue that are visible to the eye are the __________.
   a. taste buds
   b. papillae
   c. taste receptors
   d. olfactory receptors.

6. Which of the following statements about olfactory receptors is TRUE?
   a. Olfactory receptors are replaced every 5 to 8 weeks.
   b. There are fewer than 50 types of olfactory receptors.
   c. Signals from the receptors go through the brain stem and then to the cortex.
   d. Olfactory receptors respond to pressure.

6.14 ANSWERS TO CHECK YOUR PROGRESS:

1. b
2. a
3. c
4. c

5. a
6. a

6.15 MODEL QUESTIONS:

1. Why are some sensations ignored?
2. Explain the different sensory modalities.
3. Brief out the structure of different sense organs.

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LESSON – 7

PROCESS OF SENSATION- VISUAL AND AUDITORY

INTRODUCTION

Information about the world has to have a way to get into the brain, where it can be used to determine actions and responses. The way into the brain is through the sensory organs and the process of sensation. The following section gives a brief history of how scientists have tried to “shed light” on the mystery of light and sound.

LEARNING OBJECTIVES

At the end of this unit you will be able to understand

- the general process by which sensation occurs in any sense modality
- the role of sensory receptors in sensory transduction.
- the physical basis of our sense of vision, and the significance of the amplitude, brightness and saturation of a light.
- the main properties of sound waves, explaining how they affect perceived pitch and loudness.

PLAN OF THE LESSON

7.1 Perceptual properties of light

7.2 Visual processing

7.3 Perception of color: Theories of color vision

7.4 Color blindness

7.5 The hearing sense: Perception of sound

7.6 Perceiving pitch

7.7 Types of hearing impairments

7.8 Conclusion

7.9 Summary

7.10 Key words

7.1 Perceptual properties of light

It was Albert Einstein who first proposed that light is actually tiny "packets" of waves. These "wave packets" are called photons and have specific wavelengths associated with them. When people experience the physical properties of light, they are not really aware of its dual, wavelike and particle-like, nature. With regard to its psychological properties, there are three aspects to our perception of light: brightness, color, and saturation.

Brightness is determined by the amplitude of the wave—how high or how low the wave actually is. The higher the wave, the brighter the light appears to be. Low waves are dimmer.

Color, or hue, is largely determined by the length of the wave. Long wavelengths (measured in nanometres) are found at the red end of the visible spectrum (the portion of the whole spectrum of light that is visible to the human eye), whereas shorter wavelengths are found at the blue end.

7.2 Visual Processing

Light entering the eyes can be separated into the left and right visual fields. Light from the right visual field falls on the left side of each eye's retina; light from the left visual field falls on the right side of each retina. Light travels in a straight line through the cornea and lens; resulting in the image projected on the retina actually being upside down and reversed from left to right as compared to the visual fields.

The areas of the retina can be divided into halves, with the halves toward the temples of the head referred to as the temporal retinas and the halves toward the center, or nose, called the nasalretinas. The information from the left visual field (falling on the right side of each retina) goes directly to the right visual cortex, while the information from the right visual field (falling on the left side of each retina) goes directly to the left visual cortex .This is because the axons from the temporal halves of each retina project to the visual cortex on the same side of the brain while the axons from the nasal halves cross over to the visual cortex on the opposite side of the brain. The optic chiasm is the point of crossover.

The photoreceptors in the retina, the rods and cones are responsible for different aspects of vision. The rods (about 120 million of them in each eye) are found all over the retina except in the very centre, which contains only cones. Rods are sensitive to changes in brightness but not to changes in wavelength, so they see only in black and white and shades of grey. They can be very sensitive because many rods are connected to a single bipolar cell, so that if even only one rod is stimulated by a photon of light, the brain perceives the whole area of those rods as stimulated (because the brain is receiving the message from the single bipolar cell). But because the brain doesn't know exactly what part of the area (which rod) is actually sending the message, the visual acuity (sharpness) is quite low. That's why things seen in low levels of light, such as twilight or a dimly lit room, are fuzzy and greyish. Because rods are located on the periphery of the retina, they are also responsible for peripheral vision. Because rods work well in low levels of light, they are also the cells that allow theeyes to adapt to low light.

Dark adaptation occurs as the eye recovers its ability to see when going from a brightly lit state to a dark state. (The light-sensitive pigments that allow us to see are able to regenerate or "recharge" in the dark.) The brighter the light was, the longer it takes the rods to adapt to the new lower levels of light (Bartlett, 1965). This is why the bright headlights of an oncoming car can leave a person less able to see for a while after that car has passed. Fortunately, this is usually a temporary condition because the bright light was on so briefly and the rods readapt to the dark night relatively quickly.

Full dark adaptation, which occurs when going from more constant light to darkness such as turning out one's bedroom lights, takes about 30 minutes. As people get older this process takes longer, causing many older persons to be less able to see at night and in darkened rooms. This age-related change can cause night blindness, in which a person has difficulty seeing well enough to drive at night or get around in a darkened room or house.

Some research indicates that taking supplements such as vitamin A can reverse or relieve this symptom in some cases. When going from a darkened room to one that is brightly lit, the opposite process occurs. The cones have to adapt to the increased level of light, and they accomplish this light adaptation much more quickly than the rods adapt to darkness—it takes a few seconds at most. There are 6 million cones in each eye; of these, 50,000have a private line to the optic nerve (one bipolar cell for each cone). This means that the cones are the receptors for visual acuity. Cones are located all over the retina but are more concentrated at its very centre where there are no rods (the area called the fovea).

Cones also need a lot more light to function than the rods do, so cones work best in bright light, which is also when people see things most clearly. Cones are also sensitive to different wavelengths of light, so they are responsible for color vision.

7.3 Perception of color: Theories of color vision

Two theories of colors were originally proposed in the 1800s. The first is called the trichromatic ("three colors") theory. This theory was first proposed by Thomas Young in 1802 and later modified by Hermann vonHelmholtz in 1852.This theory proposed three types of cones: red cones, blue cones, and green cones, one for each of the three primary colors of light. Most people probably think that the primary colors are red, yellow, and blue, but these are the primary colors when talking about painting—not when talking about light.

In the trichromatic theory, different shades of colors correspond to different amounts of light received by each of these three types of cones. These cones then fire their message to the brain's vision centres. It is the combination of cones and the rate at which they are firing that determine the color that will be seen. For example, if the red and green cones are firing in response to a stimulus at fast enough rates, the color the person sees is yellow. If the red and blue cones are firing fast enough, the result is magenta. If the blue and green cones are firing fast enough, a kind of cyan color (blue-green) appears.

Brown and Wald (1964) identified three types of cones in the retina, each sensitive to a range of wavelengths, measured in nanometres (nm), and a peak sensitivity that roughly corresponds to three different colors (although hues/colors can vary depending on brightness and saturation). The peak wavelength of light the cones seem to be most sensitive to turns out to be just a little different from Young and von Helmholtz's original three corresponding colors: Short wavelength cones detect what we see as blue-violet (about 420 nm), medium wavelength cones detect what we see as green (about 530 nm), and long wavelength cones detect what we see as green-yellow (about 560 nm). Interestingly, none of the cones identified by Brown and Wald have a peak sensitivity to light where most of us see red (around 630 nm).

This indicates that, each cone responds to light across a range of wavelengths, and not just its wavelength of peak sensitivity. Depending on the intensity of the light, both the medium and long wavelength cones respond to light that appears red.

7.3.1 The after image

The trichromatic theory seem to be more than adequate to explain how people perceive color. But there's an interesting phenomenon that this theory cannot explain. If a person stares at a picture of the American flag for a little while—say, a minute—and then looks away to a blank white wall or sheet of paper, that person will see an afterimage of the flag.

Afterimages occur when a visual sensation persists for a brief time even after the original stimulus is removed. The phenomenon of the color afterimage is explained by the second theory of color perception, called the opponent-process theory (De Valois & De Valois, 1993;Hurvich& Jameson, 1957), based on an idea first suggested by Edwald Hering in1874 (Finger, 1994). In opponent-process theory, there are four primary colors: red, green, blue, and yellow. The colors are arranged in pairs, red with green and blue with yellow. If one member of a pair is strongly stimulated, the other member is inhibited and cannot be working—so there are no reddish-greens or bluish-yellows. So how can this kind of pairing cause a color afterimage? From the level of the bipolar and ganglion cells in the retina, all the way through the thalamus, and on to the visual cortical areas in the brain, some neurons (or groups of neurons) are stimulated by light from one part of the visual spectrum and inhibited by light from a different part of the spectrum. For example, let's say we have a red-green ganglion cell in the retina whose baseline activity is rather weak when we expose it to white light. However, the cell's activity is increased by red light, so we experience the color red. If we stimulate the cell with red light for a long enough period of time, the cell becomes fatigued. If we then swap out the red light with white light, the now-tired cell responds even less than the original baseline. Now we experience the color green, because green is associated with a decrease in the responsiveness of this cell.

Both theories play a part in color vision. Trichromatic theory can explain what is happening with the raw stimuli, the actual detection of various wavelengths of light. Opponent-process theory can explain after images and other aspects of visual perception that occur after the initial detection of light from our environment.

In addition to the retinal bipolar and ganglion cells, opponent-process cells are contained inside the thalamus in an area called the lateral geniculate nucleus (LGN). The LGN is part of the pathway that visual information takes to the occipital lobe. It is when the cones in the retina send signals through the retinal bipolar and ganglion cells that we see the red versus green pairings and blue versus yellow pairings. Together with the retinal cells, the cells in the LGN appear to be the ones responsible for opponent-processing of color vision and the afterimage effect.

7.4 Color blindness

There are two kinds of color blindness, when you can't tell red from green and when you can't tell blue from yellow. From the mention of red-green and yellow-blue color blindness, one might think that the opponent-process theory explains this problem. But in reality "color blindness" is caused by defective cones in the retina of the eye and as a more general term, color-deficient vision is more accurate, as most people with "color blindness" have two type of cones working and can see many colors.

There are really three kinds of color-deficient vision. In a very rare type, monochrome color blindness, people either have no cones or have cones that are not working at all. Essentially, if they have cones, they only have one type and, therefore, everything looks the same to the brain—shades of grey. The other types of color-deficient vision, or dichromatic vision, are caused by the same kind of problem—having one cone that does not work properly. Protanopia (red-green color deficiency) is due to the lack of functioning red cones and deuteranopia (another type of red-green color deficiency) results from the lack of functioning green cones. In both of these, the individual confuses reds and greens, seeing the world primarily in blues, yellows, and shades of gray. A lack of functioning blue cones is much less common and called tritanopia (blue-yellow color deficiency). These individuals see the world primarily in reds, greens, and shades of gray.

Color-deficient vision involving one set of cones is inherited in a pattern known assex-linked inheritance. The gene for color-deficient vision is recessive. To inherit a recessive trait, you normally need two of the genes, one from each parent. But the gene for color-deficient vision is attached to a particular chromosome (a package of genes) that helps to determine the sexof a person. Men have one X chromosome and one smaller Y chromosome (named for their shapes), whereas women have two X chromosomes. The smaller Y has fewer genes than the larger X, and one of the genes missing is the one that would suppress the gene for color-deficient vision. For a woman to have color-deficient vision, she must inherit two recessive genes, one from each parent, but a man only needs to inherit one recessive gene—the one passed on to him on his mother's X chromosome. His odds are greater; therefore, more males than females have color-deficient vision.

7.5 The hearing sense: Perception of sound

The properties of sound are indeed similar to those of light, as both senses rely on waves. But the similarity ends there, as the physical properties of sound are different from those of light.

Sound waves do not come in little packets the way light comes in photons. Sound waves are simply the vibrations of the molecules of air that surround us. Sound waves do have the same properties of light waves though—wavelength, amplitude, and purity. Wavelengths are interpreted by the brain as the frequency or pitch (high, medium, or low). Amplitude is interpreted as volume, how soft or loud a sound is. Finally, what would correspond to saturation or purity in light is called timbre in sound, a richness in the tone of the sound. And just as people rarely see pure colors in the world around us, they also seldom hear pure sounds. Just as a person's vision is limited by the visible spectrum of light, a person is also limited in the range of frequencies he or she can hear. Frequency is measured in cycles (waves) per second, or hertz (Hz). Human limits are between 20 and 20,000 Hz, with the most sensitivity from about 2000 to 4000 Hz, very important for conversational speech.

7.6 Perceiving pitch

Pitch refers to how high or low a sound is. For example, the bass tones in the music pounding through the wall of your apartment from the neighbors next door is a low pitch, whereas the scream of a 2-year-old child is a very high pitch. There are three primary theories about how the brain receives information about pitch. They are the place theory, the frequency Theory and Volley principle. The oldest of the three theories is the place theory.

7.6.1 Place Theory

It is based on an idea proposed in 1863by Hermann von Helmholtz and elaborated on and modified by Georg von Békésy in 1928. In this theory, the pitch a person hears depends on where the hair cells that are stimulated are located on the organ of Corti. For example, if the person is hearing a high-pitched sound, all of the hair cells near the oval window will be stimulated, but if the sound is low pitched, all of the hair cells that are stimulated will be located farther away on the organ of Corti.

7.6.2 Frequency theory

Frequency theory, developed by Ernest Rutherford in 1886, states that pitch is related to how fast the basilar membrane vibrates. The faster this membrane vibrates, the higher the pitch; the slower it vibrates, the lower the pitch. (In this theory, all of the auditory neurons would be firing at the same time.)

Both the theories are right upto a point. For place-theory research to be accurate, the basilar membrane has to vibrate unevenly—which it does when the frequency of the sound is above 1000 Hz. For the frequency theory to be correct, the neurons associated with the hair cells would have to fire as fast as the basilar membrane vibrates. This only works up to 1000 Hz, because neurons don't appear to fire at exactly the same time and rate when frequencies are faster than 1000 times per second. The frequency theory works for low pitches, and place theory works for moderate to high pitches.

7.6.3 Volley Principle

There is a third theory, developed by Ernest Wever and Charles Bray, called the volley principle,which appears to account for pitches from about 400 Hz up to about 4000. In this explanation, groups of auditory neurons take turns firing in a process called volleying. If a person hears a tone of about 3000 Hz, it means that three groups of neurons have taken turns sending the message to the brain—the first group for the first 1000 Hz, the second group for the next 1000 Hz, and so on.

7.7 Types of hearing impairments

Hearing impairment is the term used to refer to difficulties in hearing. A person can be partially hearing impaired or totally hearing impaired, and the treatment for hearingloss will vary according to the reason for the impairment.

7.7.1 Conduction hearing impairment

Conduction hearing impairment means that sound vibrations cannot be passed from the eardrum to the cochlea. The cause might be a damaged eardrum or damage to the bones of the middle ear (usually from an infection). In this kind of impairment, hearing aids may be of some use in restoring hearing.

7.7.2 Nerve hearing impairment

In nerve hearing impairment, the problem lies either in the inner ear or in the auditory pathways and cortical areas of the brain. Normal aging causes loss of hair cells in the cochlea, and exposure to loud noises can damage hair cells. Tinnitus is a fancy word for an extremely annoying ringing in one' sears, and it can also be caused by infections or loud noises—including loud music in headphones, so you might want to turn down that music player! Because the damage is to the nerves or the brain, nerve hearing impairment cannot be helped with ordinary hearing aids, which are basically sound amplifiers.

A technique for restoring some hearing to those with nerve hearing impairment makes use of an electronic device called a cochlear implant. This device sends signals from a microphone worn behind the ear to a sound processor worn on the belt or in a pocket, which then translates those signals into electrical stimuli that are sent to a series of electrodes implanted directly into the cochlea, allowing transduction to take place and stimulating the auditory nerve. The brain then processes the electrode information as sound.

7.8 Conclusion

Knowledge of our internal and external world becomes possible with the help of senses. Vision and audition are the two most widely used senses. Rods and cones are the receptors for vision. Rods function in low intensities of light, whereas cones function at high intensities of light. They are responsible for achromatic and chromatic vision, respectively. Light and dark adaptations are two interesting phenomena of the visual system. Hue, saturation and brightness are the basic dimensions of colour. Sound serves as stimulus for auditory sensations. Loudness, pitch, and timbre are the properties of sound. Organ of corti located in the basilar membrane is the chief organ of hearing. Difficulties in hearing occurs when there is damage in middle ear or inner ear.

7.9 Summary

Brightness corresponds to the amplitude of light waves, whereas color corresponds to the length of the light waves. Rods detect changes in brightness but do not see color and function best in low levels of light. They do not respond to different colors and are found everywhere in the retina except the centre, or fovea. Cones are sensitive to colors and work best in bright light. They are responsible for the sharpness of visual information and are found in the fovea.

Trichromatic theory of color perception assumes three types of cones: red, green, and blue. All colors would be perceived as combinations of these three. Opponent-process theory of color perception assumes four primary colors of red, green, blue, and yellow. Colors are arranged in pairs, and when one member of a pair is activated, the other is not. Color blindness is a total lack of color perception whereas color-deficient vision refers to color perception that is limited primarily to yellows and blues or reds and greens only.

Sound has three aspects: pitch (frequency), loudness, and timbre (purity). Place theory states that the location of the hair cells on the organ of Corti correspond to different pitches of sound. This can explain pitch above 1000 Hz. Frequency theory states that the speed with which the basilar membrane vibrates corresponds to different pitches of sound. This can explain pitch below 1000 Hz. The volley principle states that neurons take turns firing for sounds above 400 Hz and below 4000 Hz. Conduction hearing impairment is caused by damage to the outer or middle ear structures, whereas nerve hearing impairment is caused by damage to the inner ear or auditory pathways in the brain.

7.10 Key words

:: After images

Images that occur when a visual sensation persists for a brief time even after the original stimulus is removed

::Dark adaptation

The recovery of the eye's sensitivity to visual stimuli in darkness after exposure to bright lights.

::Frequency theory

theory of pitch that states that pitch is related to the speed of vibrations in the basilar membrane.

::Hertz (Hz)

Cycles or waves per second, a measurement of frequency.

::Light adaptation

The recovery of the eye's sensitivity to visual stimuli in light after exposure to darkness.

::Opponent-process theory

Theory of color vision that proposes visual neurons (or groups of neurons) are stimulated by light of one color and inhibited by light of another color.

::Pitch

Psychological experience of sound that corresponds to the frequency of the sound waves; higher frequencies are perceived as higher pitches.

::Place theory

Theory of pitch that states that different pitches are experienced by the stimulation of hair cells in different locations on the organ of Corti.

::Trichromatic theory

Theory of color vision that proposes three types of cones: red, blue, and green

::Volley principle

Theory of pitch that states that frequencies from about 400 Hz to 4000 Hz cause the hair cells (auditory neurons) to fire in a volley pattern, or take turns in firing.

7.11 Check Your Progress:

1. Which of the following terms refers to the perceived effect of the amplitude of light waves?

   a. color

   b. brightness

   c. saturation

   d. hue

2. If you wanted to locate a dimly lit star better at night, what should you do?

   a. Look directly at it because the cones will focus better at night.

   b. Look off to the side, using the cones in the periphery of the retina.

   c. Look directly at it because the rods can see sharply at night.

   d. Look off to the side, using the rods in the periphery of the retina.

3. Which theory of color vision best accounts for after images?

   a. trichromatic theory

   b. opponent-process theory

   c. both a and b

   d. neither a nor b

4. Which statement about color-deficient vision is TRUE?

   a. There are more men with color-deficient vision than women.

   b. All people with color-deficient vision see only in black and white.

   c. Some people with color-deficient vision see only in blue.

   d. Some people with color-deficient vision see only in blue and red.

5. Which of the following properties of sound would be the most similar to the color or hue of light?

   a. pitch

   b. loudness

   c. purity

   d timbre

6. The ___________ theory best explains how we hear sounds above 4000 Hz.

   a. place

   b. frequency

   c. volley

   d. adaptive

7. If the bones of the middle ear begin to deteriorate, you will develop ___________ hearing impairment.

   a. nerve

   b. stimulation

c. brain pathway

d. conduction

7.12 Answers to check your progress

1. b
2. d
3. c
4. a
5. a
6. c
7. d

7.13 Model Questions:

1. Explain the processing of light.
2. What are the different theories of vision?
3. What is meant by light and dark adaptation? How do they take place?
4. What is colour vision and what are the dimensions of colour?
5. How does auditory sensation take place?

LESSON 8

SENSORY PROCESSES- CHEMICAL, GUSTATORY AND TACTUAL

INTRODUCTION

We have five senses, but only two that go beyond the boundaries of ourselves. Know what smell is? . . . It's made up of the molecules of what you're smelling. We will consider olfaction first and then taste. And also to act purposefully and gracefully, we need constant information about the position of our limbs and other body parts in relation to each other and to objects in the environment.

OBJECTIVES OF THE LESSON

At the end of this lesson you will be able to understand

- the process of chemical senses
- what are somesthetic senses
- the senses of touch, pressure and temperature
- the process of pain

PLAN OF THE LESSON

8.1 Chemical Senses - Smell and Taste

The physical stimulus for our sense of smell is gas. However, to be detected the gas must be soluble in liquid. Even the smell of a solid (such as your desk or your hand or any other nearby "solid" object) results from minute gaseous emissions from the object. Efforts to identify a small number of basic smells from which others might be composed haven't been successful. Three different theories of "basic" psychological smells agree only on putrid, burnt, and fruity (or musky). There is no universally accepted list of basic psychological smells. Whereas the receptors for smell react to substances in gaseous form, the receptors for taste react to substances in liquid form. It is easier to identify tastes than smells.

8.1.1 The Nose: Smell Receptor

The receptor site for the sense of smell is located on the roof of the nasal cavity. If a new smell in the environment is detected, the normal response is to "sniff." The differences in "sniffs" from one person to another make it very difficult to state definitely how much air has been swirled past the sensing surface. This, and the remote location of the olfactory epithelium, cause problems in studying the sense of smell.

If you hold your nose and breathe in gently through your mouth, even in a room where there is a pronounced odor, you will not detect it unless air spills into your nasal cavity from the rear. In addition, if you breathe normally and quietly through your nose, you will very quickly adapt to the smells in your environment.

8.2 Operation of the Chemical Senses

There are two aspects of the sense of smell that are remarkable. One is the extreme sensitivity of the sense. You can detect as little as 7 parts per 10 billion of some musky aromas. Second, the sense of smell is also remarkable for its ability to detect specific but very small differences in chemical structure. Any theory of smell must be able to account for both of these abilities.

One of the most successful explanations of smell has come to be known as the lock-and-key-theory. It proposes that the shape, not the chemical structure, of gaseous molecules is important in detecting different odors. Much work remains to determine how different-shaped molecules can influence the sense of smell.

Olfaction (smell) is extremely important in the lives of many species because it is often their primary window to the environment. One important contrast between humans and other species is that many animals are macrosmatic (having a keen sense of smell that is important to their survival), whereas humans are microsmatic (having a less keen sense of smell that is not crucial to their survival). Smell is also extremely important in sexual reproduction because it triggers mating behavior in many species.

Although olfaction may not be as central to our sensory experience as vision, hearing, or touch, some of its effects may be occurring without our awareness. But perhaps the most convincing argument for the importance of smell to humans comes from those who suffer from anosmia, the loss of the ability to smell as a result of injury or infection. People suffering from anosmia describe the great void created by their inability to taste many foods because of the close connection between smell and flavour. Olfaction is more important in our lives than most of us realize, and, although it may not be essential to our survival, life is often enhanced by our ability to smell and becomes a little more dangerous if we lose the olfactory warning system that alerts us to spoiled food, leaking gas, or smoke from a fire.

8.2.1 Detecting Odors

Our sense of smell enables us to detect extremely low concentrations of some odorants. The detection threshold for odors is the lowest concentration at which an odorant can be detected. It is notable that there is a very large range of thresholds. T-butyl mercepatan, the odorant that is added to natural gas, can be detected in very small concentrations of less than 1 part per billion in air. In contrast, to detect the vapors of acetone (the main component of nail polish remover), the concentration must be 15,000 parts per billion, and for the vapor of methanol, the concentration must be 141,000 parts per billion.

Another aspect of odor detection is the difference threshold—the smallest difference in the concentration of two odors that can be detected. Measurements of the difference threshold highlight one of the most important problems in olfactory research—the control of concentrations in stimulus presentations. For example, when William Cain (1977) carefully measured the difference threshold by placing two odorants of different concentrations on absorbent cotton balls and asked participants to judge which was more intense, he found that the difference threshold averaged 19 percent. However, when Cain analysed the stimuli he had presented on the cotton balls, he found that stimuli that were supposed to have the same concentration actually varied considerably. This variation was apparently caused by differences in the airflow pattern through the cotton in different samples. To deal with this problem, Cain remeasured the difference threshold using a device called an olfactometer, which presents olfactory stimuli with much greater precision than cotton balls. Using this more precise method of presenting of stimulus, Cain found that the threshold dropped to 11 percent.

8.2.2 Identifying Odors

When odorant concentrations are near threshold, so a person can just detect the presence of an odor, the person usually cannot sense the quality of the odor—whether it is “floral” or “pepper minty” or “rancid.” The concentration of an odorant has to be increased by as much as a factor of 3 above the threshold concentration before the person can recognize an odor’s quality. The concentration at which quality can be recognized is called the recognition threshold. One of the more intriguing facts about odors is that even though humans can discriminate between as many as 100,000 different odors (Firestein, 2001), they often find it difficult to accurately identify specific odors. For example, when people are presented with the odors of familiar substances such as mint, bananas, and motor oil, they can easily tell the difference between them. However, when they are asked to identify the substance associated with the odor, they are successful only about half the time.

One of the amazing things about odor identification is that knowing the correct label for the odor actually seems to transform our perception into that odor. Cain (1980) gives the example of an object initially identified as “fishy goaty oily.” When the experimenter told the person that the fishy-goat y-oily smell actually came from leather, the smell was then transformed into that of leather.

8.2.3 The Olfactory Mucosa

Part of the olfactory mucosa (OM) is a dime-sized region located high in the nasal cavity that contains the receptors for smell. The mucosa is located on the roof of the nasal cavity and just below the olfactory bulb. Odorant molecules are carried into the nose in an air stream, which brings these molecules into contact with the mucosa.

8.2.4 Olfactory Receptor Neurons

Just as the rod and cone receptors in the retina contain molecules called visual pigments that are sensitive to light, olfactory receptor neurons (ORNs) in the mucosa are dotted with molecules called olfactory receptors that are sensitive to chemical odorants. Other parallels between visual pigments and olfactory receptors are that they are both proteins that cross the membrane of the receptor neurons (rods and cones for vision; ORNs for olfaction) seven times, and they are both sensitive to a specific range of stimuli. Each type of visual pigment is sensitive to a band of wavelengths in a particular region of the visible spectrum, and each type of olfactory receptor is sensitive to a narrow range of odorants.

An important difference between the visual system and the olfactory system is that while there are only four different types of visual pigments (one rod pigment and three cone pigments), there are 350 different types of olfactory receptors, each sensitive to a particular group of odorants. The large number of olfactory receptors is important because it is one reason we can identify 100,000 or more different odors, but this large number of receptor types increases the challenges in understanding how olfaction works. One thing that makes things slightly simpler is another parallel with vision: Just as a particular rod or cone receptor contains only one type of visual pigment, a particular olfactory receptor neuron (ORN) contains only one type of olfactory receptor.

8.2.5 Activation of the Olfactory Bulb

Activation of receptors in the mucosa causes electrical signals in the ORNs that are distributed across the mucosa. These ORNs send signals to structures called glomeruli in the olfactory bulb. All of the 10,000 ORNs of a particular type send their signals to just one or two glomeruli. Each glomerulus therefore collects information about the firing of a particular type of ORN. The functional group associated with a particular type of compound (COOH for the acids; OH for the alcohols) determines the general area of the olfactory bulb that is activated, and the compound's chain length determines the position within each area.

8.2.6 The Biology of Olfaction

Biologically, the sense of smell, or olfaction, begins with chemical events in the nose. There, odors (in the form of airborne chemical molecules) interact with receptor proteins associated with specialized nerve cells. These cells, incidentally, are the body's only nerve cells that come in direct contact with the outside environment. Through the receptors they reach olfactory bulb.

From there, our sensations of smell are passed on to many other parts of the brain. Unlike all the other senses, smell signals are not relayed through the thalamus, suggesting that smell has very ancient evolutionary roots.

8.2.7 The Psychology of Smell

Olfaction has an intimate connection with both emotion and memory. This may explain why the olfactory bulbs lie very close to, and communicate directly with, structures in the limbic system and temporal lobes that are associated with emotion and memory. Therefore, it is not surprising that both psychologists and writers have noticed that certain smells can evoke emotion-laden memories, sometimes of otherwise-forgotten events. If you think about it for a moment, you can probably recall a vivid memory “image” of the aroma associated with a favorite food—perhaps fresh bread or a spicy dish—from your childhood.

8.3 Gustation

We will now move from olfaction, which detects molecules that enter the nose in gaseous form, to taste, which detects molecules that enter the mouth in solid or liquid form, usually as components of the foods we eat.

8.4 Functions of Taste

The taste and smell are thought of as “gatekeepers” that help us determine which substances we should consume and which we should avoid. This is especially true for taste because we often use taste to choose which foods to eat and which to avoid. Taste accomplishes its gatekeeper function by the connection between taste quality and a substance’s effect. Thus, sweetness is often associated with compounds that have nutritive or caloric value and that are, therefore, important for sustaining life. Sweet compounds cause an automatic acceptance response and also trigger anticipatory metabolic responses that prepares the gastrointestinal system for processing these substances. Bitter compounds have the opposite effect—they trigger automatic rejection responses to help the organism avoid harmful substances. Examples of harmful substances that taste bitter are the poisons strychnine, arsenic, and cyanide.

Salty tastes often indicate the presence of sodium. When people are deprived of sodium or lose a great deal of sodium through sweating, they will often seek out foods that taste salty in order to replenish the salt their body needs. People can, however, learn to modify their responses to certain tastes, as when they develop a taste for foods they may have initially found unappealing.

8.4.1 Basic Taste Qualities

When dealing with the problem of describing taste quality, we are in a much better position than we were for olfaction. The sense of taste (taste in food, not taste in clothing or friends) and the sense of smell are very closely related. Have you ever noticed that when your nose is all stopped up, your sense of taste is affected, too? That's because the sense of taste is really a combination of taste and smell. Without the input from the nose, there are actually only four, and possibly five, kinds of taste sensors in the mouth: salty, sour, sweet, bitter, and umami (which has been described as meaty, brothy, or savory, and is often associated with the flavor-enhancing properties of MSG, monosodium glutamate).

Early research that supported the idea of basic tastes showed that people can describe most of their taste experiences on the basis of the four basic taste qualities (this research was done before umami became the fifth basic taste). In one study, Donald McBurney (1969) presented taste solutions to participants and asked them to make magnitude estimates of the intensity of each of the four taste qualities for each solution. He found that some substances have a predominant taste and that other substances result in combinations of the four tastes. For example, sodium chloride (salty), hydrochloric acid (sour), sucrose (sweet), and quinine (bitter) are compounds that come the closest to having only one of the four basic tastes, but the compound potassium chloride (KCl) has substantial salty and bitter components. Similarly, sodium nitrate (NaNO3) results in a taste consisting of a combination of salty, sour, and bitter. Results such of these have led most researchers to accept the idea of basic tastes.

8.5 Processing of taste

One of the central questions in taste research has been the identification of the physiological code for taste quality. The process of tasting begins with the tongue, when receptors are stimulated by taste stimuli. In fact, the receptors on taste buds work exactly like receptor sites on neurons—they receive molecules of various substances that fit into the receptor like a key into a lock. The surface of the tongue contains many ridges and valleys caused by the presence of structures called papillae, which fall into four categories:

(1) filiform papillae, which are shaped like cones and are found over the entire surface of the tongue, giving it its rough appearance;

(2) fungiform papillae, which are shaped like mushrooms and are found at the tip and sides of the tongue;

(3) foliate papillae, which are a series of folds along the back of the tongue on the sides; and

(4) circumvilliate papillae, which are shaped like flat mounds surrounded by a trench and are found at the back of the tongue.

All of the papillae except the filiform papillae contain taste buds, and the whole tongue contains about 10,000 taste buds. Because the filiform papillae contain no taste buds, stimulation of the central part of the tongue, which contains only these papillae, causes no taste sensations. However, stimulation of the back or perimeter of the tongue results in a broad range of taste sensations.

Each taste bud contains 50–100 taste cells, which have tips that protrude into the taste pore. Transduction occurs when chemicals contact receptor sites located on the tips of these taste cells. Electrical signals generated in the taste cells are transmitted from the tongue in a number of different nerves: (1) the chorda tympani nerve (from taste cells on the front and sides of the tongue); (2) the glossopharyngeal nerve (from the back of the tongue); (3) the vagus nerve (from the mouth and throat); and (4) the superficial petronasal nerve (from the soft palette—the top of the mouth).

The fibres from the tongue, mouth, and throat make connections in the brain stem in the nucleus of the solitary tract, and from there, signals travel to the thalamus and then to two areas in the frontal lobe—the insula and the frontal operculum cortex—that are partially hidden behind the temporal lobe. In addition, fibres serving the taste system also reach the orbitofrontal cortex (OFC), which also receives olfactory signals.

8.5.1 Developmental Changes in Taste

Infants have heightened taste sensitivity, which is why babies universally cringe at the bitter taste of lemon. This super sensitivity, however, decreases with age. As a result, many elderly people complain that food has los t its taste—which really means that they have lost much of their sensory ability to detect differences in the taste and smell of food. Compounding this effect, taste receptors can be easily damaged by alcohol, smoke, acids, or hot foods. Fortunately, we frequently replace our gustatory receptors—as we do our smell receptors.

Because of this constant renewal, the taste system boasts the most resistance to permanent damage of all our senses, and a total loss of taste is extremely rare.

8.5.2 Supertasters

Individuals of any age vary in their sensitivity to taste sensations, a function of the density of papillae on the tongue. Those with the most taste buds are supertasters who live in a “neon” taste world relative to the rest of us—which accounts for their distaste for certain foods, such as broccoli or “diet” drinks, in which they detect a disturbingly bitter flavor. Such differences also speak to the problem of whether different people sense the world in the same way.

Bartoshuk’s research suggests that, to the extent that the sense receptors exhibit some variation from one person to another, so does our sensory experience of the world. This variability is not so bizarre as to make one person’s sensation of sweet the same as another person’s sensation of sour. Rather, the variations observed involve simply the intensity of taste sensations, such as the bitter detected by supertasters.

Taste researchers have detected differences in taste preferences between supertasters and those with normal taste sensations. In particular, supertasters more often report disliking foods that they find too sweet or too fatty. Researchers have observed that super tasters, on the average, weigh less than their non super tasting counterparts.

8.6 Somesthetic Senses

So far, vision, hearing, taste, and smell senses are covered. That leaves touch. What is thought of as the sense of touch is really several sensations, originating in several different places in—and on—the body. These senses are referred as the body senses, or somesthetic senses. The first part of that word, soma, means “body,”. The second part, esthetic, means “feeling,” hence, the name. There are three somesthetic sense systems, the skin senses (having to do with touch, pressure, temperature, and pain), the kinesthetic sense (having to do with the location of body parts in relation to each other), and the vestibular senses (having to do with movement and body position).

8.7 Sense of touch, pressure and temperature

Skin is an organ. Its purposes include more than simply keeping bodily fluids in and germs out; skin also receives and transmits information from the outside world to the central nervous system (specifically, to the somatosensory cortex). Information about light touch, deeper pressure, hot, cold, and even pain is collected by special receptors in the skin's layers.

8.7.1 Types of receptors in the skin

There are about half a dozen different receptors in the layers of the skin. Some of them will respond to only one kind of sensation. For example, the Pacinian corpuscles are just beneath the skin and respond to changes in pressure. There are nerve endings that wrap around the ends of the hair follicles which are sensitive to both pain and touch. There are free nerve endings just beneath the uppermost layer of the skin that respond to changes in temperature and to pressure—and to pain. There are pain nerve fibres in the internal organs as well as receptors for pressure. There are actually different types of pain. There are receptors that detect pain (and pressure) in the organs, a type of pain called visceral pain.

Pain sensations in the skin, muscles, tendons, and joints are carried on large nerve fibres and are called somatic pain. Somatic pain is the body's warning system that something is being, or is about to be, damaged and tends to be sharp and fast. Another type of somatic pain is carried on small nerve fibres and is slower and more of a general ache. This somatic pain acts as a kind of reminder system, keeping people from further injury by reminding them that the body has already been damaged. For example, if you hit your thumb with a hammer, the immediate pain sensation is of the first kind—sharp, fast, and bright. But later the bruised tissue simply aches, letting you know to take it easy on that thumb.

People may not like pain, but its function as a warning system is vitally important. There are people who are born without the ability to feel pain, rare conditions called congenital analgesia and congenital insensitivity to pain with anhidrosis (CIPA). Children with these disorders cannot feel pain when they cut or scrape themselves, leading to an increased risk of infection when the cut goes untreated. They fear nothing—which can be a horrifying trial for the parents and teachers of such a child. These disorders affect the neural pathways that carry pain, heat, and cold sensations. (Those with CIPA have an additional disruption in the body's heat–cold sensing perspiration system [anhidrosis], so that the person is unable to cool off the body by sweating.)

A condition called phantom limb pain occurs when a person who has had an arm or leg removed sometimes "feels" pain in the missing limb. As many as 50 to 80 percent of people who have had amputations experience various sensations: burning, shooting pains, or pins-and-needles sensations where the amputated limb used to be. Once believed to be a psychological problem, some now believe that it is caused by the traumatic injury to the nerves during amputation.

8.8 Processing of Pain

If you have severe pain, nothing else matters. A wound or a toothache can dominate all other sensations. Yet, pain is also part of your body's adaptive mechanism that makes you respond to conditions that threaten damage to your body. Unlike other sensations, pain can arise from intense stimulation of various kinds, such as a very loud sound, heavy pressure, a pinprick, or an extremely bright light. But pain is not merely the result of stimulation. It is also affected by our moods and expectations.

8.8.1 Pain Receptors

In the skin, several types of specialized nerve cells, called nociceptors, sense painful stimuli and send their unpleasant messages to the central nervous system. Some nociceptors are most sensitive to heat, while others respond mainly to pressure, chemical trauma, or other tissue injury. There are even specialized nociceptors for the sensation of itching—itself a type of pain.

8.8.2 Pain in the Brain

Even though they may seem emanate from far-flung parts of the body, we actually feel painful sensations in the brain. There two distinct regions have primary roles in processing incoming pain messages. One, involving a pathway terminating in the parietal lobe, registers the location, intensity, and the sharpness or dullness of pain. The other, a group of structures deep in the frontal cortex and in the limbic system, registers just how unpleasant the painful sensation is. People with damage to this second region may notice a painful stimulus but report that it does not feel unpleasant.

8.8.3 Phantom Limbs

One intriguing puzzle about pain concerns the mysterious sensations often experienced by people who have lost an arm or leg—a condition known as a phantom limb. In such cases, the amputee feels sensations—sometimes quite painful ones—that seem to come from the missing body part. The phantom limb sensations do not originate in damaged nerves in the sensory pathways. Nor are they purely imaginary. Rather, they arise in the brain itself. It is the result of the brain generating sensation when none comes from the missing limb. The odd phenomenon of phantom limbs teaches that understanding pain requires understanding not only painful sensations but also mechanisms in the brain that both process and inhibit pain.

8.8.4 The Gate-Control Theory

No one has yet developed a theory that explains everything about pain, but Melzack and Wall's (1965, 1983) gate-control theory explains a lot. It explains why pain can sometimes be blocked or facilitated "top-down" by our mental state. The "gate" itself involves special interneurons that, when inhibited, "open" the pain pathway running up the spinal cord toward the brain, by releasing a substance called P. Closing the gate interferes with the transmission of pain messages in the spinal pathway.

Messages from non pain nerve fibres, such as those involved in touch, can inhibit pain transmission. This explains why you vigorously shake your hand when you hit your finger with a hammer. Just as important, messages from the brain can also close the gate. This is how opiate drugs, such as morphine, work—by initiating a cascade of inhibitory messages that travel downward to block incoming pain messages. The gate on the pain pathway can also be opened and closed by top-down psychological processes, such as hypnosis or the distraction of important events.

8.8.5 Dealing with Pain

People with congenital insensitivity to pain do not feel what is hurting them, and their bodies often become scarred and their limbs deformed from injuries they could have avoided if their brains were able to warn them of danger. Because of their failure to notice and respond to tissue-damaging stimuli, these people tend to die young.

In general, pain serves as an essential defence signal: It warns us of potential harm, and it helps us to survive in hostile environments and to get treatment for sickness and injury. Sometimes, however, chronic pain seems to be a disease in itself, with neurons in the pain pathways becoming hypersensitive, amplifying normal sensory stimulation into pain messages. Research also suggests that chronic pain may, at least sometimes, arise from genes that get "turned on" in nerve-damaged tissue

8.8.6 Analgesics

Analgesic drugs, ranging from over-the-counter remedies such as aspirin and ibuprofen to prescription narcotics such as morphine, are widely used and effective. These act in a variety of ways. Morphine, suppresses pain messages in the spinal cord and the brain; aspirin interferes with a chemical signal produced by damaged tissue.

Those using pain-killing drugs should be aware of unwanted side effects, such as digestive tract or liver damage and even addiction. But studies have shown that if you must use narcotics to control severe pain, the possibility of your becoming addicted is far less than it would be if you were using narcotics recreationally.

8.8.7 Psychological Techniques for Pain Control

Many people can also learn to control pain by psychological techniques, such as hypnosis, relaxation, and thought-distraction procedures. For instance, a child receiving a shot at the doctor's office might be asked to take a series of deep breaths and look away. Pain can also be modified by placebos, mock drugs made to appear as real drugs. For example, a placebo may be an injection of mild saline solution (salt water) or a pill made of sugar.

Such fake drugs are routinely given to a control group in tests of new pain drugs. Their effectiveness, of course, involves the people's belief that they are getting real medicine. It is important to note, however, that the brain's response to a placebo is much the same as that of pain-relieving drugs: closing the spinal gate. Because this placebo effect is common, any drug deemed effective must prove itself stronger than a placebo.

The expectation of pain relief is enough to cause the brain to release painkilling endorphins. We believe this is so because brain scans show that essentially the same pain-suppression areas "light up" when patients take placebos or analgesic drugs.

The physical mechanisms that keep track of body position, movement, and balance actually consist of two different systems, the vestibular sense and the kinesthetic sense. The vestibular sense is the body position sense that orients us with respect to gravity. It tells us the posture of our bodies—whether straight, leaning, reclining, or upside down. The vestibular sense also tells us when we are moving or how our motion is changing. The receptors for this information are tiny hairs (much like those we found in the basilar membrane) in the semicircular canals of the inner ear. These hairs respond to our movements by detecting corresponding movements in the fluid of the semi-circular canals. Disorders of this sense can cause extreme dizziness and disorientation.

The kinesthetic sense, the other sense of body position and movement, keeps track of body parts relative to each other. Your kinesthetic sense makes you aware of crossing your legs, for example, and tells you which hand is closer to your cell phone when it rings. Kinesthesis provides constant sensory feedback about what the muscles in your body are doing during motor activities, such as whether to continue reaching for your cup of coffee or to stop before you knock it over (Turvey, 1996).

Receptors for kinesthesis reside in the joints, muscles, and tendons. These receptors, as well as those for the vestibular sense, connect to processing regions in the brain's parietal lobes—which help us make a sensory "map" of the spatial relationship among objects and events. This processing usually happens automatically and effortlessly, outside of conscious awareness, except when we are deliberately learning the movements for a new physical skill, such as swinging a golf club or playing a musical instrument.

8.9 Conclusion

Different people probably have similar sensations in response to a stimulus because their sense organs and parts of the brain they use in sensation are similar. The brain does not sense the external world directly. The sense organs transduce stimulation and deliver stimulus information to the brain in the form of neural impulses. Our sensory experiences are, therefore, what the brain creates from the information delivered in these neural impulses.

8.10 Summary

Gustation is the sense of taste. Taste buds in the tongue receive molecules of substances, which fit into receptor sites. The five basic types of taste are sweet, sour, salty, bitter, and umami (brothy). Olfaction is the sense of smell. The olfactory receptors in the upper part of the nasal passages receive molecules of substances and create neural signals that then go to the olfactory bulbs under the frontal lobes. The somesthetic senses include the skin senses and the vestibular senses.

Pacinian corpuscles respond to pressure, certain nerve endings around hair follicles respond to pain and pressure, and free nerve endings respond to pain, pressure, and temperature. The gate-control theory of pain states that when receptors sensitive to pain are stimulated, a neurotransmitter called substance P is released into the spinal cord, activating other pain receptors by opening “gates” in the spinal column and sending the message to the brain. The kinesthetic senses allow the brain to know the position and movement of the body through the activity of special receptors responsive to movement of the joints and limbs. The vestibular sense also contributes to the body’s sense of spatial orientation and movement through the activity of the otolith organs (up-and-down movement) and the semi-circular canals (movement through arcs).

8.11 Key Words

::Anosmia

The loss of the ability to smell as a result of injury or infection.

::kinesthetic sense

Having to do with the location of body parts in relation to each other

:: Macrosmatic

Having a keen sense of smell that is important to their survival

::Microsmatic

Having a less keen sense of smell that is not crucial to their survival

::Olfaction

The sense of smell.

::Olfactory mucosa (OM)

A dime-sized region located high in the nasal cavity

::Phantom limb

The mysterious sensations often experienced by people who have lost an arm or leg

::placebos

Mock drugs made to appear as real drugs.

::skin senses

Having to do with touch, pressure, temperature, and pain

::Somesthetic sense

The body senses

::Vestibular senses

Having to do with movement and body position.

8.12 Check your progress:

1. The receptors on our taste buds work most like __________.
   a. receptors in the ears. c. receptor sites on neurons.
   b. receptors in the eyes. d. receptors in the skin.

2. Which of the following statements about olfactory receptorsis FALSE?
   a. Olfactory receptors are replaced every few years.
   b. There are at least 1,000 types of olfactory receptors.
   c. Signals from the receptors go directly to the olfactory bulbs in the brain.
   d. Olfactory receptors have hair like projections called cilia.

3. After some time has passed, you can no longer smell the odor of wet paint that you noticed when you first entered your classroom. Which is the most likely reason for this?
   a. The smell has gone away.
   b. You’ve adapted to the smell, even though it’s still there.
   c. Your nose fell asleep.
   d. You fell asleep.

4. Pain sensations in the skin, muscles, tendons, and joints that are carried on large nerve fibers are called __________.
   a. visceral pain.
   b. somatic pain.

c. referred pain.

d. indigenous pain.

5. In gate-control theory, substance P __________.

a. opens the spinal gates for pain.

b. closes the spinal gates for pain.

c. is unrelated to pain.

d. is similar in function to endorphins.

8.13 Answers to check your progress

1. c
2. a
3. b
4. b
5. a

8.14 Model Questions

1. Explain the process of chemical senses.
2. Describe the somesthetic senses.
3. Discuss the psychological techniques to reduce pain
4. Describe the process involved in olfactory sense.

LESSON 9
PROCESSING OF PERCEPTION

INTRODUCTION

Perception does not just happen, but is the end result of complex “behind the scenes” processes, many of which are not available to our awareness. One way to illustrate the behind-the-scenes processes involved in perception is by describing a sequence of steps, which is called as the perceptual process.

OBJECTIVES OF THE LESSON

After the completion of this lesson you will be able to understand

- how the perceptions are determined by the processes you are unaware of.
- the difference between perceiving something and recognizing it
- the importance of attention

Plan of the lesson

9.1 Perceptual process

The perceptual process, is a sequence of processes that work together to determine our experience of and reaction to stimuli in the environment. The perceptual process is divided into four categories: Stimulus, Electricity, Experience and Action, and Knowledge. Stimulus refers to what is out there in the environment, what we actually pay attention to, and what stimulates our receptors. Electricity refers to the electrical signals that are created by the receptors and transmitted to the brain. Experience and Action refers to our goal—to perceive, recognize, and react to the stimuli. Knowledge refers to knowledge we bring to the perceptual situation.

9.1.1 The Stimulus

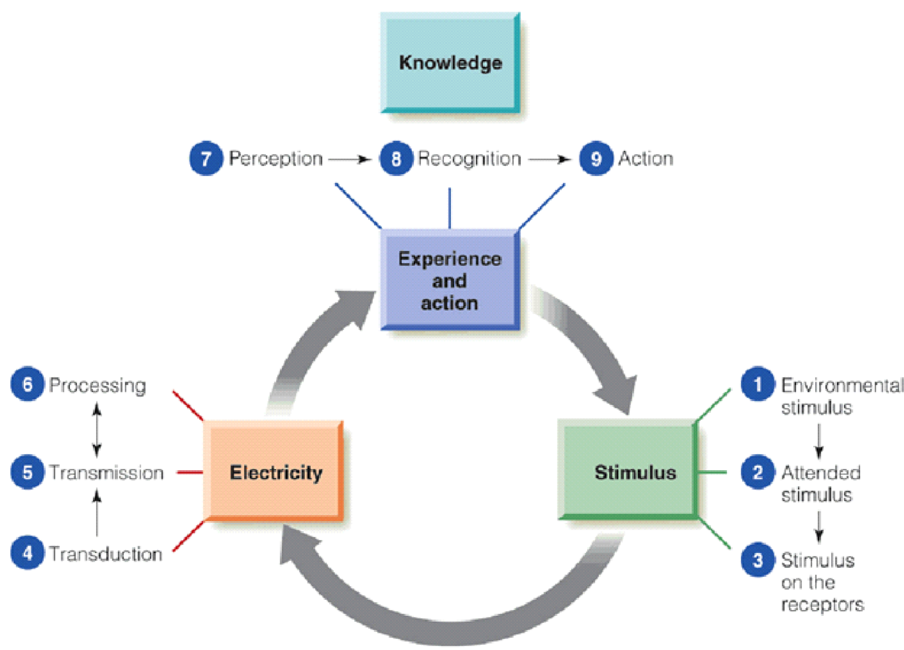


Figure 9.1

The stimulus exists both "out there," in the environment, and within the person's body. There are two aspects of the stimulus in the environment: Environmental Stimulus and Attended Stimulus. The environmental stimulus is all of the things in our environment that can be potentially perceived. Consider, for example, the potential stimuli that are presented to a person, who is taking a walk in the woods. As the person walks along the trail, is confronted with a large number of stimuli —trees, the walking path, the rustling noises made by a small animal scampering through the leaves. Because there is far too much happening it is difficult to take in everything at once. So, the individual scans the scene, looking from one place to another at things that are of his or her interest. When the attention is captured by a particularly distinctive looking tree off to the right, the individual shifts his focus on the tree, making it the center of his attention. This stimulus (tree) becomes the attended stimulus. The attended stimulus changes from moment to moment, as the individual shifts the attention from place to place.

9.1.2 The Stimulus on the Receptors

When the person focuses the attention on the tree, looks directly at it and this creates an image of the tree and its immediate surroundings on the receptors of her retina, a 0.4-mm-thick network of light-sensitive receptors and other neurons that line the back of the retina. This step is important because the stimulus—the tree—is transformed into another form—an image on the retina. Because the tree has been transformed into an image, it can be described as a representation of the tree. It's not the actual tree, but it stands for the tree. The next steps in the perceptual process carry this idea of representation a step further, when the image is transformed into electricity.

9.1.3 Electricity

One of the central principles of perception is that everything we perceive is based on electrical signals in our nervous system. These electrical signals are created in the receptors, which transform energy from the environment (such as the light on the retina) into electrical signals in the nervous system—a process called transduction.

9.1.3.1 Transduction

Transduction is the transformation of one form of energy into another form of energy. For example, when you touch the "withdrawal" button on an ATM machine, the pressure exerted by your finger is transduced into electrical energy, which causes a device that uses mechanical energy to push your money out of the machine.

Transduction occurs in the nervous system when energy in the environment—such as light energy, mechanical pressure, or chemical energy—is transformed into electrical energy. In our example, the pattern of light created on the individual's retina by the tree is transformed into electrical signals in thousands of his visual receptors.

9.1.3.2 Transmission

After the tree's image has been transformed into electrical signals in the receptors, these signals activate other neurons, which in turn activate more neurons. Eventually these signals travel out of the eye and are transmitted to the brain. The transmission step is crucial because if signals don't reach the brain, there is no perception.

9.1.3.3 Processing

As electrical signals are transmitted through the retina and then to the brain, they undergo neural processing, which involves interactions between neurons. To understand this we will compare how signals are transmitted in the nervous system to how signals are transmitted by your cell phone. Let's first consider the phone. When a person says "hello" into a cell phone, this voice signal is changed into electrical signals, which are sent out from the cell phone. This electrical signal, which represents the sound "hello," is relayed by a tower to the receiving cell phone, which transforms the signal into the sound "hello." An important property of cell phone transmission is that the signal that is received is the same as the signal that was sent.

The nervous system works in a similar way. The image of the tree is changed into electrical signals in the receptors, which eventually are sent out the back of the eye. This signal, which represents the tree, is relayed through a series of neurons to the brain, which transforms this signal into a perception of the tree. Thus, with a cell phone, electrical signals that represent a stimulus ("hello") are transmitted to a receiver (another cell phone), and in the nervous system, electrical signals representing a stimulus (the tree) are also transmitted to a receiver (the brain). There are, however, differences between information transmission in cell phones and in the nervous system. With cell phones, the signal received is the same as the signal sent. The goal for cell phones is to transmit an exact copy of the original signal. However, in the nervous system, the signal that reaches the brain is transformed so that, although it represents the original stimulus, it is usually very different from the original signal.

The transformation that occurs between the receptors and the brain is achieved by neural processing, which happens as the signals that originate in the receptors travel through a maze of interconnected pathways between the receptors and the brain and within the brain. In the nervous system, the original electrical representation of the stimulus that is created by the receptors is transformed by processing into a new representation of the stimulus in the brain.

9.1.4 Experience and Action

The next stage of the perceptual process, where the “backstage activity” of transduction, transmission, and processing is transformed into things we are aware of—perceiving, recognizing, and acting on objects in the environment.

9.2 Steps in Perception

Perception is conscious sensory experience. It occurs when the electrical signals that represent the tree are transformed by the brain into the experience of seeing the tree. Once it is perceived as tree the other things have happened as well—she has recognized the form as a “tree” and not a “pole,” and takes action based on the perception by walking closer to the tree to get a better look at it. These two additional steps—recognition and action—are behaviors that are important outcomes of the perceptual process.

9.2.1 Recognition

Recognition is our ability to place an object in a category, such as “tree,” that gives it meaning. Although we might be tempted to group perception and recognition together, they are separate processes. For example, consider the case of Dr. P., a well-known musician and music teacher, began misperceiving common objects, for example addressing a parking meter as if it were a person or expecting a carved knob on a piece of furniture to engage him in conversation, it became clear that his problem was more serious than just a little forgetfulness. It was clear from an eye examination that he could see well and, by many other criteria, it was obvious that he was not crazy. Dr. P.’s problem was eventually diagnosed as visual form agnosia—an inability to recognize objects—that was caused by a brain tumor. He perceived the parts of objects but couldn’t identify the whole object. The normally easy process of object recognition had, for Dr. P., been derailed by his brain tumor. He could perceive the object and recognize parts of it, but couldn’t perceptually assemble the parts in a way that would enable him to recognize the object as a whole. Cases such as this show that it is important to distinguish between perception and recognition.

9.2.2 Action

Action includes motor activities such as moving the head or eyes and locomoting through the environment. Action is an important outcome of the perceptual process because of its importance for survival. David Milner and Melvyn Goodale (1995) propose that early in the evolution of animals the major goal of visual processing was not to create a conscious perception or “picture” of the environment, but +to help the animal control navigation, catch prey, avoid obstacles, and detect predators—all crucial functions for the animal’s survival.

The fact that perception often leads to action—whether it be an animal’s increasing its vigilance when it hears a twig snap in the forest or a person’s deciding to look more closely at something that looks interesting—means that perception is a continuously changing process. The changes that occur as people perceive is the reason the steps of the perceptual process are arranged in a circle. Although we can describe the perceptual process as a series of steps that “begin” with the environmental stimulus and “end” with perception, recognition, and action, the overall process is so dynamic and continually changing that it doesn’t really have a beginning point or an ending point.

9.2.3 Knowledge

The perceptual process also includes—Knowledge. Knowledge is any information that the perceiver brings to a situation. Knowledge is placed above the circle because it can affect a number of the steps in the perceptual process. Information that a person brings to a situation can be things learned years ago, or knowledge obtained from events that have just happened. An example of how knowledge acquired years ago can influence the perceptual process is the ability to categorize objects. Another way to describe the effect of information that the perceiver brings to the situation is by distinguishing between bottom-up processing and top-down processing.

Bottom-up processing (also called data-based processing) is processing that is based on incoming data. Incoming data always provide the starting point for perception because without incoming data, there is no perception.

Top-down processing (also called knowledge-based processing) refers to processing that is based on knowledge. Knowledge isn’t always involved in perception but, as we will see, it often is—sometimes without even being aware of it.

Bottom-up processing is essential for perception because the perceptual process usually begins with stimulation of the receptors. Thus, when a pharmacist reads what to you might look like an unreadable scribble on your doctor’s prescription, she starts with the patterns that the doctor’s handwriting creates on her retina. However, once these bottom-up data have triggered the sequence of steps of the perceptual process, top-down processing can come into play as well. The pharmacist sees the squiggles the doctor made on the prescription and then uses her knowledge of the names of drugs, and perhaps past experience with this particular doctor's writing, to help understand the squiggles. Thus, bottom-up and top-down processing often work together to create perception.

9.3 Approaches to study of perception

The goal of perceptual research is to understand each of the steps in the perceptual process that lead to perception, recognition, and action which is simply known as perception. To accomplish this goal, perception has been studied using two approaches: the psychophysical approach and the physiological approach.

The psychophysical approach to perception was introduced by Gustav Fechner, a physicist who, coined the term psychophysics to refer to the use of quantitative methods to measure relationships between stimuli (physics) and perception (psycho). An example of research using the psychophysical approach would be measuring the stimulus–perception relationship (PP) by asking an observer to decide whether two very similar patches of color are the same or different.

The physiological approach to perception involves measuring the relationship between stimuli and physiological processes (PH1 in Figure 9.2) and between physiological processes and perception (PH2 in Figure 9.2).

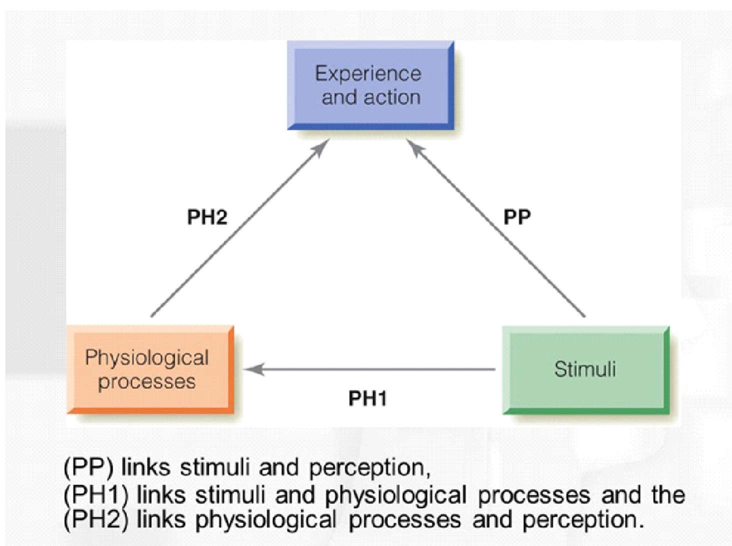


Figure 9.2

These physiological processes are most often studied by measuring electrical responses in the nervous system, but can also involve studying anatomy or chemical processes.

Though there is difference between the psychophysical approach and the physiological approach, they both are working toward a common goal—to explain the mechanisms responsible for perception. Thus, when we measure how a neuron responds to different colors (relationship PH1) or the relationship between a person's brain activity and that person's perception of colors (relationship PH2), our goal is to explain the physiology behind how we perceive colors. Anytime we measure physiological responses, our goal is not simply to understand how neurons and the brain work; our goal is to understand how neurons and the brain create perceptions. As we study perception using both psychophysical and physiological methods, we will also be concerned with how the knowledge, memories, and expectations that people bring to the situation influence their perceptions. These factors are called cognitive influences on perception. One of the things that becomes apparent from the psychophysical and physiological approaches is that each one provides information about different aspects of the perceptual process. Thus, to truly understand perception, we have to study it using both approaches.

9.4 Characteristics of human perception: The Stimulus on the Receptors Is Ambiguous

When you look at the page of this book, the image cast by the page on the retina is ambiguous. It may seem strange, because it is obvious that the page is rectangular, but viewed from straight on, the rectangular page creates a rectangular image on the retina. However, other objects, such as the tilted rectangle or slanted trapezoid, can also create the same image. The fact that a particular image on the retina (or a computer vision machine's sensors) can be created by many different objects is called the inverse projection problem. Another way to state this problem is as follows: If we know an object's shape, distance, and orientation, we can determine the shape of the object's image on the retina. However, a particular image on the retina can be created by an infinite number of objects. The information from a single view of an object can be ambiguous. Humans solve this problem by moving to different viewpoints, and by making use of knowledge they have gained from past experiences in perceiving objects.

9.4.1 Objects Can Be Hidden or Blurred

Sometimes objects are hidden or blurred. This problem of hidden objects occurs any time one object obscures part of another object. This occurs frequently in the environment, but people easily understand that the part of an object that is covered continues to exist, and they are able to use their knowledge of the environment to determine what is likely to be present.

9.4.2 Objects Look Different From Different Viewpoints

Another problem facing any perception is that objects are often viewed from different angles. This means that the images of objects are continually changing, depending on the angle from which they are viewed. The ability to recognize an object seen from different viewpoints is called viewpoint invariance. These difficulties proves that perception is more complex than it seems.

9.5 Attention

To understand perception as it happens in the real world, we need to go beyond just considering how we perceive isolated objects. Description of the processes involved in attention makes you to understand perception as it occurs within the richness of the natural environment. We begin by considering why we pay attention to specific things in the environment.

9.5.1 Perceiving the Environment

In everyday life we often have to pay attention to a number of things at once, a situation called divided attention. For example, when driving down the road, you need to simultaneously attend to the other cars around you, traffic signals, and perhaps what the person in the passenger seat is saying, while occasionally glancing up at the rear view mirror. But there are limits to our ability to divide our attention. For example, reading your textbook while driving would most likely end in disaster. Although divided attention is something that does occur in our everyday experience, our main interest is on selective attention—focusing on specific objects and ignoring others.

9.5.2 Selective Attention

One mechanism of selective attention is eye movements— scanning a scene to aim the fovea at places we want to process more deeply. The eye is moving constantly to take in information from different parts of a scene. Though eye movements are an important mechanism of selective attention, it is also important to note that there is more to attention than just moving the eyes to look at objects. We pay attention to things that are not directly on our line of vision and also can look directly at something without paying attention to it.

For example, while reading a book, you become aware that although you were moving your eyes across the page and "reading" the words, you have no idea what you just read. Even though you were looking at the words, you apparently were not paying attention. This example indicates tells us that there is a mental aspect of attention that occurs in addition to eye movements.

This connection between attention and what is happening in the mind was described more than 100 years ago by William James (1890/1981), in his textbook "Principles of Psychology". According to James, we focus on some things to the exclusion of others. As you walk down the street, the things you pay attention to—a classmate that you recognize, the "Don't Walk" sign at a busy intersection, and the fact that just about everyone except you seems to be carrying an umbrella—stand out more than many other things in the environment. There are several reasons behind this.

9.5.3 Stimulus Salience

Stimulus salience refers to characteristics of the environment that stand out because of physical properties such as color, brightness, contrast, or orientation. Areas with high stimulus salience are conspicuous, such as a brightly colored red ribbon on a green Christmas tree. Capturing attention by stimulus salience is a bottom up process—it depends solely on the pattern of stimulation falling on the receptors. But attention is not just based on what is bright or stands out. Cognitive factors are important as well. A number of cognitively based factors have been identified as important for determining where a person looks.

9.5.4 Knowledge About Scenes

The knowledge we have about the things that are often found in certain types of scenes and what things are found together within a scene can help determine where we look. There are situations in which your knowledge about specific types of scenes might influence where you look. You probably know a lot, for example, about kitchens, college campuses, automobile instrument panels, and shopping malls, and your knowledge about where things are usually found in these scenes can help guide your attention through each scene.

9.5.5 Nature of the Observer's Task

When a person is carrying out a task, the demands of the task override factors such as stimulus saliency. This is explained by the fixations and eye movements that occurred as a person was making a peanut butter sandwich. The process of making the sandwich begins with the movement of a slice of bread from the bag to the plate. This operation is accompanied by an eye movement from the bag to the plate. The peanut butter jar is then fixated, then lifted and moved to the front as its lid is removed. The knife is then fixated, picked up, and used to scoop the peanut butter, which is then spread on the bread. The person fixated on few objects or areas that were irrelevant to the task and that eye movements and fixations were closely linked to the action the person was about to take. For example, the person fixated the peanut butter jar just before reaching for it.

9.5.6 Learning From Past Experience

If a person has learned the key components of making a peanut butter sandwich, this learning helps direct attention to objects, such as the jar, the knife, and the bread, that are relevant to the task.

It is clear that a number of factors determine how a person scans a scene. Salient characteristics may capture a person's initial attention, but cognitive factors become more important as the observer's knowledge of the meaning of the scene begins determining where he or she fixates. Even more important than what a scene is, is what the person is doing within the scene. Specific tasks, such as making a peanut butter sandwich or driving, exert strong control over where we look.

9.6 Role of attention in perception

Although there is no question that attention is a major mechanism of perception, there is evidence that we can take in some information even from places where we are not focusing our attention.

9.6.1 Effect of Lack of Focused Attention: Inattentional Blindness

Evidence that attention is necessary for perception is provided by a phenomenon called inattentional blindness— failure to perceive a stimulus that isn't attended, even if it is in full view.

Imagine looking at a display in a department store window. When you focus your attention on the display, you probably fail to notice the reflections on the surface of the window. Shift your attention to the reflections, and you become unaware of the display inside the window. Daniel

Simons and Christopher Chabris (1999) created a situation in which one part of a scene is attended and the other is not. They created a 75-second film that showed two teams of three players each. One team was passing a basketball around, and the other was "guarding" that team by following them around and putting their arms up as in a basketball game. Observers were told to count the number of passes, a task that focused their attention on one of the teams. After about 45 seconds, one of two events occurred. Either a woman carrying an umbrella or a person in a gorilla suit walked through the "game," an event that took 5 seconds. After seeing the video, observers were asked whether they saw anything unusual happen or whether they saw anything other than the six players. Nearly half—46 percent— of the observers failed to report that they saw the woman or the gorilla.

In another experiment, when the gorilla stopped in the middle of the action, turned to face the camera, and thumped its chest, half of the observers still failed to notice the gorilla. These experiments demonstrate that when observers are attending to one sequence of events, they can fail to notice another event, even when it is right in front of them.

9.6.2 Change Blindness

Instead of presenting several stimuli at the same time, a stimulus is presented first, then another slightly different stimulus. People often have trouble detecting the change even though it is obvious when you know where to look. In a similar experiment in which people are presented with one picture, followed by a blank field, followed by the same picture but with an item missing, followed by the blank field, and so on. The pictures were alternated in this way until observers were able to determine what was different about the two pictures. It is found that the pictures had to be alternated back and forth a number of times before the difference was detected. This difficulty in detecting changes in scenes is called change blindness.

9.6.3 Enhancement of perception

William James stated that attending to a stimulus makes it more "clear and vivid." Information processing is more effective at the place where attention is directed. There is also evidence that when attention is directed to one place on an object, the enhancing effect of this attention spreads throughout the object. In addition, paying attention to a location results in faster responding when a target is presented at that location. This "spreading enhancement" may help us perceive partially obscured object.

9.7 Conclusion

Perception involves several processes and steps which can be explained through the psychophysical and physiological approaches. Human perception happens because of unique characteristics which even a machine cannot do. Selective attention reduces the interference from irrelevant sensory sources.

9.8 Summary

The perceptual process is divided into four categories: Stimulus, Electricity, Experience and Action, and Knowledge. In addition perception involves recognition and action which completes the perceptual process. The steps in perceptual process can be understood through the psychophysical approach and physiological approach. Human perception has certain unique characteristics. Attention is an important determinant of perception. We can perceive some things, such as the gender of a face, without focused attention, but that focused attention is necessary for detecting many of the details within a scene and for detecting the details of specific objects in the scene.

9.9 Key Words

::Attended stimulus

The stimulus which captures the attention

:: Bottom-up processing (data-based processing)

Processing that is based on incoming data.

:: Change blindness.

Difficulty in detecting changes in scenes

:: Environmental stimulus

All of the things in our environment that can be potentially perceived

:: Inattentional blindness

Failure to perceive a stimulus that isn't attended, even if it is in full view.

:: Knowledge

Any information that the perceiver brings to a situation.

:: Perception

Conscious sensory experience

:: Perceptual process

A sequence of processes that work together to determine our experience of and reaction to stimuli in the environment.

:: Physiological approach

Perception involves measuring the relationship between stimuli and physiological processes and between physiological processes and perception

:: Psychophysical approach

The use of quantitative methods to measure relationships between stimuli (physics) and perception (psycho)

:: Recognition

Our ability to place an object in a category that gives it meaning

:: Selective attention

Focusing on specific objects and ignoring others.

:: Stimulus

What stimulates our receptors.

:: Stimulus salience

Characteristics of the environment that stand out because of physical properties such as color, brightness, contrast, or orientation.

:: Top-down processing (knowledge-based processing)

Processing that is based on knowledge

:: Transduction

The transformation of one form of energy into another form of energy

:: Transmission

Activation of other neurons through the electrical signals

9.10 Check your progress

1. The first stage in perception process involves

   (a) Attention and meaning

   (b) Selection and attention

   (c) Stimulus and response

   (d) Attention and logic

2. Which of the following will influence an individual's perception

   (a) Individual needs

   (b) Previous experience

   (c) Sensory limitations

   (d) All of the above

3. A person's ______________ comprises internal factors such as ability, intelligence and personality, and will determine how an individual to certain stimuli

   (a) Perceptual set

   (b) Psychological threshold

   (c) Cognitive set

   (d) Sensory limit

4. The psychological factors affecting perceptual selection are

   (a) Learning, personality, ego

   (b) Personality, ego and mental processes

(c) Motives, personality, mental processes

(d) Personality, learning, motives

5. We tend to pay more attention to environmental stimuli which are

(a) Novel (b) Bright

(b) Moving (d) All the above

9.11 Answers to check your progress

1. b
2. d
3. a
4. d
5. d

9.12 Model Questions

1. What are two reasons that we focus on some things and ignore others?
2. What is selective attention?
3. What is divided attention?
4. Describe the factors that influence how we direct our attention in a scene.

LESSON 10
PERCEPTION

INTRODUCTION

Our perceptions are based on how we interpret all the different sensations, which are sensory impressions we get from the stimuli in the world around us. Perception enables us to navigate the world and to make decisions about everything, from which T-shirt to wear or how fast to run away from a bear. Perception involves the organization and interpretation of stimuli to give them meaning. To understand and recognise perception blends into cognition, a more complex and interpretive process involves memory and thought.

Objectives of the lesson

After the completion of this lesson you will be able to understand

- the approaches to perception
- perceptual constancies
- depth perception
- illusion

Plan of the lesson

10.1 Theoretical Explanations for Perception

The fact that most people perceive most illusions and ambiguous figures in essentially the same way suggests that fundamental perceptual principles are at work. There are two influential theories that explain how we form our perceptions: Gestalt theory and learning-based inference. Although these two approaches may seem contradictory at first, they really emphasize complementary influences on perception. The Gestalt theory emphasizes how we organize incoming stimulation into meaningful perceptual patterns—because of the way our brains are innately "wired." On the other hand, learning-based inference emphasizes learned influences on perception, including the power of expectations, context, and culture. In other words, Gestalt theory emphasizes nature, and learning-based inference emphasizes nurture.

10.2 Gestalt Theory

A group of German psychologists, argued that the brain is innately wired to perceive not just stimuli but also patterns in stimulation. They called such a pattern a Gestalt, the German word for "perceptual pattern" or "configuration." Thus, from the raw material of stimulation, the brain forms a perceptual whole that is more than the mere sum of its sensory parts. This perspective is known as Gestalt psychology.

The Gestaltists liked to point out that we perceive a square as a single figure rather than merely as four individual lines. Similarly, when you hear a familiar song, you do not focus on the individual notes. Rather, your brain extracts the melody, which is your perception of the overall pattern of notes. Such examples, the Gestalt psychologists argued, show that we always attempt to organize sensory information into meaningful patterns, the most basic elements of which are already present in our brains at birth. Because this approach has been so influential, we will examine some of the Gestalt discoveries in more detail.

10.2.1 Figure and Ground

One of the most basic of perceptual processes identified by Gestalt psychology divides our perceptual experience into figure and ground. A figure is simply a pattern or image that grabs our attention. As we noted, psychologists sometimes call this a Gestalt. Everything else becomes ground, the backdrop against which we perceive the figure. A melody becomes a figure heard against a background of complex harmonies, and a spicy chunk of pepperoni becomes the figure against the ground of cheese, sauce, and bread that makes up a pizza. Visually, a figure could be a bright flashing sign or a word on the background of a page. And in the ambiguous faces/vase seen in Figure (10.1), figure and ground reverse when the faces and vase alternately “pop out” as figure.

Figure 10.1

10.2.2 Closure

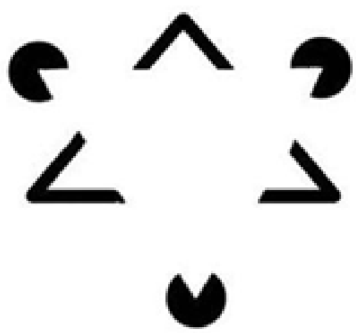


Figure 10.2

Our minds seem built to abhor a gap, as you saw in the figure above. Note especially the illusory white triangle—superimposed on the circles and black lines. Moreover, you will note that you have mentally divided the white area into two regions, the triangle and the background. Where this division occurs, you perceive subjective contours: boundaries that exist not in the stimulus but only in the subjective experience of your mind. Your perception of these illusory triangles demonstrates a second powerful organizing process identified by the Gestalt psychologists.

Closure makes you to see incomplete figures as wholes by supplying the missing segments, filling in gaps, and making inferences about potentially hidden objects. So when you see a face peeking around a corner, your mind automatically fills in the hidden parts of the face and body. In general, humans have a natural tendency to perceive stimuli as complete and balanced even when pieces are missing.

10.2.3 The Gestalt Laws of Perceptual Organization

Perceptual organization involves the grouping of elements in an image to create larger objects. There are six of the laws of organization that the Gestalt psychologists proposed to explain how perceptual grouping occurs.

10.2.3.1 Law of good figure or the law of simplicity: Pragnanz

Pragnanz, roughly translated from the German, means "good figure." The law of pragnanz, also called the law of good figure or the law of simplicity, is the central law of Gestalt psychology: Every stimulus pattern is seen in such a way that the resulting structure is as simple as possible. The familiar Olympic symbol in Figure 10.3 is an example of the law of simplicity at work. We see this display as five circles and not as a larger number of more complicated shapes.

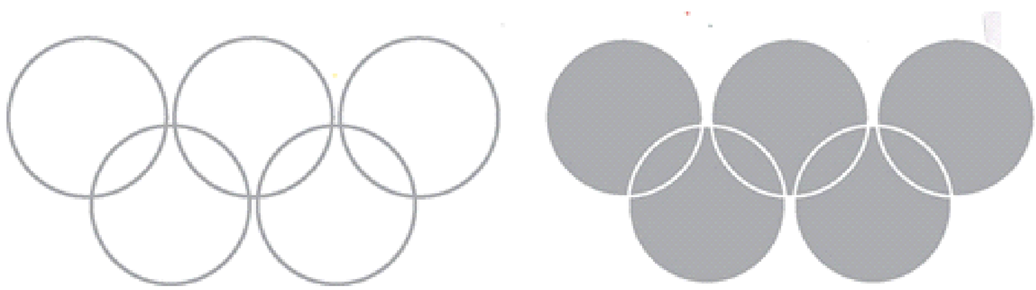


Figure 10.3

10.2.3.2 Law of Similarity

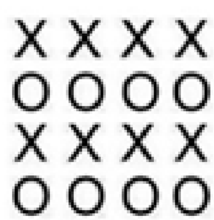


Figure 10.4

we group things together that have a similar look (or sound, or feel, and so on). So in Figure , you see that the X s and O s form distinct rows, rather than colomns, because of similarity. Likewise, when you watch a football game, you use the colors of the uniforms to group the players into two teams because of similarity, even when they are mixed together during a play. Any such tendency to perceive things as belonging together because they share common features reflects the law of similarity.

10.2.3.3Law of Good Continuation

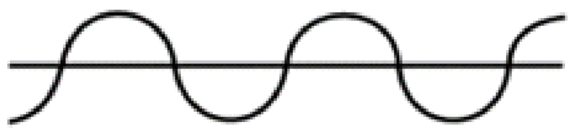


Figure 10.5

A straight line appears as a single, continuous line, even though a curved line repeatedly cuts through it. In general, the law of continuity says that we prefer smoothly connected and continuous figures to disjointed ones. Continuity also operates in the realm of social perception, where we commonly make the assumption of continuity in the personality of an individual whom we haven't seen for some time. So, despite interruptions in our contact with that person, we will expect to find continuity—to find him or her to be essentially the same person we knew earlier.

10.2.3.4 Law of Proximity (Nearness)

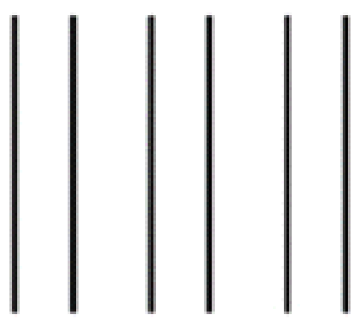


Figure 10.6

Our perception of Figure10.6 as three pairs of straight lines illustrates the law of proximity, or nearness: Things that are near each other appear to be grouped together.

10.2.3.5 Law of Common Region

Figure 10.7

Elements that are within the same region of space appear to be grouped together. Even though the circles inside the ovals are farther apart than the circles that are next to each other in neighboring ovals, we see the circles inside the ovals as belonging together. This occurs because each oval is seen as a separate region of space. Notice that in this example common region overpowers proximity. Because the circles are in different regions, they do not group with each other, as they did in Figure, but with circles in the same region.

10.2.3.6 Law of Uniform Connectedness

The principle of uniform connectedness states: A connected region of visual properties, such as lightness, color, texture, or motion, is perceived as a single unit.

Figure 10.8

10.2.3.7 Law of Synchrony

The principle of synchrony states: Visual events that occur at the same time are perceived as belonging together.

10.2.3.8 Law of Common Fate

The law of common fate states: Things that are moving in the same direction appear to be grouped together. Thus, when you see a flock of hundreds of birds all flying together, you tend to see the flock as a unit, and if some birds start flying in another direction, this creates a new unit (Figure). Notice that common fate is like synchrony in that both principles are dynamic, but synchrony can occur without movement, and the elements don't have to change in the same direction as they do in common fate.

10.2.3.9 Law of Meaningfulness or Familiarity

According to the law of familiarity, things that form patterns that are familiar or meaningful are likely to become grouped together.

10.3 Learning-Based Inference: The Nurture of Perception

In 1866, Hermann von Helmholtz pointed out the important role of learning (or nurture) in perception. His theory of learning-based inference emphasized how people use prior learning to interpret new sensory information. Based on experience, the observer makes inferences — guesses or predictions—about what the sensations mean. This theory explains, for example, why you assume a birthday party is in progress when you see lighted candles on a cake: You have learned to associate cakes, candles, and birthdays.

Ordinarily, such perceptual inferences are fairly accurate. On the other hand, we have seen that confusing sensations and ambiguous arrangements can create perceptual illusions and erroneous conclusions. Our perceptual interpretations are, in effect, hypotheses about our sensations. For example, babies learn to expect that faces will have certain features in fixed arrangements (pair of eyes above nose, mouth below nose, etc.). In fact, we so thoroughly learn about faces in their usual configuration that we fail to "see" facial patterns that violate our expectations, particularly when they appear in an unfamiliar orientation. According to the theory of learning-based inference, the most important factors include the context, our expectations, and our perceptual set.

10.3.1 Context and Expectations

Once you identify a context, you form expectations about what persons, objects, and events you are likely to experience. To see what we mean, take a look at the following:

It says THE CAT, right? Now look again at the middle letter of each word. Physically, these two letters are exactly the same, yet you perceived the first as an H and the second as an A. Why? Clearly, your perception was affected by what you know about words in English. The context provided by T__E makes an H highly likely and an A unlikely, whereas the reverse is true of the context of C__T. Here's a more real-world example: You have probably had difficulty recognizing people you know in situations where you didn't expect to see them, such as in a different city or a new social group. The problem, of course, is not that they looked different but that the context was unusual: You didn't expect them to be there. Thus, perceptual identification depends on context and expectations as well as on an object's physical properties.

10.3.2 Perceptual Set

Another way learning serves as a platform from which context and expectation exert an influence on perception involves perceptual set —which is closely related to expectation. Under the influence of perceptual set, we have a readiness to notice and respond to certain stimulus cues—like a sprinter anticipating the starter's pistol. In general, perceptual set involves a focused alertness for a particular stimulus in a given context. For example, a new mother is set to hear the cries of her child. Likewise, if you drive a sporty red car, you probably know how the highway patrol has a perceptual set to notice speeding sporty red cars. Often, a perceptual set leads you to transform an ambiguous stimulus into the one you were expecting. To experience this yourself, read quickly through the series of words that follow in both rows:

FOX; OWL; SNAKE; TURKEY; SWAN; D?CK

BOB; RAY; DAVE; BILL; TOM; D?CK

Notice how the words in the two rows lead you to read D?CK differently in each row.

The meanings of the words read prior to the ambiguous stimulus create a perceptual set. Words that refer to animals create a perceptual set that influences you to read D?CK as "DUCK." Names create a perceptual set leading you to see D?CK as DICK.

10.3.3 Cultural Influences on Perception

Which of the following three items go together: chicken, cow, grass?

An American is more likely to group chicken and cow together, because they are both animals. But a Chinese, will more likely to put the latter two together, because cows eat grass. In general, says cross-cultural psychologist Richard Nisbett, Americans tend to put items in categories by abstract type rather than by relationship or function. Nisbett and his colleagues have also found that East Asians typically perceive in a more holistic fashion than do, that is, the Asians pay more attention to, and can later recall more detail about, the context than do Americans.

Specifically, when looking at a scene, people raised in America tend to spend more time scanning the "figure," while those raised in China usually focus more on details of the "ground". "The Americans are more zoom and the East Asians are more panoramic,". Such distinctions are now even showing up as subtle differences on scans comparing brain activity of Asians and Americans on simple perceptual judgment tasks. Cross-cultural psychologists have pointed to still other cultural differences in perception. Consider, for example, the famous Ponzo illusion, based on linear perspective depth cues (Figure 10.9).

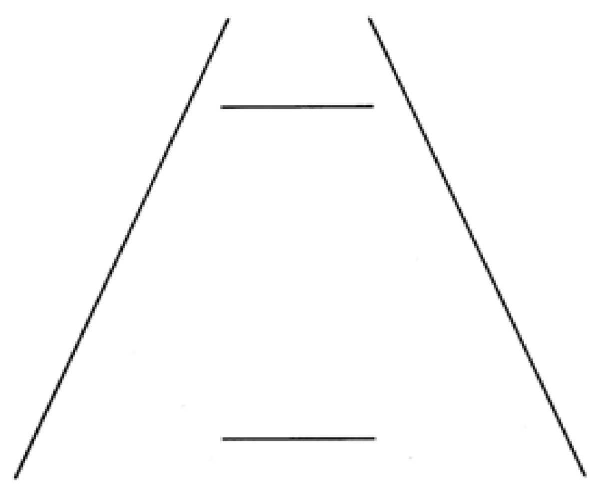


Figure 10.9

In your opinion, which bar is longer: the one on top or the one on the bottom? In actuality, both bars are the same length. Research shows, however, that responses to these figures depend strongly on culture-related experiences. Most readers of this book will report that the top bar appears longer than the bottom bar, yet people from some cultural backgrounds are not so easily fooled.

This may be because, the world you have grown up in probably included many structures featuring parallel lines that seemed to converge in the distance: railroad tracks, long buildings, highways, and tunnels. Such experiences leave you vulnerable to images, such as the Ponzo illusion, in which cues for size and distance are unreliable.

But what about people from cultures where individuals have had far less experience with this cue for distance? Research on this issue has been carried out on the Pacific island of Guam, where there are no Ponzo like railroad tracks. There, too, the roads are so winding that people have few opportunities to see roadsides “converge” in the distance. People who have spent their entire lives on Guam, then, presumably have fewer opportunities to learn the strong perceptual cue that converging lines indicate distance. And, sure enough—just as researchers had predicted—people who had lived all their lives on Guam were less influenced by the Ponzo illusion than were respondents from the mainland United States. That is, they were less likely to report that the top line in the figure was longer. These results strongly support the argument that people’s experiences affect their perceptions.

10.4 Perceptual constancy

Perception helps to adapt to a complex and ever changing environment. Perceptual constancy is the tendency to perceive aspects of the world as unchanging despite changes in the sensory input we receive from them.

10.4.1 Size constancy

One form of perceptual constancy is size constancy, the tendency to interpret an object as always being the same size, regardless of its distance from the viewer (or the size of the image it casts on the retina). So if an object that is normally perceived to be about 6 feet tall appears very small on the retina, it will be interpreted as being very far away.

10.4.2 Shape constancy

Another perceptual constancy is the tendency to interpret the shape of an object as constant, even when it changes on the retina. This shape constancy is why a person still perceives a coin as a circle even if it is held at an angle that makes it appear to be an oval on the retina. Dinner plates on a table are also seen as round, even though from the angle of viewing they are oval.

10.4.3 Brightness constancy

A third form of perceptual constancy is brightness constancy, the tendency to perceive the apparent brightness of an object as the same even when the light conditions change. If a person is wearing black pants and a white shirt, for example, in broad daylight the shirt will appear to be much brighter than the pants. But if the sun is covered by thick clouds, even though the pants and shirt have less light to reflect than previously, the shirt will still appear to be just as much brighter than the pants as before—because the different amount of light reflected from each piece of clothing is still the same difference as before.

10.5 Depth perception

The capability to see the world in three dimensions is called depth perception. It's a handy ability because without it you would have a hard time judging how far away objects are. Depth perception develop very early in infancy, if it is not actually present at birth. People who have had sight restored have almost no ability to perceive depth if they were blind from birth. Depth perception, like the constancies, seems to be present in infants at a very young age.

Various cues exist for perceiving depth in the world. Some require the use of only one eye (monocular cues) and some are a result of the slightly different visual patterns that exist when the visual fields of both eyes are used (binocular cues).

10.5.1 Monocular cues

Monocular cues are often referred to as pictorial depth cues because artists can use these cues to give the illusion of depth to paintings and drawings.

1. Linear perspective: When looking down a long interstate highway, the two sides of the highway appear to merge together in the distance. This tendency for lines that are actually parallel to seem to converge on each other is called linear perspective. It works in pictures because people assume that in the picture, as in real life, the converging lines indicate that the "ends" of the lines are a great distance away from where the people are as they view them.

2. Relative size: The principle of size constancy is at work in relative size, when objects that people expect to be of a certain size appear to be small and are, therefore, assumed to be much farther away. Movie makers use this principle to make their small models seem gigantic but off in the distance

3. Overlap: If one object seems to be blocking another object, people assume that the blocked object is behind the first one and, therefore, farther away. This cue is also known as interposition.

4. Aerial (atmospheric) perspective: The farther away an object is, the hazier the object will appear to be due to tiny particles of dust, dirt, and other pollutants in the air, a perceptual cue called aerial (atmospheric) perspective. This is why distant mountains often look fuzzy, and buildings far in the distance are blurrier than those that are close.

5. Texture gradient: If there are any large expanses of pebbles, rocks, or patterned roads (such as a cobblestone street) nearby, go take a look at them one day. The pebbles or bricks that are close to you are very distinctly textured, but as you look farther off into the distance, their texture becomes smaller and finer. Texture gradient is another trick used by artists to give the illusion of depth in a painting.

6. Motion parallax: The next time you're in a car, notice how the objects outside the car window seem to zip by very fast when they are close to the car, and objects in the distance, such as mountains, seem to move more slowly. This discrepancy in motion of near and far objects is called motion parallax.

7. Accommodation: A monocular cue that is not one of the pictorial cues, accommodation makes use of something that happens inside the eye. The lens of the human eye is flexible and held in place by a series of muscles. The discussion of the eye the earlier lesson mentioned the process of visual accommodation as the tendency of the lens to change its shape, or thickness, in response to objects near or far away. The brain can use this information about accommodation as a cue for distance. Accommodation is also called a "muscular cue."

10.5.2 Binocular cues

As the name suggests, these cues require the use of two eyes.

1. Convergence:

Convergence, refers to the rotation of the two eyes in their sockets to focus on a single object. if the object is close, the convergence is pretty great (almost as great as crossing the eyes). If the object is far, the convergence is much less. Hold your finger up in front of your nose, and then move it away and back again. That feeling you get in the muscles of your eyes is convergence.

2. Binocular disparity:

Binocular disparity is a scientific way of saying that because the eyes are a few inches apart, they don't see exactly the same image. The brain interprets the images on the retina to determine distance from the eyes. If the two images are very different, the object must be pretty close. If they are almost identical, the object is far enough away to make the retinal disparity very small. You can demonstrate this cue for yourself by holding an object in front of your nose. Close one eye, note where the object is, and then open that eye and close the other. There should be quite a difference in views. But if you do the same thing with an object that is across the room, the image doesn't seem to "jump" or move nearly as much, if at all. In spite of all the cues for perception that exist, even the most sophisticated perceiver can still fail to perceive the world as it actually is.

10.6 Perceptual illusions

An illusion is a perception that does not correspond to reality: People think they see something when the reality is quite different. Another way of thinking of illusions is as visual stimuli that "fool" the eye. (Illusions are not hallucinations: an illusion is a distorted perception of something that is really there, but a hallucination originates in the brain, not in reality.)

Sometimes illusions are based on early sensory processes, subsequent processing, or higher level assumptions made by the brain's visual system. We've already discussed one visual illusion (previous lesson), color afterimages, which are due to opponent-processes in the retina or lateral geniculate nucleus (LGN) of the thalamus after light information has been detected by the rods and cones. Another post detection, but still rather early, process has been offered for yet another illusion.

10.6.1 Muller-Lyer illusion

One of the most famous visual illusions, the Müller-Lyer illusion, is shown in Figure 10.10.

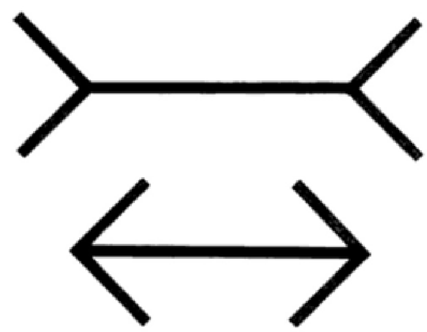


Figure 10.10

The distortion happens when the viewer tries to determine if the two lines are exactly the same length. They are identical, but one line looks longer than the other. (It's always the line with the angles on the end facing outward.) The explanation is that most people live in a world with lots of buildings. Buildings have corners. When a person is outside a building, the corner of the building is close to that person, while the walls seem to be moving away (like the line with the angles facing inward). When the person is inside a building, the corner of the room seems to move away from the viewer while the walls are coming closer (like the line with the angles facing outward). In their minds, people "pull" the inward-facing angles toward them like the outside corners of a building, and they make the outward-facing angles "stretch" away from them like the inside corners of the room

10.6.2 The moon illusion

Another common illusion is the moon illusion, in which the moon on the horizon appears to be much larger than the moon in the sky. One explanation for this is that the moon high in the sky is all alone, with no cues for depth surrounding it. But on the horizon, the moon appears behind trees and houses, cues for depth that make the horizon seem very far away. The moon is seen as being behind these objects and, therefore, farther away from the viewer. Because people know that objects that are farther away from them yet still appear large are very large indeed, they "magnify" the moon in their minds—a misapplication of the principle of size constancy. This explanation of the moon illusion is called the apparent distance hypothesis.

10.6.3 Illusions of motion

Sometimes people perceive an object as moving when it is actually still. One example of this takes place as part of a famous experiment in conformity called the autokinetic effect. In this effect, a small, stationary light in a darkened room will appear to move or drift because there are no surrounding cues to indicate that the light is not moving. Another is the stroboscopic motion seen in motion pictures, in which a rapid series of still pictures will seem to be in motion. Many a student has discovered that drawing little figures on the edges of a notebook and then flipping the pages quickly will also produce this same illusion of movement. Another movement illusion related to stroboscopic motion is the phi phenomenon, in which lights turned on in sequence appear to move. For example, if a light is turned on in a darkened room and then turned off, and then another light a short distance away is flashed on and off, it will appear to be one light moving across that distance. This principle is used to suggest motion in many theatre marquee signs, flashing arrows indicating direction that have a series of lights going on and off in a sequence, and even in strings of decorative lighting, such as the "chasing" lights seen on houses at holiday times.

10.7 Conclusion

Perception involves the organization and interpretation of sensory messages into a meaningful experience. The laws of organization are specified by the Gestalt psychologists and they include proximity, similarity, good continuation, closure, and common fate. The major function of the perceptual system is to achieve perceptual constancy- to keep the appearance of objects the same inspite of large changes in the stimuli received by the sense organs. The major constancies are brightness, shape and size. Illusions are perceptual experiences that do not conform to physical reality.

10.8 Summary

Perception is the knowledge-based interpretation of sensations. Much of this interpretation takes place automatically, but sometimes conscious effort is required to translate sensations into meaningful experience. Our perceptual systems automatically discriminate figure from ground. They also automatically group stimuli into patterns on the basis of the Gestalt principles of proximity, similarity, continuity, closure, texture, simplicity, common fate, and three others known as synchrony, common region, and connectedness. The perception of distance, or depth perception, depends partly on stimulus cues and partly on the physical structure of the visual system. Stimulus cues include relative size, height in the visual field, interposition, linear perspective, reduced clarity, light and shadow, and textural gradients. Cues based on the structure of the visual system include convergence of the eyes (the fact that the eyes must move to focus on the same object), binocular disparity (the fact that the eyes are set slightly apart), and accommodation (changes in the shape of the lenses as objects are brought into focus). The perception of motion results, in part, from the movement of stimuli across the retina. Expanding or looming stimulation is perceived as an approaching object. Movement of the retinal image is interpreted along with information about movement of the head, eyes, and other body parts, so that one's own movement can be discriminated from the movement of external objects. Stroboscopic motion is a movement illusion arising when a series of slightly different still images is seen in rapid succession. Because of perceptual constancy, the brightness, size, and shape of objects are seen as constant despite changes in the sensations received from those objects. Size constancy and shape constancy depend on the relationship between the retinal image of the object and the knowledge-based perception of its distance. Brightness constancy depends on the perceived relationship between the brightness of an object and its background. Size illusions are distortions of reality that result when principles of perception are applied inappropriately. Many illusions are caused by misreading depth cues and by evaluating stimuli in the context of their surroundings.

10.9 Key words

:: Binocular cues

Cues that require the use of two eyes.

:: Brightness constancy

The tendency to perceive the apparent brightness of an object as the same even when the light conditions change

::Depth perception

The ability to see the world in three dimensions

:: Figure and Ground

A figure is simply a pattern or image that grabs our attention. Everything else becomes ground, the backdrop against which we perceive the figure

:: Gestalt theory

Emphasizes how we organize incoming stimulation into meaningful perceptual patterns

:: Illusion

Perception that does not correspond to reality

:: Law of Common Fate

Things that are moving in the same direction appear to be grouped together

::Law of Common Region

Elements that are within the same region of space appear to be grouped together

:: Law of Good Continuation

Tendency to prefer smoothly connected and continuous figures to disjointed ones

.::Law of good figure or the law of simplicity(Pragnanz)

Every stimulus pattern is seen in such a way that the resulting structure is as simple as possible.

:: Law of Meaningfulness or Familiarity

Things that form patterns that are familiar or meaningful are likely to become grouped together

::Law of Proximity (Nearness)

Things that are near each other appear to be grouped together.

::Law of Similarity

Tendency to perceive things as belonging together because they share common features

:: Law of Synchrony

Visual events that occur at the same time are perceived as belonging together.

:: Law of Uniform Connectedness

A connected region of visual properties, such as lightness, color, texture, or motion, is perceived as a single unit

:: Learning-based inference

Emphasizes learned influences on perception

:: Monocular cues

Pictorial depth cues

::Perceptual constancy

The tendency to perceive aspects of the world as unchanging despite changes in the sensory input

:: Shape constancy

The tendency to interpret the shape of an object as constant, even when it changes on the retina

:: Size constancy

The tendency to interpret an object as always being the same size, regardless of its distance

10.10 Check your progress

1. Which of the following words does NOT describe perception

(a) A passive process

(b) A psychological process

(c) No direct contact with the physical world

(d) Using sense organs

2. The Gestalt psychologists produced a series of principles. Some of the most significant principle include

(a) Grouping, clusters, contrast

(b) Figure and ground, grouping, closure

(c) Figure and ground, grouping, clusters

(d) None of the above

3. The tendency to complete an incomplete figure to (mentally) fill in the gaps and to perceive them as whole is called

(a) Figure

(b) Grouping

(c) Ground

(d) Closure

4. The perception process demonstrates the integration of our

(a) Physiology, environment and conscious self

(b) Conscious self, unconscious self and physiology

(c) Environment, conscious self and unconscious self

(d) Unconscious self, physiology and environment

10.11 Answers to check your progress

1. a
2. b
3. d
4. b

10.12 Model questions

1. Describe the process of perception as a series of steps.

2. What is the role of higher-level or “cognitive” processes in perception?

3. Describe the Gestalt laws of perception.

LESSON - 11

LEARNING – CLASSICAL CONDITIONING

Preview

In the previous chapter key features of perception was highlighted. With regards to its laws and also illusions was discussed. In this chapter the concept of learning will be introduced. The first method of conditioning called classical conditioning will be discussed in detail. The principles and factors that influence classical conditioning will also be explored.

Learning Objectives

After studying this chapter you will be able to:

- Understand the concept of learning.
- Understand conditioning and its types.
- Understand the early experiments of classical conditioning.
- Understand the principles of classical conditioning.
- Understand the factors that influence classical conditioning.
- Understand to flow of ideas from Pavlov to Watson and the emergence of Behaviorism.

Plan of Study

11.1 Introduction To Learning

In everyday sense, learning often refers to formal methods of acquiring new knowledge or skills, such as learning in the classroom or learning to play the flute. In Psychology, however, the topic of learning is much broader. Psychologists formally define learning as a process that produces a relatively enduring change in behaviour or knowledge as a result of an individual's experience. As the result of experience, you acquire new behaviors or modify old behaviors so as to better cope with your surroundings.

In this broad sense of the word learning occurs in every setting not just in classrooms. And, learning takes place at every age. Father the psychological study of learning is not limited to humans. From alligators to zebras, learning is an important aspect of the behaviour of virtually all animals.

Much of this chapter will focus on a very basic form of learning called conditioning. Conditioning is the process of learning associations between environmental events and behavioural responses. This description may make you think conditioning has only a limited application to your life. Suppose however that at the beginning of your next Psychology class your instructor announced, “There is a surprise test today, put all your books on the floor and take out a pencil and a clean sheet of paper.”Would you feel a twinge of anxiety? If you did it would be an example of the power of conditioned learning. You've learned to feel anxious when you hear the word test.

From simple actions, like answering the telephone, to more complex skills, like programming a cell phone, much of your everyday behaviour reflects learning through conditioning. There are two basic types of conditioning –classical conditioning and operant conditioning. Classical conditioning explains how certain stimuli can trigger an automatic response. And, as you will see in the following chapters, operant conditioning is useful in understanding how we acquire New, voluntary actions. Finally, we will also consider the process of observational learning or how we acquire New behaviors by observing the actions of others.

11.2 Introduction To Classical Conditioning

One of the major contributors to the study of learning was not a psychologist bit a Russian physiologist who was awarded a Nobel Prize for his work on digestion. Ivan Pavlov was a brilliant scientist who directed several research laboratories in St. Petersburg, Russia, at the turn of the twentieth century. Pavlov's involvement with Psychology began as a result of an observation he made while investigating the role of saliva in digestion, using dogs as his experimental subjects.

In order to get a dog to produce saliva, Pavlov (1904) put food on the dog's tongue. After he had worked with the same dog for several days in a row, Pavlov noticed something curious. The dog began salivating before Pavlov put the food on its tongue. In fact, the dog began salivating when Pavlov entered the room or even at the sound of his approaching footsteps. But salivating is a reflex –a largely involuntary automatic response to an external stimulus. The dog should salivate only after the food was presented not before. Why would the reflex occur before the stimulus was presented? What was causing this unexpected behaviour?

If you own a dog, You've probably observed the same basic phenomenon. Your dog gets excited and begins to sooner when you shake a box of dog biscuits, even before you've given him a doggie treat. In everyday language, your pet has learned to anticipate food in association with some signal – namely, the sound of dog biscuits rattling in a box.

Pavlov abandoned his research on digestion and devoted the remaining 30 years of his life to investigating different aspects of this phenomenon. Let's look at what he discovered in more detail.

11.3 Principles of Classical Conditioning

The process of conditioning that Pavlov discovered was the first to be extensively studied in psychology. Thus, it's called classical conditioning. Also called respondent conditioning or Pavlovian conditioning, classical conditioning deals with behaviours that are elicited automatically by some stimulus. Elicit means draw out or bring forth that is the stimulus doesn't produce a new behaviour but rather causes an existing behaviour to occur.

Classical conditioning always involves some kind of reflexive behaviour. Remember, a reflex is a relatively simple, unlearned behaviour, governed by the nervous system. In Pavlov's original studies of digestion, the dogs salivate reflexively when food was placed on their tongues. But when the dogs began salivating in response to the sight of Pavlov or to the sound of his footsteps, a new, learned stimulus elicited the salivary response. This, in classical conditioning, a new stimulus-response sequence is learned.

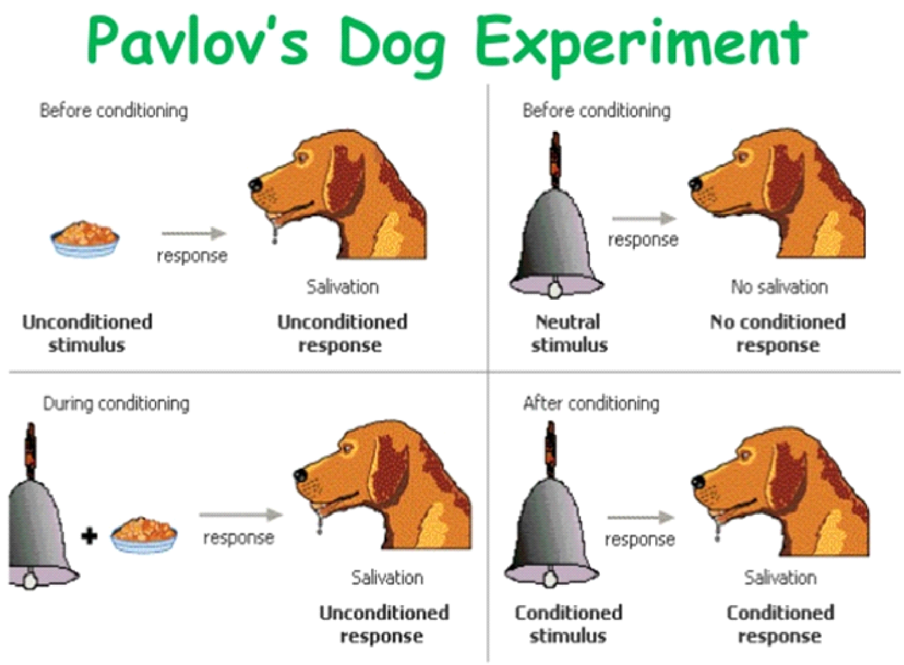
How does this kind of learning take place? Essentially, classical conditioning is a process of learning an association between two stimuli. Classical conditioning involves pairing a neutral stimulus (e.g., the sight of Pavlov) with an unlearned natural stimulus (food in the mouth) that automatically elicits a reflexive response (the dog salivates). If the two stimuli (Pavlov + Food) are repeatedly paired, eventually the neutral stimulus (Pavlov) elicits the same basic reflexive response as the natural stimulus (food) – even in the absence of the natural stimulus. So, when the dog in the laboratory started salivating at the sight of Pavlov before the food was placed on its tongue, it was because the dog had formed a new, learned association between the sight of Pavlov and the food.

Pavlov used special terms to describe each element of the classical conditioning process. The natural stimulus that reflexively produces a response without prior learning is called the unconditioned stimulus (abbreviated UCS). In this example, the unconditioned stimulus is the food in the dog's mouth. The unlearned, reflexive response is called the unconditioned response (or UCR). The unconditioned response is the dog's salivation.

To learn more about his discovery, Pavlov (1927) controlled the stimuli that preceded the presentation of food. For example, in one set of experiments, he used a bell as a neutral stimulus – neutral because dogs don't normally salivate to the sound of a ringing bell. Pavlov first rang the bell and then gave the dog food. After this procedure was repeated several times, the dog began to salivate when the bell was rung, before the food was put in its mouth. At that point, the dog was classically conditioned to salivate to the sound of a bell alone. That is, the dog had learned a new association between the sound of the bell and the presentation of food.

Pavlov called the sound of the bell the conditioned stimulus. The conditioned stimulus (or CS) is the stimulus that is originally neutral but comes to elicit a reflexive response. He called the dog's salivation to the sound of the bell the conditioned response (or CR), which is the learned reflexive response to a previously neutral stimulus.

Classical conditioning terminology can be confusing. You may find it helpful to think of the word conditioned as having the same meaning as "learned". Thus, the "conditioned stimulus" refers to the "learned stimulus", the "unconditioned response" refers to the "unlearned response", and so forth.



It's also important to note that in this case the unconditioned response and the conditioned response describe essentially the same behavior – the dog's salivating. Which label is applied depends on which stimulus elicits the response. If the dog is salivating in response to a neutral stimulus that was not acquired through learning, the salivation is an unconditioned response. If, however, the dog has learned to salivate to a neutral stimulus that doesn't normally produce the automatic response, the salivation is a conditioned response.

11.4 Factors That Affect Conditioning

Over the three decades that Pavlov (1928) spent studying classical conditioning, he discovered many factors that could affect the strength of the conditioned response. For example, he discovered that the more frequently the conditioned stimulus and the unconditioned stimulus were paired, the stronger was the association between the two.

Pavlov also discovered that the timing of the stimulus presentations affected the strength of the conditioned response. He found that conditioning was most effective when the conditioned stimulus was presented immediately before the unconditioned stimulus.

Pavlov (1927) also noticed that once a dog was conditioned to salivate to a particular stimulus, new stimuli could also elicit the conditioned salivary response. For example, Pavlov conditioned a dog to salivate to a low-pitched tone. When he sounded a slightly higher-pitched tone, the conditioned salivary response would also be elicited. Pavlov called this phenomenon stimulus generalization. Stimulus generalization occurs when stimuli that are similar to the original conditioned stimulus also elicit the conditioned response, even though they have never been paired with the unconditioned stimulus.

Just as a dog can learn to respond to similar stimuli, so it can learn the opposite – to distinguish between similar stimuli. For example, Pavlov repeatedly gave a dog some food following a low-pitched tone. The dog learned to distinguish between the two tones, salivating to the high-pitched tone but not to the low-pitched tone. This phenomenon, stimulus discrimination, occurs when a particular conditioned response is made to one stimulus but not to other similar stimuli.

Here's an example of stimulus generalization versus discrimination. Recall our example of dog who drools (the CR) when he hears the rattling sound (the CS) of dog biscuits in the box. If your dog also drools one day when you shake a box of goldfish crackers as you pour them in a serving bowl, stimulus generalization has taken place. Eventually, your dog learns that to distinguish between one sound that predicts the delivery of a doggie treat (the rattling dog biscuits) and you shake the box of dog biscuits, but he doesn't when you shake the box of crackers. At this point, stimulus discrimination has taken place.

Once learned, can conditioned responses be eliminated? Pavlov (1927) found that conditioned responses could be gradually weakened. If the conditioned stimulus (the ringing bell) was repeatedly presented without being paired with the unconditioned stimulus (the food), the conditioned response seemed to gradually disappear. Pavlov called this process of decline and eventual disappearance of the conditioned response extinction.

Pavlov also found that the dog did not simply return to its unconditioned state following extinction. If the animal was allowed a period of rest (such as a few hours) after the response was extinguished, the conditioned response would reappear when the conditioned stimulus was again presented. This reappearance of a previously extinguished conditioned response after a period of time without exposure to the conditioned stimulus is called spontaneous recovery. The phenomenon of spontaneous recovery demonstrates that extinction is not unlearning. That is, the learned response may seem to disappear, but it is not eliminated or erased.

11.5 The Founding of Behaviorism

John B. Watson

Over the course of three decades, Pavlov systematically investigated different aspects of classical conditioning. Throughout this process, he used dogs almost exclusively as his experimental subjects. Since Pavlov believed he had discovered the mechanism by which all learning occurs, it seems ironic that he had very little to say about applications of classical conditioning to human behavior. This irony is less puzzling when you understand that Pavlov wanted nothing to do with the newly established science of psychology. Why?

At the beginning of the twentieth century, psychology's early founders had defined the field as the scientific study of mind. They advocated the use of introspective self-reports to achieve two fundamental goals: describing and explaining conscious thought and perceptions. Because the early psychologists wanted to study subjective states of consciousness, Pavlov did not see psychology as an exact or precise science, like physiology or chemistry. As Pavlov (1927) wrote, " It is still open to discussion whether psychology is a natural science or whether it can be regarded as a science at all."

At about the same time Pavlov was conducting his systematic studies of classical conditioning in the early 1900s, a young psychologist named John B. Watson was attracting attention in the United States. Watson, like Pavlov, believed that psychology was following the wrong path by focusing on the study of subjective mental processes. In 1913, Watson directly challenged the early founders of psychology when he published a landmark article entitled "Psychology as the Behaviorist Views It." With the publication of this article, Watson founded a new school, or approach, in psychology, called behaviorism. Watson strongly advocated that psychology should be redefined as the scientific study of behavior. As he later (1924) wrote, "Let us limit ourselves to things that can be observed, and formulate laws concerning only those things. Now what can we observe? We can observe behavior – what the organism does or says."

But having soundly rejected the methods of introspection and the study of consciousness, the young Watson was somewhat at a loss for a new method to replace them. By 1915 when Watson was elected president of the American Psychological Association, he had learned of Pavlov's research. Watson (1916) embraced the idea of the conditioned reflex as the model he had been seeking to investigate and explain human behavior.

Watson believed that virtually all human behavior is a result of conditioning and learning – that is, due to past experiences and environmental influences. In championing behaviorism, Watson took his views to an extreme, claiming that neither talent, personality nor intelligence was inherited.

11.6 Summary

- Learning is defined as a relatively enduring change in behavior or knowledge that is due to past experience.
- Conditioning is the process of learning associations between environmental events and behavioral responses
- Ivan Pavlov, a Russian physiologist, discovered the principles of classical conditioning while studying the digestive system of dogs.
- Classical conditioning deals with reflexive behaviors that are elicited by a stimulus and results from learning an association between two stimuli.
- Factors that affect the strength of the conditioned response include the frequency with which the conditioned and unconditioned stimuli are paired and the timing of the stimulus presentations.
- John B. Watson defined psychology as the scientific study of behavior and founded behaviorism. According to Watson, all human behavior is a result of conditioning and learning.

11.7 Keywords

Learning: A process that produces a relatively enduring change in behavior or knowledge as a result of past experience.

Conditioning: The process of learning associations between environmental events and behavioral responses.

Classical Conditioning: The basic learning process that involves repeatedly pairing a neutral stimulus with a response-producing stimulus until the neutral stimulus elicits the same response; also called respondent conditioning or Pavlovian conditioning.

Unconditional Stimulus (UCS): The natural stimulus that reflexively elicits a response without the need for prior learning.

Unconditioned Response (UCR): The unlearned, reflexive response that is elicited by an unconditioned stimulus.

Conditioned Stimulus (CS): A formerly neutral stimulus that acquires the capacity to elicit a reflexive response.

Conditioned Response (CR): The learned, reflexive response to a conditioned stimulus.

Stimulus Generalization: The occurrence of a learned response not only to the original stimulus, but to other, similar stimuli as well.

Stimulus Discrimination: The occurrence of a learned response to a specific stimulus, but not to other, similar stimuli.

Extinction: The gradual weakening and apparent disappearance of conditioned behavior. In classical conditioning, extinction occurs when the conditioned stimulus is repeatedly presented without the unconditioned stimulus.

Spontaneous Recovery: The reappearance of a previously extinguished conditioned response se after a period of time without exposure to the conditioned stimulus.

Behaviorism: School of psychology and theoretical viewpoint that emphasizes the scientific study of observable behaviors, especially as they pertain to the process of learning.

11.8 Check Your Progress

For each of the following examples, use the diagram below to help identify the neutral stimulus, UCS, UCR, CS and CR.

1. When Cindy's four-month-old infant cried, she would begin breast-feeding him. One evening, Cindy went to a movie with her husband, leaving her baby at home with a sitter. When an infant in the theater began to cry, Cindy experienced the "let-down" reflex, and a few drops of milk stained her new silk blouse.

During Conditioning:

Neutral stimulus + UCS UCR

(a) _____________ + (b) __________ (c) ______________

After Conditioning:

Conditioned Stimulus(CS) Conditioned Response (CR)

(d) ___________________ (e) _____________________

2. Nine months after two planes hit the World Trade Center, exploded, and demolished, and demolished Ken's New York City neighborhood, Ken still flinches every time he hears a low-flying jet overhead.

During Conditioning:

Neutral stimulus + UCS UCR

(a)_____________ + (b) ______________ (c)______________

After Conditioning:

Conditioned Stimulus (CS) Conditioned Response (CR)

(d) ___________________ (e) _____________________

3. After swimming in the lake near his home one day, Frank emerged from the water covered with slimy, blood sucking leeches all over his legs and back. He was revolted as he removed the leeches. Now, every time he passes the lake, Frank shudders in disgust.

During Conditioning:

Neutral stimulus + UCS UCR

(a)____________ + (b) ____________________ (c)______________

After Conditioning:

Conditioned Stimulus (CS) Conditioned Response (CR)

(d) ___________________ (e) _____________________

4. Every time two-year-old Jodie heard the door bell ring, she raced to open the front door. On Halloween night, Jodie answered the doorbell and encountered a scary monster with nine flashing eyes. Jodie screamed in fear and ran away. Now Jodie screams and hides whenever the doorbell rings.

During Conditioning:

Neutral stimulus + UCS UCR

(a)____________ + (b) ____________________ (c)______________

After Conditioning:

Conditioned Stimulus (CS) Conditioned Response (CR)

(d) ___________________ (e) _____________________

11.9 Answers To Check Your Progress

1. (a) baby crying; (b) nursing baby; (c) let-down reflex, breast milk flow; (d) baby's cry; (e) let-down reflex, breast milk flows.
2. (a) sound of plane; (b) explosion; (c) flinching, fear; (d) sound of plane; (e) flinching, fear.

3. (a) lake; (b) leeches; (c) disgust; (d) lake; (e) disgust
4. (a) doorbell; (b) scary monster; (c) fear; (d) doorbell; (d) fear.

11.10 Model Questions

1. Define Learning.
2. What is classical conditioning? Explain the principles of classical conditioning.
3. What are the factors that influence classical

LESSON 12
OPERANT CONDITIONING

Preview

In the previous chapter the concept of learning was introduced. An elaborate explanation of the pioneering research in the role of salivation in digestion carried out by Ivan Pavlov that highlighted not digestion but the principles of learning was discussed. The varied factors that influence classical conditioning was discussed. Conclusively, also a journey from Pavlov to Watson and the emergence of Behaviorism was explored. In this chapter the concept of operant conditioning will be introduced. An elaborate discussion of reinforcement and punishment and their types will be done. The concept of discriminative stimuli and shaping and maintaining behavior will also be explored.

Learning Objectives

After studying this chapter you will be able to:

- Understand the concept of operant conditioning.
- Understand reinforcement and illustrate the types of reinforcement
- Understand punishment and its types
- Understand effective and ineffective methods of punishment.
- Understand shaping and maintaining behavior

Plan of Study

12.1 Introduction To Operant Conditioning

12.2 Thorndike and The Law of Effect

12.3 Burrhus Frederick Skinner and the Search for "Order in Behavior"

12.4 Reinforcement

12.5 Punishment

12.6 Shaping and Maintaining Behavior

12.7 Summary

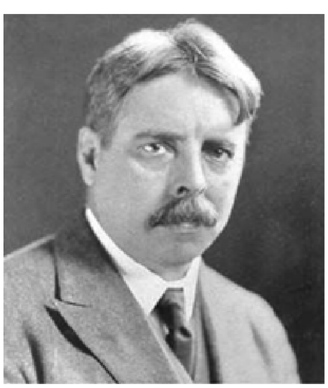
12.8 Keywords

12.1 Introduction To Operant Conditioning

Classical conditioning can help explain the acquisition of many learned behaviors, including emotional and physiological responses. However, recall that classical conditioning involves reflexive behaviors that are automatically elicited by a specific stimulus. Most everyday behaviors don't fall into this category. Instead, they involve nonreflexive, or voluntary actions that can't be explained with classical conditioning. Raising your hand in class, formatting a computer diskette, operating a vending machine, spiking a volleyball over the net, combing out a child's wet hair, hailing a cab- these are just a few quick examples of the enormous range of non-reflexive, or voluntary, behaviors that people perform every day.

The investigation of how voluntary behaviors are acquired began with a young American psychology student named Edward L. Thorndike. A few years before Pavlov began his extensive studies of classical conditioning. Thorndike was using cats, chicks and dogs to investigate how voluntary behaviors are acquired. Thorndike's pioneering studies helped set the stage for the later work of another American psychologist named B.F. Skinner. It was Skinner who developed operant conditioning, another form of conditioning that explains how we acquire and maintain voluntary behaviors.

12.2 Thorndike and the Law of Effect



Edward Thorndike

Edward L. Thorndike was the first psychologist to systematically investigate animal learning and how voluntary behaviors are influenced by their consequences. At the time, Thorndike was only in his early twenties and a psychology graduate student. He conducted his pioneering studies to complete his dissertation and earn his doctorate in psychology. Published in 1898, Thorndike's dissertation, titled Animal Intelligence: An Experimental Study of the Associative Processes in Animals, is the most famous dissertation ever published in psychology. When Pavlov later learned of Thorndike's studies, he expressed admiration and credited Thorndike with having started objective animal research well before his own studies of classical conditioning.

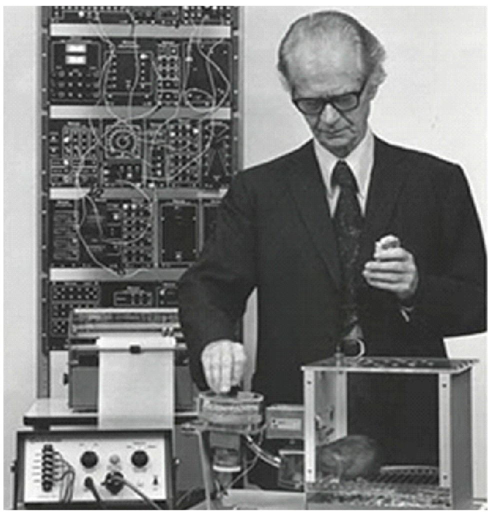
Thorndike's dissertation focused on the issue of whether animals, like humans, use reasoning to solve problems. In an important series of experiments, Thorndike (1898) put hungry cats in specially constructed cages that he called "puzzle boxes". A cat could escape the cage by some simple act, such as pulling a loop or pressing a lever that would unlatch the cage door. A plate of food was placed just outside the cage, where the hungry cat could see and smell it.

Thorndike found that when the cat was first put into the puzzle box, it would engage in many different, seemingly random behaviors to escape. For example, the cat would scratch at the cage door, claw at the ceiling, and try to squeeze through the wooden slats. Eventually, however, the cat would accidentally pull on the loop or step on the lever, opening the door latch and escaping the box. After several trials in the same puzzle box, a cat gradually took less and less time to get the cage door open. Thorndike carefully recorded the time of each trial and plotted the data to create a "time-curve" that depicted the rate of the cat's learning.

Assessing his results, Thorndike (1898) concluded that the cats did not display any humanlike insight or reasoning in unlatching the puzzle box door. Instead, he explained the cats' learning as a process of trial and error. Thorndike actually preferred the phrase "trail and success" to emphasize the relationship between actions and their consequences. Over the course of many trials, the cats gradually learned to associate certain responses with successfully escaping the box and gaining the food reward. According to Thorndike, these successful behaviors became "stamped in" so that a cat was more likely to repeat these behaviors when placed in the puzzle box again. Unsuccessful behaviors were gradually eliminated.

On the basis of his observations, Thorndike (1911) eventually formulated the law of effect: Responses followed by a satisfying state of affairs" are "strengthened" and more likely to occur again in the same situation. Conversely, responses followed by an unpleasant or annoying state of affairs are “weakened” and less likely to occur again.

12.3 Burrhus Frederick Skinner and the Search for “Order in Behavior”



B.F. Skinner

From the time he was a graduate student in psychology until his death, the famous American psychologist B.F. Skinner searched for the “lawful processes” that would explain “order in behavior”. Skinner was a staunch behaviorist. Like Watson, Skinner strongly believed that psychology should restrict itself to studying only phenomena that could be objectively measured and verified – outwardly observable behavior and environmental events.

Skinner (1974) acknowledged the existence of what he called “internal factors,” such as thoughts, expectations, and perceptions. However, Skinner believed that internal thoughts, beliefs, emotions, or motives could not be used to explain behavior. These fell into the category of “private events” that defy direct scientific observation and should not be included in an objective, scientific explanation of behavior.

Along with being influenced by John Watson’s writings, Skinner greatly admired Pavlov’s work. Skinner acknowledged that Pavlov’s classical conditioning could explain the learned association of stimuli in certain reflexive responses. But classical conditioning was limited to existing behaviors that were reflexively elicited. Skinner (1979) was convinced that he had “found a process of conditioning that was different from Pavlov’s and much more like most learning in daily life”. To Skinner the most important form of learning was demonstrated by new behaviors that were actively emitted by the organism, such as the active behaviors produced by Thorndike’s cats in trying to escape the puzzle boxes.

Skinner (1953) coined the term operant to describe any “active behavior that operates upon the environment to generate consequences.” In everyday language, Skinner’s principles of operant conditioning explain how we acquire the wide range of voluntary behaviors that we perform in daily life.

12.4 Reinforcement

In a nutshell, Skinner’s operant conditioning explains learning as a process in which behavior is shaped and maintained by its consequences. One possible consequence of a behavior is reinforcement. Reinforcement is said to occur when a stimulus or an event follows an operant and increases the likelihood of the operant being repeated. Notice that reinforcement is defined by the effect it produces – increasing or strengthening the occurrence of a behavior in the future.

12.4.1 Positive and Negative Reinforcement

There are two forms of reinforcement: positive reinforcement and negative reinforcement. Both increase future behavior, but they do so in different ways. It’s easier to understand these differences if you note at the outset that Skinner did not use the terms positive and negative in their everyday sense of meaning “good” and “bad” or “desirable’ and “undesirable”. Instead, think of the words positive and negative in terms of their mathematical meanings. Positive is the equivalent of a plus sign (+), meaning that something is added. Negative is the equivalent of a minus sign (-), meaning that something is subtracted or removed. If you keep that distinction in mind, the principles of positive and negative reinforcement should be easier to understand.

Positive reinforcement involves following an operant with the addition of a reinforcing stimulus. In positive reinforcement situations a response is strengthened because something is added or presented. Everyday examples of positive reinforcement in action are easy to identify. Here are some quick examples:

- A rat presses a lever (the operant) and receives a food pellet (the reinforcing stimulus).

- You reach your sales quota at work (the operant) and you get a bonus check (the reinforcing stimulus).

In each example, if the addition of the reinforcing stimulus has the effect of making you more likely to repeat the operant in similar situations in the future, then positive reinforcement has occurred. It's important to point out that what constitutes a reinforcing stimulus can vary from person to person, species to species, and situation to situation.

Negative reinforcement involves an operant that is followed by the removal of an aversive stimulus. In negative reinforcement situations, a response is strengthened because something is being subtracted or removed. Remember that the word negative in negative reinforcement is used like a mathematical minus sign (-).

Aversive stimuli typically involve physical or psychological discomfort that an organism seeks to escape or avoid. Consequently, behaviors are said to be negatively reinforced when they let you either (1) escape aversive stimuli that are already present or (2) avoid aversive stimuli before they occur. That is, we're more likely to repeat the same escape or avoidance behaviors in similar situations in the future.

Many students find the concept of negative reinforcement confusing until they realize just how common it is in everyday life. Here are some examples of negative reinforcement involving escape or avoidance behavior:

- You switch on the air conditioning (the operant) to escape the summer heat (the aversive stimulus).
- You get to class on time (the operant) to avoid being scolded (the aversive stimulus) by your instructor.

In each example, if escaping or avoiding the aversive event has the effect of making you more likely to repeat the operant in similar situations in the future, then negative reinforcement has taken place.

12.4.2 Primary and Conditioned Reinforcers

Skinner also distinguished two kinds of reinforcing stimuli: primary and conditioned. A primary reinforce is one that is naturally reinforcing for a given species. That is, even if an individual has not had prior experience with the particular stimulus, the stimulus or event still has reinforcing properties. For example, food, water, adequate warmth, and sexual contact are primary reinforcers for most animals, including humans.

A conditioned reinforcer, also called a secondary reinforce, is one that has acquired reinforcing value by being associated with a primary reinforce. The classic example of a conditioned reinforce is money. Money is reinforcing not because those flimsy bits of paper and little pieces of metal have value in and of themselves, but because we've learned that we can use them to acquire primary reinforcers and other conditioned reinforcers. Awards, frequent-flyer points, and college degrees are just a few other examples of conditioned reinforcers.

Sometimes there are many links in the association between a conditioned reinforce and a primary reinforce. You can't plunk your college diploma down on the counter to purchase a loaf of bread at the grocery store, but your college degree can lead to a job that provides you with money to exchange or the primary reinforce of food. The respect of your peers and the approval of your instructors or managers can be powerful conditioned reinforcers. Conditioned reinforcers can be as subtle as a smile, a touch, or a nod of recognitions.

12.5 Punishment

Positive and negative reinforcement are processes that increase the frequency of a particular behavior. The opposite effect is produced by punishment. Punishment is a process in which a behavior is followed by an aversive consequence that decreases the likelihood of the behavior being repeated. Many people tend to confuse punishment and negative reinforcement, but these two processes produce entirely different effects on behavior. Negative reinforcement always increases the likelihood that an operant will be repeated in the future. Punishment always decreases the future performance of an operant.

12.5.1 Punishment By Application

Skinner (1953) identified two types of aversive events that can act as punishment. Punishment by application, also called positive punishment, involves a response being followed by the presentation of an aversive stimulus. The word positive in the phrase positive punishment signifies that something is added or presented in the situation. In this case, its an aversive stimulus. Here are some everyday examples of punishment by application:

- An employee wears jeans to work (the operant) and is reprimanded by his supervisor for dressing inappropriately (the punishing stimulus).

- You make a comment (the operant) in your workgroup meetings, and a co-worker responds with a sarcastic remark (the punishing stimulus).

In each of these examples, if the presentation of the punishing stimulus has the effect of decreasing the behavior it follows, then punishment has occurred. Although the punishing stimuli in these examples were administered by other people, punishing stimuli also occur as natural consequences for some behaviors. Inadvertently touching a hot iron, a live electrical wire, or a sharp object (the operant) can result in a painful injury.

12.5.2 Punishment By Removal

The second type of punishment is punishment by removal, also called negative punishment. The word negative indicates that some stimulus is subtracted or removed from the situation. In this case, it is the loss or withdrawal of a reinforcing stimulus following a behavior. That is, the behavior's consequence is the loss of some privilege, possession, or other desirable object or activity. Here are some everyday examples of punishment by removal:

- After he speeds through a stop sign and broadsides a school bus (the operant), a person's driver's license is suspended (loss of reinforcing stimulus).
- A student fails two classes (the operant) and loses his financial aid (loss of reinforcing stimulus).

In each example, if the behavior decreases in response to the removal of the reinforcing stimulus, then punishment has occurred.

12.5.3 Effective Punishment

It's important to stress that, like reinforcement, punishment is defined by the effect it produces. In everyday usage, people often refer to a particular consequence as a punishment when, strictly speaking it's not. Why? Because the consequence has not reduced future occurrences of the behavior.

Skinner (1953) as well as other researchers have noted that several factors influence the effectiveness of punishment. For example, punishment is more effective if it immediately follows a response than if it is delayed. Punishment is also more effective if it consistently, rather than occasionally, follows a response. Though speeding tickets and prison sentences are commonly referred to as punishments, these aversive consequences are inconsistently applied and often administered only after a long delay. Thus, they don't always effectively decrease specific behaviors.

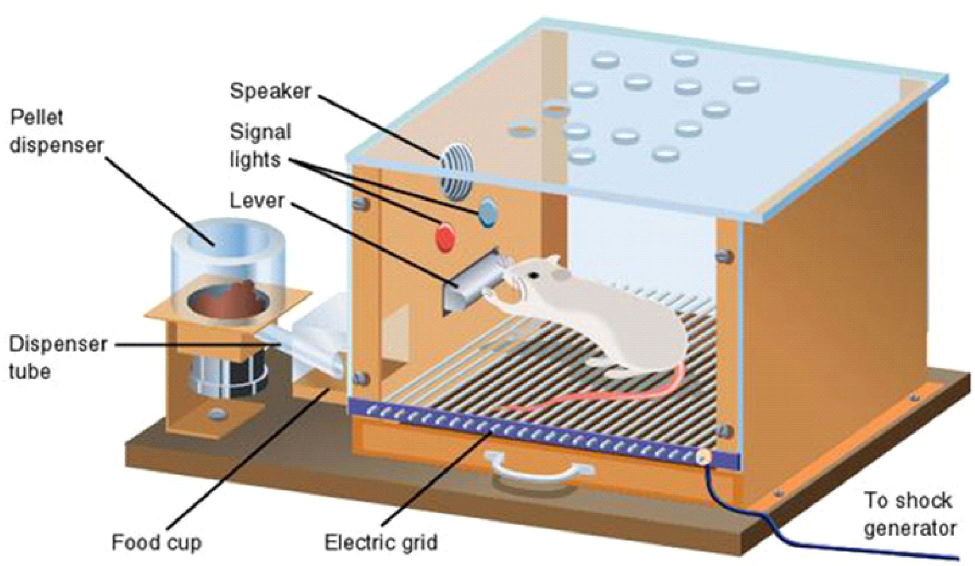
12.5.4 Drawbacks of Punishment

Even when punishment works, its use has several drawbacks. First, punishment may decrease a specific response, but it doesn't necessarily teach or promote a more appropriate response to take its place. Second, punishment that is intense may produce undesirable results, such as complete passivity, fear, anxiety, or hostility. Finally, the effects of punishment are likely to be temporary. A child who is sent to her room for teasing her little brother may well repeat the behavior when her mother's back is turned. As Skinner (1971) noted, "Punished behavior is likely to reappear after the punitive consequences are withdrawn.

12.6 Shaping and Maintaining Behavior

To scientifically study the relationship between behavior and its consequences in the laboratory, Skinner invented the operant chamber, more popularly known as the Skinner box. An operant chamber is a small cage with a food dispenser. Attached to the cage is a device that automatically records the number of operants made by an experimental animal, usually a rat or pigeon. For a rat, the typical operant is pressing a bar; for a pigeon, it is pecking at a small disk. Food pellets are usually used for positive reinforcement.

SKINNER BOX



When a rat is first placed in a Skinner box, it typically explores its new environment, occasionally nudging or pressing the bar in the process. The researcher can accelerate the rat's bar-pressing behavior through a process called shaping. Shaping involves reinforcing successively closer approximations of a behavior until the correct behavior is displayed. For example, the researcher might first reinforce the rat with a food pellet whenever it moves to the half of the Skinner box in which the bar is located. Other responses would be ignored. Once that response has been learned, reinforcement is withheld until the rat moves even closer to the bar. Then the rat might be reinforced only when it touches the bar. Step by step, the rat is reinforced for behaviors that correspond ever more closely to the final goal behavior – pressing the bar.

Skinner believed that shaping could explain how people acquire a wide variety of abilities and skills – everything from tying shoes to operating sophisticated computer programs. To illustrate, consider how parent s can use shaping to teach a toddler to dress herself. At first they might praise her for simply picking up a shirt, and then for managing to pull it over her head. Once that step is mastered, she would be reinforced only when she poked her head and arms through the appropriate shirt holes. Eventually praise is forthcoming only when, as a preschooler, she picks out clothes that match, or when, as an adolescent, she chooses an outfit that doesn't mortify her parents.

12.6.1 The Partial Reinforcement Effect: Building Resistance to Extinction

Once a rat had acquired a bar-pressing behavior, Skinner found that the most efficient way to strengthen the response was to immediately reinforce every occurrence of bar pressing. This pattern of reinforcement is called continuous reinforcement. In everyday life, of course, it's common for responses to be reinforced only sometimes – a pattern called partial reinforcement. For example, practicing your basketball skills isn't followed by putting the ball through the hoop on every shot. Sometimes you're reinforced by making a basket, and sometimes you're not.

Now suppose that despite all your hard work, your basketball skills are dismal. If practicing free throws was never reinforced by making a basket, what would you do? You'd probably eventually quit playing basketball. This is an example of extinction. In operant conditioning, when a learned response no longer results in reinforcement, the likelihood of the behavior being repeated gradually declines.

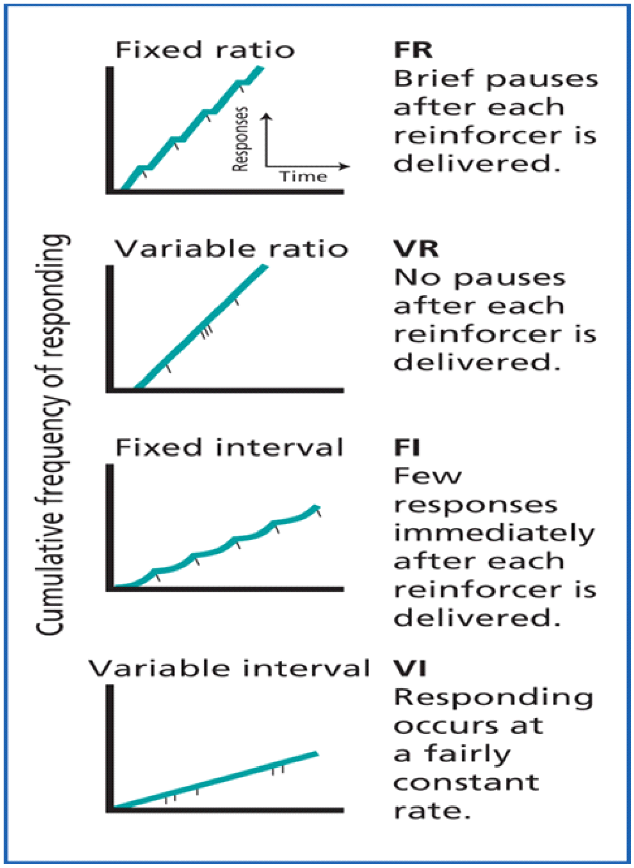
Skinner (1956) first noticed the effects of partial reinforcement when he began running low on food pellets one day. Rather than reinforcing every bar press, Skinner tried to stretch out his supply of pellets by rewarding responses only periodically. He found that the rats not only continued to respond, but actually increased their rate of bar pressing.

One important consequence of partially reinforcing behavior is that partially reinforced behaviors tend to be more resistant to extinction than are behaviors conditioned using continuous reinforcement. This phenomenon is called the partial reinforcement effect. For example, when Skinner shut off the food dispensing mechanism, a pigeon conditioned using continuous reinforcement would continue pecking at the disk 100 times or so before the behavior decreased significantly, indicating extinction. In contrast, a pigeon conditioned with partial reinforcement continued to peck at the disk thousands of times! If you think about it, this is not surprising. When pigeons, rats or humans have experienced partial reinforcement, they've learned that reinforcement may yet occur, despite delays and nonreinforced responses, if persistent responses are made.

In everyday life, the partial reinforcement effect is reflected in behaviors that persist despite the lack of reinforcement. Gamblers may persist despite a string of losses, writers will persevere in the face of repeated rejections slips, and the family dog will continue begging for the scraps of food that it has only occasionally received at the dinner table in the past.

12.6.2 The Schedules of Reinforcement

Skinner (1956) found that specific preset arrangements of partial reinforcement produced different patterns and rates of responding. Collectively, these different reinforcement arrangements are called schedules of reinforcement.



Fixed-Ratio Schedule (FR)

With a fixed ratio (FR) schedule, reinforcement occurs after a fixed number of responses. For example, a rat might be on a 25-to-1 fixed-ratio (abbreviated FR-25), meaning it has to press the bar 25 times in order to receive one food pellet. Not surprisingly, shaping is usually needed to get a rat to the point at which it will press the bar 25 times in order to get one food pellet. The rat may start on continuous reinforcement, followed by an FR-2 schedule, then an FR-4 schedule and so on.

Fixed-ratio schedules typically produce a high rate of responding that follows a burst-pause-burst pattern. The rat displays a burst of bar pressing, receives a pellet of food, pauses briefly, then displays another burst of responding. In everyday life, the fixed-ratio schedule is reflected in any activity that requires a precise number of responses in order to obtain reinforcement. Piecework – work for which you are paid for producing a specific number of items, such as being paid $1 for every 100 envelopes you stuff- is an example of an FR-100 schedule.

Variable-Ratio Schedule (VR)

With a variable-ratio (VR) schedule, reinforcement occurs after an average number of responses, which varies from trial to trial. For example, a rat on a variable-ratio- 2-schedule (abbreviated VR-20) would be reinforced after an average of 20 responses. But the rat might have to press the bar 25 times on the first trial before being reinforced and only 15 times on the second trial before reinforcement. Although the number of responses required on any specific trial is unpredictable, over repeated trials the ratio of responses to reinforceers works out to be the predetermined average.

Variable-ratio schedules of reinforcement produce high, steady rates of responding with hardly any pausing between trials or after reinforcement. Why do variable-ratio schedules produce such persistent responses? One explanation is that although it's impossible to predict which responses will result in reinforcement, the more responses that are made, the greater the likelihood of reinforcement. The combination of these two factors can make some behaviors, such as gambling "addictive" for some people. Gambling is the classic example of a variable-ratio schedule in real life. Each spin of the roulette wheel, toss of the dice, or purchase of a lottery ticket could be the big one, and the more often you gamble, the more opportunities you have to win.

Fixed –Interval Schedule (FI)

With a fixed-interval (FI) schedule, a reinforce is delivered for the first response emitted after the preset time interval has elapsed. A rat on a two-minute fixed-interval schedule would receive no food pellets for any bar presses made during the first two minutes, whether it pressed the bar twice or 100 times. But the first bar press after the two-minute interval has elapsed would be reinforced.

Fixed-interval schedules typically produce a pattern of responding in which the number of responses tends to increase as the time for the next reinforce draws near. Long pauses in responding after reinforcement are especially common when the fixed interval is large. For example, a rat conditioned at an FI-10 minutes schedule may go for several minutes without pressing the bar. But as the end of the 10-minute interval draws near, bar pressing steadily increases until reinforcement occurs.

Daily life contains examples if reinforcement that follows a very similar pattern to the laboratory example of fixed-interval reinforcement. For instance, if your instructor gives you a test every four weeks, your studying behavior would probably follow the same pattern of responding as the rat's bar pressing behavior. As the end of the four-week interval draws near, studying behavior increases. After the test, studying behavior drops off until the end of the next four-week interval draws near. The same effect can occur with an employee's annual performance review. As the time for the performance review gets closer, the employee's productive behaviors (the operant) tend to increase.

Variable-Interval Schedule (VI)

On a variable-interval (VI) schedule, reinforcement occurs for the first response emitted after an average amount of time has elapsed, but the interval varies from trial to trial. In other words, the length of time that must pass before a particular reinforcement is delivered is unpredictable, but over a series of trials, it works out to a predetermined average. A rat on a VI-30 seconds schedule might be reinforced on trial 1 for the first bar press after only 10 seconds have elapsed, for the first bar press after 50 seconds have elapsed on trial 2, and for the first bar press after 30 seconds have elapsed on trial 3. This works out to an average of one reinforce every 30 seconds.

Generally the unpredictable nature of variable-interval schedules tends to produce moderate but steady rates of responding, especially when the average interval is relatively short. In daily life, we experience variable interval schedules when we have to wait for events that follow an approximate, rather than a precise schedule. Trying to connect to the internet via a dial-up model during peak usage hours in one example. When you encounter a busy signal you periodically try connecting because you know that at some point you'll be able to access the network. However, it's impossible to predict exactly when your attempt to connect to the network (the operant response) will be reinforced (the modem squeals and you hear the familiar, "Welcome! You've got mail!"). on a variable-interval schedule, reinforcement depends on the passage of time rather than on the number of responses. Thus, a moderately steady rate of responses will pay off in the long run.

12.7 Summary

- Edward Thorndike investigated the learning of active behaviors and formulated the law of effect.

- B.F. Skinner’s operant conditioning principles explain how operants, or new, voluntary behaviors are acquired.
- Operant conditioning explains learning as a process in which behavior is shaped and modified by its consequences.
- Reinforcement increases the likelihood of an operant being repeated.
- In positive reinforcement, a response is strengthened because a reinforcing stimulus is added or presented.
- In negative reinforcement, a response is strengthened because an aversive stimulus is subtracted or removed.
- Reinforcers may be primary reinforcers of conditioned reinforcers.
- Punishment decreases the likelihood of an operant being repeated.
- Two forms of punishment are punishment by application and punishment by removal.
- As a method of controlling behavior, punishment has many drawbacks.
- New behaviors can be acquired through the process of shaping.
- An operant chamber, or Skinner box, is often used to study the acquisition of new behaviors by laboratory animals.
- Once acquired, behaviors are maintained through continuous reinforcement of partial reinforcement.
- Schedules of reinforcement include the fixed-ratio (FR), variable-ration (VR), fixed-interval (FI), and variable-interval (VI) schedules.

12.8 Keywords

Law of effect: Learning principle proposed by Thorndike that responses followed by a satisfying effect become strengthened and are more likely to recur in a particular situation, while responses followed by a dissatisfying effect are weakened and less likely to recur in a particular situation.

Operant: Skinner’s term for an actively emitted (or voluntary) behavior that operates on the environment to produce consequences.

Operant Conditioning: The basic learning process that involves changing the probability of a response being repeated by manipulating the consequences of that response; also called Skinnerian conditioning.

Reinforcement: The occurrence of a stimulus or event following a response that increases the likelihood of that response being repeated.

Positive Reinforcement: A situation in which a response is followed by the addition of a reinforcing stimulus, increasing the likelihood that the response will be repeated in similar situations.

Negative Reinforcement: A situation in which a response results in the removal, avoidance, or escape from an aversive stimulus, increasing the likelihood that the response will be repeated in similar situations.

Primary Reinforcer: A stimulus that is naturally or inherently reinforcing for a given species, such as food, wates, or other biological necessities.

Conditioned Reinforcer: A stimulus that has acquired reinforcing value by being associated with a primary reinforce, also called a secondary reinforce.

Punishment: The presentation of a stimulus or event following a behavior that acts to decrease the likelihood of the behavior's being repeated.

Punishment by Application: A situation in which an operant is followed by the presentation or addition of an aversive stimulus; also called positive punishment.

Punishment by Removal: A situation in which an operant is followed by the removal or subtraction of a reinforcing stimulus; also called negative punishment.

Operant Chamber or Skinner Box: The experimental apparatus invented by B.F. Skinner to study the relationship between environmental events and active behaviors.

Shaping: The operant conditioning procedure of selectively reinforcing successively closer approximations of a goal behavior until the goal behavior is displayed.

Continuous Reinforcement: A schedule of reinforcement in which every occurrence of a particular response is reinforced.

Partial Reinforcement: A situation is which the occurrence of a particular response is only sometimes followed by a reinforcer.

Extinction: The gradual weakening and disappearance of conditioned behavior. In operant conditioning, extinction occurs when an emitted behavior is no longer followed by a reinforcer.

Partial Reinforcement Effect: The phenomenon in which behaviors that are conditioned using partial reinforcement are more resistant to extinction than behaviors that are conditioned using continuous reinforcement.

Schedules of Reinforcement: The delivery of a reinforce according to a present pattern based on the number of responses or the time interval between responses.

Fixed-Ratio (FR) Schedule: A reinforcement schedule in which as reinforce is delivered after a fixed number of responses has occurred.

Variable-Ratio (VR) Schedule: A reinforcement schedule in which a reinforce is delivered after a average number of responses, which varies unpredictably from trial to trial.

Fixed-Interval (FI) Schedule: A reinforcement schedule in which a reinforce is delivered for the first response that occurs after a fixed-time interval has elapsed.

Variable-Interval (VI) Schedule: A reinforcement schedule in which a reinforce is delivered for the first response that occurs after an average time interval, which varies unpredictably from trial to trial.

12.9 Check Your Progress

PART:A

Identify the operant conditioning process that is being illustrated in each of the following examples. Choose from: positive reinforcement, negative reinforcement, punishment by application and punishment by removal.

1. Feeling sorry for a woman on the side of the road, Howard offered her a ride. The woman robbed Howard and stole his car. Howard no longer picks up women because of ____.

2. As you walk out of the shoe store at the Super Mall and turn toward another store, you spot a person whom you greatly dislike. You immediately duck back into the shoe store to avoid an unpleasant interaction with him. Because ______________________________________ has occurred, you are more likely to take evasive action when you encounter people you dislike in the future.

PART : B

Indicate which of the following schedules of reinforcement is being used for each example: variable interval (VI); fixed interval (FI); variable ratio (VR); fixed ration (FR).

1. _____________________________A keypunch clerk is paid $1 for every 100 correct accounting entries made on the computer.
2. _______________________________ Miguel works 40 hours a week in an office and gets paid every Friday afternoon.
3. ________________________________ On the average, the campus shuttle bus passes the library about once every hour.

12.10 Answers To Check Your Progress

PART:A

1. Punishment by removal
2. Negative reinforcement

PART: B

1. Fixed ratio
2. Fixed interval
3. Variable interval.

12.11 Model Questions

1. Define operant conditioning
2. Define punishment. Discuss the different types of punishment.
3. Explain the schedules of reinforcement.

LESSON - 13

OBSERVATIONAL AND COGNITIVE LEARNING

Preview

In the previous chapter we discussed about the evolution of operant conditioning from the law of effect to reinforcements and punishments. Key contributions of Thorndike and B.F. Skinner were considered. An elaborate consideration of the types of reinforcements and punishments were discussed. A clear depiction of how a voluntary behavior can be shaped using varied schedules of reinforcements were also discussed. In this chapter we will consider the famous contribution of Albert Bandura: “observational learning”; also other cognitive aspects of learning in both classical and operant conditioning will be discussed.

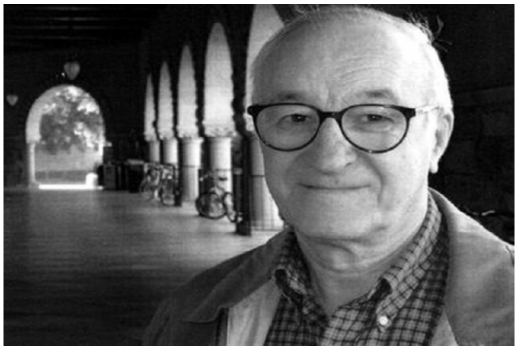
Learning Objectives

After studying this chapter you will be able to:

- Understand the theory of observational learning.
- Understand the cognitive aspects of classical conditioning.
- Understand the cognitive aspects of operant conditioning.

Plan of Study

13.1 Observational Learning



Albert Bandura

Classical conditioning and operant conditioning emphasize the role of direct experiences in learning, such as directly experiencing a reinforcing or punishing stimulus following a particular behavior. But much human learning occurs indirectly, by watching what others do, then imitating it. In observational learning, learning takes place through observing the actions of others.

Albert Bandura is the psychologist most strongly identified with observational learning. Bandura (1974) believes that observational learning is the result of cognitive processes that are actively judgmental and constructive, not merely “mechanical copying”. To illustrate his theory, let’s consider his famous experiment involving the imitation of aggressive behaviors (Bandura, 1965). In the experiment, four-year-old children separately watched a short film showing an adult playing aggressively with a Bobo doll- a large, inflated balloon doll that stands upright because the bottom is weighted with sand. All the children saw the adult hit, kick and punch the Bobo doll in the film.

However, there were three different versions of the film, each with a different ending. Some children saw the adult reinforced with soft drinks, candy and snacks after performing the aggressive actions. Other children saw a version in which the aggressive adult was a punished for the actions with a scolding and a spanking by another adult. Finally, some children watched a version of the film in which the aggressive adult experienced no consequences.

After seeing the film, each child was allowed to play alone in a room with several toys, including a Bobo doll. The playroom was equipped with a one-way window so that the child’s behavior could be observed. Bandura found that the consequences the children observed in the film made a difference. Children who watched the film in which the adult was punished were much less likely to imitate the aggressive behaviors than were children who watched either of the other two film endings.

Then Bandura added an interesting twist to the experiment. Each child was asked to show the experimenter what the adult did in the film. For every behaviors they could imitate, the child was rewarded with snacks and stickers. Virtually all the children imitated the adult's behaviors they had observed in the film, including the aggressive behaviors. The particular version of the film the children had seen made no difference.

Bandura (1965) explained these results much as Tolman explained latent learning, which will be discussed in the next section. Reinforcement in not essential for learning to occur. Rather, the expectation of reinforcement affects the performance of what has been learned.

Bandura (1986) suggests that four cognitive processes interact to determine whether imitation will occur. First, you must pay attention to the other person's behavior. Second, you must remember the other person's behavior so that you can perform it at a later time. That is you must form and store a mental representation of the behavior to be imitated. Third, you must be able to transform this mental representation into actions that you are capable of reproducing. These three factors: attention, memory and motor skills – are necessary for learning to take place through observation.

Fourth, there must be some motivation for you to imitate the behavior. This factor is crucial to the actual performance of the learned behavior. You are more likely to imitate a behavior if there is some expectation that doing so will produce reinforcement or reward.

13.2 Cognitive Aspects of Classical Conditioning

According to Pavlov, classical conditioning occurs simply because two stimuli are associated closely in time. The conditioned stimulus (the bell) precedes the unconditioned stimulus (the food) usually by no more than a few seconds. But is it possible that Pavlov's dogs were learning more than the mere association of two stimuli that occurred very close together in time?

To answer that question, let's begin with an analogy. Suppose that on your way to class you have to go through a railroad crossing. Every time a train approaches the crossing, warning lights flash. Being rather intelligent for your species, after a few weeks you conclude that the flashing lights will be quickly followed by a freight train barreling down the railroad tracks. You've learned an association between the flashing lights and an oncoming train, because the lights are a reliable signal that predict the presence of the train.

Now imagine that a friend of yours also has a cross train tracks but at a different location. The railroad has had nothing but problems with the warning lights at that crossing. Sometimes the warning lights flash before a train roars through, but sometimes they don't. and sometimes they flash when no train is coming. Does your friend learn an association between the flashing lights and oncoming trains? No, because here the flashing lights are an unreliable signal – they seem to have no relationship to a train's arrival.

Psychologist Robert A Rescorla demonstrated that classically conditioned rats also assess the reliability of signals, much like you and your friend did at the different railroad crossings. In Rescorla's 1968 experiment, one group of rats heard a tone (the conditioned stimulus) that was paired 20 times with a brief shock (the unconditioned stimulus). A second group of rats experienced the same number of tome-shock pairing, but this group also experienced an additional 20 shocks with no tone.

The Rescorla tested for the conditioned fear response by presenting the tone alone to each group of rats. According to the traditional classical conditioning model, both groups of rats should have displayed the same evels of conditioned fear. After all, each group had received 20 tone-shock pairings. However, this is not what Rescorla found. The rats in the first group displayed a much stronger fear response to the tone than did the rats in the second group. Why?

According to Rescorla (1988), classical conditioning depends on the information the conditioned stimulus provides about the unconditioned stimulus. For learning to occur, the conditioned stimulus must be a reliable signal that predicts the presentations of the unconditioned stimulus. For the first group of rats, that was certainly the situation. Every time the tone sounded, a shock followed. But for the second group, the tone was an unreliable signal. Sometimes the tone preceded the shock, and sometimes the shock occurred without warning.

Rescorla concluded that the rats in both groups were actively processing information about the reliability of the signals they encountered. Rather than merely associating two closely paired stimuli, as Pavlov suggested, the animals assess the predictive value of stimuli. Applying this interpretation to classical conditioning, we can conclude that Pavlov's dogs learned that the bell was a signal that reliably predicted that food would follow.

According to this view, animals use cognitive processes to draw inferences about the signals they encounter in their environments. To Rescorla (1988), classical conditioning "is not a stupid process by which the organism willy-nilly forms associations between any two stimuli that happen to co-occur." Rather, his research suggests that "the animal behaves like a scientist, detecting causal relations among events and using a range of information about those events to make the relevant inferences." (Rescorla, 1980).

13.3 Cognitive Aspects of Operant Conditioning

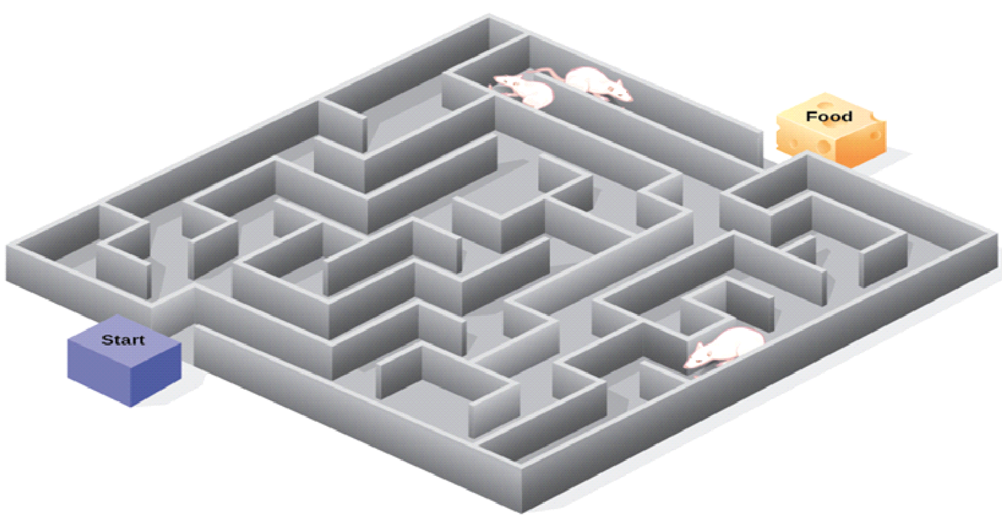
In Skinner's view, operant conditioning did not need to invoke cognitive factors to explain the acquisition of operant behaviors. Words such as expect, prefer, choose and decide could not be used to explain how behaviors were acquired, maintained, or extinguished. Similarly, Thorndike and other early behaviorists believed that complex, active behaviors were no more than a chain of stimulus-response connections that has been "stamped in" by their effects.

However not all learning researchers agreed with Skinner and Thorndike. Edward C. Tolman firmly believed that cognitive processes played an important role in learning of complex behaviors – even in the lowly laboratory rat. According to Tolman, although such cognitive processes could not be observed directly, they could still be experimentally verified and inferred by careful observation of outward behavior.

Much of Tolman's research involved rats in mazes. When Tolman began his research in the 1920s, many studies of rats in mazes had been done. In a typical experiment, a rat would be placed in the "start" box. A food reward would be put in the "goal" box at the end of the maze. The rat would initially make many mistakes in running in the maze. After several trials, it would eventually learn to run the maze quickly and with very few errors.

But what had the rats learned? According to the traditional behaviorists, the rats had learned a sequence of responses, such as "first-corner-turn left; second corer- turn left; third corner turn right" and so on. Each response was associated with the "stimulus" of the rat's position in the maze. And the entire sequence of response was "stamped in" by the food reward at the end of the maze.

Tolman (1948) disagreed with that view. He noted that several investigators had reported as incidental findings that their maze-running rats had occasionally taken their own shortcuts to the food box. In one case, an enterprising rat had knocked the cover off the maze, climbed over the maze well and out of the maze, and scampered directly to the food box. To Tolman, such reports indicated that the rats had learned more than simply the sequence of responses required to get to the food. Tolman believed instead that the rats eventually built up, through experience, a cognitive map of the maze a mental representation of its layout.



Tolman challenged the prevailing behaviorist model on another important point. According to Thorndike, for example, learning would not occur unless the behavior was "strengthened", or “stamped in”, by a rewarding consequence. But Tolman showed that this was not necessarily the case. In a classic experiment, three groups of rats were put in the same maze once a day for several days. For group 1, a food reward awaited the rats at the end of the maze. Their performance in the maze steadily improved; the number of errors and the time it took the rats to reach the foal box showed a steady decline with each trial. The rats in group 2 were placed in the maze each day with no food reward. They consistently made many errors, and their performance showed only slight improvement. The performance of the rats in group 1 and 2 was exactly what the traditional behaviorist model would have predicted.

Now consider the behavior of the rats in group 3. These rats were placed in the maze with no food reward for the first 10 days of the experiment. Like the rats in group 2, they made many errors as they wandered about the maze. But, beginning on day 11, they received a food reward at the end of the maze. There was a dramatic improvement in group 3’s performance from day 11 to day 12. Once the rats had discovered that food awaited them at the end of the maze, they made a beeline for the goal. On day 12, the rats in group 3 ran the maze with very few errors, improving their performance to the level of the rats in group 1 that had been rewarded on every trial!

Tolman concluded that reward – or reinforcement – is not necessary for learning to take place. The rats in group 3 had learned the layout of the maze and formed a cognitive map of the maze simply be exploring it for 10 days. However, they had not been motivated to demonstrate that learning until a reward was introduced. Rewards, then, seem to affect the performance of what has been learned rather than learning itself. To describe learning that is not immediately demonstrated in over behavior, Tolman used the term latent learning. From these and other experiments, Tolman concluded that learning involves the acquisition of knowledge rather than simply changes in outward behavior.

13.4 Summary

- Albert Bandura systematically investigated how new behaviors could be acquired through observational learning.
- Observational learning involves the cognitive processes of attention, memory, motor skills, and motivation.
- Robert Rescorla demonstrated that classical conditioning involves learning the relations between events and assessing the reliability of signals.

- Edward Tolman's research on cognitive maps and latent learning demonstrated the involvement of cognitive processes in learning active behaviors.

13.5 Keywords

Observational Learning: Learning that occurs through observing the actions of others.

Cognitive Map: Tolman's term that describes the mental representation of the layout of a familiar environment.

Latent Learning: Term coined by Tolman to describe learning that occurs in the absence of reinforcement but is not behaviorally demonstrated until a reinforce becomes available.

13.6 Check Your Progress

Identify the process and the psychologist who contributed the process in the following questions:

1. When Brittany's grandmother gave her a toy broom, the two-year old immediately tried to sweep the floor with it.

   Process: ______________________________ Psychologist: _______________________

2. Lisa transfers to a new college and spends her first few days on campus getting oriented. A week later she decides to have lunch at the college cafeteria. Although she has never eaten there before, she has no problem finding it.

   Process: ______________________________ Psychologist: _______________________

13.7 Answers To Check Your Progress

1. Process: Observational learning Psychologist : Albert Bandura
2. Process: Latent Learning Psychologist: Edward L. Tolman

13.8 Model Questions

1. Discuss the cognitive aspects of classical conditioning
2. Write a short note on latent learning
3. Explain Albert Bandura's theory of observational learning in detail.

LESSON - 14
INTRODUCTION TO MEMORY

Preview

In the previous chapter we considered the cognitive aspects of learning. The theory of reliability of signals that tends to be cognitively processed was discussed. Also the concept of latent learning and Tolman's extensive research experiments were discussed. The concept of observational learning contributed by Albert Bandura was also discussed in detail. In this chapter we will discuss the stage model of memory in detail and also discuss the various types of memory and its contributions to our sense of self and the world around us.

Learning Objectives

After studying this chapter you will be able to:

- Understand the three stages of memory and how their functions are related.
- Understand the nature and functions of the three stages of memory
- Understand the role of the varied types of memory

Plan of Study

14.1 Introduction To Memory

14.2 The Stage Model of Memory

14.3 Sensory Memory

14.4 Short-Term, Working Memory

14.5 Long-Term Memory

14.6 Summary

14.7 Keywords

14.8 Check Your Progress

14.9 Answers To Check Your Progress

14.10 Model Questions

14.1 Introduction To Memory

Memory refers to the mental processes that enable us to acquire, retain and retrieve information. Rather than being a single process, memory involves three fundamental processes: encoding, storage, and retrieval.

Encoding refers to the process of transforming information into a form that can be entered and retained by the memory systems. Storage is the process of retaining information in memory so that it can be used at a later time. Retrieval involves recovering the stored information so that we are consciously aware of it.

14.2 The Stage Model of Memory

One very influential model, the stage model of memory, given by Atkinson and Shiffrin (1968), is useful in explaining the basic workings of memory. In this model, memory involves three distinct stages: sensory memory, short-term memory and long-term memory. The stage model is based on the idea that information is transferred from one memory stage to another. Each memory stage is thought to differ in terms of the following:

- Capacity: How much information can be stored?
- Duration: How long the information can be stored?
- Function: What is done with the stored information?

A detailed explanation of the varied stages of the stage model of memory will now be explored in the remaining sections of this chapter.

14.3 Sensory Memory

Has something like this ever happened to you? You're engrossed in a suspenseful movie video. From another room, a family member calls out, "Where'd you put the phone book?" You respond with, "What?" Then, a split second later, the question registers in your mind. Before the other person can repeat the question, you reply, "Oh, it's on the kitchen counter."

You were able to answer the question because your sensory memory registered and preserved the other person's words for a few fleeting seconds – jus long enough for you to recall what had been said to you while your attention was focused on the movie. Sensory memory stores a detailed record of a sensory experience, but only for a few fleeting seconds at the most.

The first stage of memory is called sensory memory. Sensory memory registers a great deal of information from the environment and holds it for a brief period of time. After a few seconds or less, the information fades away.

14.3.1 The Duration of Sensory Memory

The characteristics of visual sensory memory was first identified largely through the research of psychologist George Sperling in 1960. In his experience, Sperling flashed the images of 12 letters on a screen for one-twentieth of a second. The letters were arranged in four rows of three letters each. Subjects focused their attention on the screen and immediately after the screen went blank, reported as many letters as they could remember.

On average, subjects could report only 4 or 5 of the 12 letters. However, several subjects claimed that they had actually seen all the letters but that the complete image had faded from their memory as they spoke, disappearing before they could verbally report more than 4 or 5 letters.

Based on this information, Sperling tried a simple variation on the original experiment. He arranged the 12 letters in three rows of 4 letters each. Then, immediately after the screen went blank, he sounded a high-pitched, medium-pitched or low-pitched tone. If the subjects heard the high-pitched tone, they were to report the letters in the top row; the medium pitched tone signaled the middle row; and the low-pitched tone signaled the bottom row. If the subjects actually did see all the letters, Sperling reasoned, then they should be able to report the letters n a given row by focusing their attention on the indicated row before their visual memory faded.

This is exactly what happened. If the tone followed the letter display is under one-third of a second, subjects could accurately report about three of the four letters in whichever row was indicated by the tone. However, if the interval between the screen going blank and the sound of the tone was more than one-third of a second, the accuracy of the reports decreased dramatically. By the time one second had elapsed, the image in the subject's visual sensory memory had already faded beyond recall.

This classic experiment demonstrated that our visual sensory memory holds great deal of information very briefly, for about half a second. This information is available just long enough for us to pay attention to specific elements that are significant to us at that moment. This meaningful information is then transferred from the very brief storage of sensory memory to the somewhat longer storage of short-term memory.

14.3.2 Types of Sensory Memory

Memory researchers believe there is a separate sensory memory for each sense – vision, hearing, touch, smell, and so on. Of the different senses, however visual and auditory sensory memories have been the most thoroughly studied. Visual sensory memory is sometimes referred to as iconic memory, because it is brief memory of an image, or icon. Auditory sensory memory is sometimes referred to as echoic memory a brief memory that is like an echo.

Researchers have found slight differences in the duration of sensory memory for visual and auditory information. Your visual sensory memory typically holds an image of your environment for about one-quarter to one-half second before it is replaced by yet another overlapping snapshot. This is easy to demonstrate. Quickly wave a pencil back and forth in front of your face. Do you see the fading image of the pencil trailing behind it? That's your visual sensory memory at work. It momentarily holds the snapshot of the environmental image you see before it is almost instantly replaced by another overlapping image.

Your auditory sensory memory holds sound information a little longer, up to a few seconds. This brief auditory sensory trace for sound allows you to hear speech as continuous words, or a series of musical notes as a melody, rather than as disjointed sounds. It also explains why you are able to "remember" something that you momentarily don't "hear," as in the example of the family member asking you where the phone book is.

An important function of sensory memory is to very briefly store sensory impressions so that they overlap slightly with one another. Thus, we perceive the world around us as continuous, rather than as a series of disconnected visual images or disjointed sounds.

14.4 Short-Term, Working Memory

You can think of short-term memory, or working memory, as the "workshop" of consciousness. It is the stage of memory in which information transferred from sensory memory and information retrieved from long-term memory become conscious. When you recall a past event or mentally add two numbers, the information is temporarily held and processed in your short-term memory. Your short-term memory also allows you to make sense out of this sentence by holding the beginning of the sentence in active memory while you read the rest of the sentence. Thus, working memory provides temporary storage or information that is currently being used in some conscious cognitive activity.

14.4.1 The Duration of Short-Term Memory

Information in short-term memory lasts longer than information in sensory memory, but its duration is still very short. At best, you can hold most types of information in short-term memory up to about 30 seconds before it's forgotten. However, information can be maintained in short-term memory longer than 30 seconds if it is rehearsed, or repeated, over and over. Because consciously rehearing information will maintain it in short-term memory, this process is called maintenance rehearsal. For example, when you look up an office number on a building directory, you use maintenance rehearsal to maintain it in short-term memory until you reach the office. Information that is not actively rehearsed quickly fades, or decays, from short-term memory.

14.4.2 The Capacity of Short-Term Memory

Along with having a relatively short duration, short-term memory also has a relatively limited capacity. George Miller (1956) described the limits of short-term memory in a classic paper entitled "The Magical Number Seven, Plus or Minus Two." Miller found hat the capacity of short-term memory is limited to about seven items, or bits of information, at one time. So it's no accident that local telephone numbers are seven digits long. This seven-item limit to short-term memory seems to be universal.

So what happens when your short term memory store is filled to capacity? New information displaces, or bumps out, currently held information. Maintenance rehearsal is one way to avoid the loss of information from short-term memory. By consciously repeating the information you want to remember, you keep it active in short-term memory and prevent it from being displaced by new information.

Although the capacity of your short term memory is limited, there are ways to increase the amount of information you can hold in short-term memory at any given moment. This can be done through a process called chunking – the grouping of related items together into a single unit. But to do so, chunking also often involves the retrieval of meaningful information from long-term memory.

14.5 Long-Term Memory

Long-term memory refers to the storage of information over extended periods of time. Technically, any information stored longer than the roughly 30-second duration of short-term memory is considered to be stored in long-term memory. So, a long-term memory can be recalling what you were doing 5 minutes ago or 10 years ago. In terms of maximum duration, some long-term memories can last a lifetime.

Compared with the limited bits of information that can be stored in sensory memory and short-term memory, the amount of information that can be held in long-term memory is limitless.

14.5.1 Encoding Long-Term Memories

One very important function that takes place in short-term memory is encoding, or transforming the new information into a form that can be retrieved later. Elaborative rehearsal, which involves focusing on the meaning of information to help encode and transfer it to long-term memory is used to encode information into LTM. With elaborative rehearsal, you relate the information to other information you already know. That is, rather than simply repeating the information over and over to yourself, you elaborate on the new information in some meaningful way. Elaborative rehearsal significantly improves memory for new material. This point is especially important for students, because elaborative rehearsal is a helpful strategy. If you elaborated in the information in some meaningful way, you would be more likely to recall it. First, applying information to yourself, called the self-reference effect, improves your memory for information. Second, the use of visual imagery, especially vivid images, also enhances encoding.

Why should elaborative rehearsal be a more effective way of encoding new information than maintenance rehearsal? Psychologist Fergus Craik and Robert Lockhart (1972) proposed that the level at which new information is processed determines how well the new information will be encoded and remembered. Craik and Lockhart's approach to understanding the relationship between coding processes and memory is called the levels-of-processing framework.

According to the levels-of-processing framework, information processed at a "deeper" level is more likely to be remembered than information processed at a "shallow" level. Deep processing involves processing the meaning of the new information, rather than its more superficial characteristics. According to this framework, simple repetition, or maintenance rehearsal, would represent shallow processing of information. In contrast, elaborative rehearsal would represent deep processing of material.

The fact that deep processing results in more effective encoding and better memory of new information has many practical applications for students. How can you process new information at a deep, rather than a shallow, level? You can do the following:

- Actively question new information
- Think about the implications of information.
- Figure out how new information relates to information you already know.
- Try to generate your own examples of the concept, especially examples from your own experiences.
- Make sure you understand and question the evidence.

Such mental activities promote “deeper” processing and enhance your memory for new information.

14.5.3 Types of Information in Long-Term Memory

There are three major categories of information stored in long-term memory. Procedural memory refers to the long-term memory of how to perform different skills, operations and actions. Typing, riding a bike, running, and making scrambled eggs are all examples of procedural information stored in the long-term memory. Often, we can’t recall exactly when or how we learned procedural information. And usually its difficult to describe procedural memory in words.

In contrast to procedural memory, episodic memory refers to your long term memory of specific events are episodes, including the time and place that they occurred. Your memory of attending a friend’s wedding or your first day ate college would both be examples of episodic memories. Closely related to episodic memory is autobiographical memory, which refers to the events of your life – your personal life history. Autobiographical memory plays a key role in your sense of self.

The third category of long-term memory is semantic memory – general knowledge that includes facts, names, definitions, concepts, and ideas. Semantic memory represents your personal encyclopedia of accumulated data and trivia stored in your long-term memory. Typically, you store semantic memories in long-term memory without remembering when or where you learned the information.

14.5.4 Implicit and Explicit Memory

Long-term memory appears to be composed of separate but interacting subsystems and abilities. What are these subsystems? One basic distinction that has been made is between explicit memory and implicit memory. Explicit memory is memory with awareness – information or knowledge that can be consciously recollected, including episodic and semantic information. Explicit memories are also called declarative memories, because, if asked, you can “declare” the information.

In contrast, implicit memory is memory without awareness. Implicit memories cannot be consciously recollected, but they still affect your behavior, knowledge, or performance of some task. Implicit memories are also called nondeclarative memories, because you’re unable to “declare” the information. Procedural memories, including skills and habits, typically reflect implicit memory processes.

14.6 Summary

- Memory refers to the mental processes that enable us to acquire, retain and retrieve information.
- Key memory processes are encoding, storage and retrieval.
- The stage model of memory describes human memory as the process of transferring information from one memory stage to another.
- The three stages of memory are sensory memory, short term memory and long term memory.
- Sensory memory briefly stores information about the environment.
- George Sperling discovered that visual sensory memory holds information for about half a second before the information fades.
- There is a separate sensory memory for each sense.
- Visual and auditory sensory memory are the most thoroughly studied.
- Auditory sensory memory lasts up to a few seconds.
- Short term memory also called working memory, provides temporary storage for information transferred from sensory memory and information recalled from long term memory.
- Most information fades from the short term memory within about 30 seconds.
- Maintenance rehearsal keeps information active in short-term memory.
- The capacity of short term memory is limited to about seven items plus or minus two.

- Chunking can be used to increase the amount of information held in short-term memory.
- Long-term memory stores limitless amount of information for extended periods of time.
- Encoding transforms information into a form that can be stored and retrieved later.
- The most effective encoding strategies involve elaborative rehearsal.
- The levels of processing framework suggests that information that is processed deeply will be encoded more effectively.
- Long term memory includes procedural, episodic and semantic memory.
- Explicit memory can be consciously recalled.
- Implicit memories cannot be consciously recalled, but affect behavior or performance.

14.7 Keywords

Memory: The mental processes that enable us to retain and use information over time.

Encoding: The process of transforming information into a form that can be entered into and retained by the memory system.

Storage: The process of retaining information in memory so that it can be used at a later time.

Retrieval: The process of recovering information stored in memory so that we are consciously aware of it.

Stage model of memory: A model describing memory as consisting of three distinct stages: sensory memory, short-term memory and long-term memory.

Sensory Memory: The stage of memory that registers information from the environment and holds it for a very brief period of time.

Short-term memory: The active stage of memory in which information is stored for about 30 seconds.

Long-term memory: The stage of memory that represents the long-term storage of information.

Maintenance Rehearsal: The mental or verbal repetition of information in order to maintain it beyond the usual 30-second duration of short term memory.

Chunking: Increasing the amount of information that can be held in short term memory by grouping related items together into a single unit or chunk.

Elaborative Rehearsal: Rehearsal that involves focusing on the meaning of information to help encode and transfer it to long term memory.

Levels of processing framework: The view that information that is processed at a deeper (more meaningful) level is more likely to be remembered than information that is processed at a shallow (less meaningful) level.

Procedural Memory: Category of long-term memory that includes memories of different skills, operations and actions.

Episodic Memory: Category of long-term memory that includes memories of particular events.

Semantic Memory: Category of long-term memory that includes memories of general knowledge of facts, names and concepts.

Explicit Memory: Information or knowledge that can be consciously recollected; also called declarative memory.

Implicit Memory: Information or knowledge that affects behavior or task performance but cannot be consciously recollected; also called nondeclarative memory.

14.8 Check Your Progress

Comparing The Three Stages of Memory

Identify each of the following descriptions as characteristic of sensory memory (SM), short-term memory (STM), or long-term memory (LTM).

Function

1. Storage of information for later retrieval : ________________________

2. Brief storage of sensory impressions : ________________________

3. Temporary storage of new information; interaction with stored information : ____________________

Duration

4. Potentially permanent : ____________________

5. Approximately 20 to 30 seconds : ____________________

6. Approximately ½ to 3 seconds : ____________________

Capacity

7. Limited capacity of about seven items : ____________________

8. Large but fleeting capacity : ____________________

9. Unlimited capacity : ____________________

14.9 Answers To Check Your Progress

1. LTM
2. SM
3. STM
4. LTM
5. STM
6. SM
7. STM
8. SM
9. LTM

14.10 Model Questions

1. Define memory
2. What are the different types of memory?
3. Discuss the stage model of memory as highlighted by Atkinson and Shiffrin.

LESSON - 15
CONSTRUCTING MEMORIES

Preview

In the previous chapter the concept of memory had been introduced. The stage model of memory highlighting the three stages of memory, namely: Sensory Memory, Short-Term Memory and Long Term Memory was discussed in detail. Significant features like the duration, capacity and function of each of the stages was also considered. In conclusion the distinct types and dimensions of memory was also discussed. In this chapter we will consider the reconstruction and construction of memory. In this chapter we will highlight on the concept of the constructive process of memory. We will further discuss about schemas, memory distortions, source confusion and false memories. A final remark on distortions in eyewitness testimony will also be discussed.

Learning Objectives

After studying this chapter you will be able to:

- Understand memory as a constructive process.
- Understand the role of schemas in memory distortions.
- Understand source confusion and false memories.
- Understand the how distortions in eyewitness testimony tends to occur.

Plan of Study

15.1 Memory as a Constructive Process

15.2 Schemas and Memory Distortions

15.3 Source Confusion and False Memories

15.4 Distortions in Eyewitness Testimony

15.5 Summary

15.6 Keywords

15.7 Check Your Progress

15.8 Answers To Check Your Progress

15.9 Model Questions

15.1 Memory as a Constructive Process

Retrieving information from long term memory is not like viewing a digital replay. Our memories are often incomplete or sketchy. We may literally construct (or, as some say, reconstruct) a memory by piecing together bits of stored information in a way that seems real and accurate. Memory construction can be amusing at times. Many of us have a tendency to recall the world through slightly rosy glasses, which helps us feel good about ourselves. However, memory construction can also have serious personal and societal consequences.

15.2 Schemas and Memory Distortions

Since very early in life, you have been actively forming schemas – organized clusters of knowledge and information about particular topics. The topic can be almost anything – an event, an object, a situation, or a concept. For example, consider the schema you have for a typical kitchen. It probably includes food, a refrigerator, a toaster, a sink, cabinets, silverware, and so forth. You started forming your kitchen schema early in life by gradually identifying the common elements first in your own kitchen, then in other people's kitchen.

On the other hand, schemas are useful in forming new memories. Using the schemas you already have stored in long-term memory allows you to quickly integrate new experiences into your knowledge base. Schemas can also contribute to memory distortions.

To illustrate this point, let's try to re-create some of the conditions in an ingenious study by William Brewer and James Treyens (1981). Imagine that you've signed up to participate in a psychology experiment. When you show up at the psychology professor's office for the study, the professor asks you to wait briefly in his office. The professor comes back and escorts you to a different room. After you sit down, you are told the real purpose of the study : to test your memory of the details of the professor's office. Most often subjects remembered, that the office contained books, a filing cabinet, a telephone, a lamp, pens, pencils and a coffee cup. But none of these items were in the professor's office.

Why did the participants in this study erroneously "remember" items that weren't there? When the participants reconstructed their memories of the office they remembered objects that were not in the room but that did fit the schema of a professor's office. Thus, the incorrect details that they thought they remembered were all items that would be consistent with a typical professor's office.

Schemas can also contribute to memory distortions when we learn new information that is inconsistent with previously learned information. In one clever study, subjects read a brief story about “Bob” and “Margie”, a happy, compatible couple engaged to be married. Just before the subjects left the experiment, the experimenter casually mentioned that Bob and Margie broke up and never did get married. When the subjects were later tested for their recall of the written story, they introduced new, inaccurate details to make the story more consistent with the experimenter’s remark. Unknowingly, the subjects had fabricated or distorted details of the story to make it consistent with the experimenter’s remark and with their own schemas about relationships and marriage.

In combination, the office study and the Bob and Margie study underscore several important points. First, they show how the schemas we already hold can influence what we remember. Second, they demonstrate that once a memory is formed, it has the potential to be changed by new information. And third, they demonstrate how easily memories can become distorted. Notice that neither of these studies involved elaborate efforts to get subjects to distort the memories being formed or remembered.

15.3 Source Confusion and False Memories

Memory distortions an also occur because of source confusion, which arises when the true source of the memory is forgotten. One of the most easily forgotten parts of a memory is its source – how, when, or where it was acquired. A false memory is a distorted or inaccurate memory that feels completely real and is often accompanied by all the emotional impact of a real memory. False memories are a result of source confusion. Such false memories can arise when you confuse something that you’ve only imagined, heard about, read about, or seen in a film with something that really happened to you.

15.4 Distortions in Eyewitness Testimony

Given the fallibility of human memory, it’s understandable that precautions are often taken when specific details may be critically important. One important area in which it’s often impossible to take such precautions is eyewitness testimony. The guilt or innocence of people in criminal and civil cases often hinges on the accuracy of witnesses’ memories. Psychologists are well aware of how easily memories can be distorted in the laboratory. If such distortions also occur in real life, they could have serious implications.

Psychologist Elizabeth Loftus, is one of the most widely recognized authorities on eyewitness testimony. Loftus has not only conducted extensive research in this area but has also testified as an expert witness in many high profile cases.

To illustrate how eyewitness testimony can become distorted, let's consider a study that has become a classic piece of research. Loftus had subjects watch a film of an automobile accident; write a description of what they saw, and then answer a series of questions. There was one critical question in the series: "About how fast were the cars going when they contacted each other?" Different subjects were given different versions of that question. For some subjects, the word contacted was replaced with hit. Other subjects were given bumped, collided or smashed. Depending on the specific word used in the question, subjects provided very different estimated of the speed at which the cars in the film were travelling. The subjects who gave the highest speed got smashed. Clearly, how a question is asked can influence what is remembered.

A week after seeing the film, the subjects were asked another series of questions. This time, the critical question was "Did you see any broken glass?" Although no broken glass was shown in the film, the majority of the subjects whose question had used the word smashed a week earlier said "yes". Once again, following the initial memory (the film of the automobile accident), new information (the word smashed) distorted the construction of the memory (remembering broken glass that wasn't really there).

More recently, Loftus and her colleagues demonstrated that subjects can intentionally be led to make inaccurate reports after being exposed to misleading information. This misinformation effect is relatively easy to produce. In one study, subjects watched a series of slides about a burglary in which a screwdriver was a key element. The subjects then read a written account of the event. However, the written account contained misleading information. It referred to a hammer instead of a screwdriver. The subjects were then tested for their memory of the event.

The results? After exposure to the misleading information, about 60 percent of the subjects quickly and confidently said that a hammer, rather than a screwdriver; had been used in the burglary. Subjects were as confident about their fabricated memories as they were about their genuine memories of other details of the original event.

Finally, we don't want to leave you with the impression that it's astonishing that anybody remembers anything accurately. In reality, people's memories tend to be quite accurate for overall details. When memory distortions occur, they usually involve limited bits of information.

Still, the surprising ease with which bits of memory can become distorted is unnerving. The distorted memories can ring true in our minds and feel just as real as accurate memories. Rather than being set in stone, human memories are more like clay: They can change shape with just a little bit of pressure.

15.5 Summary

- Memories can be distorted by schemas and other preexisting information that we have stored before acquiring a new memory.
- Schemas can also contribute to memory distortions when we learn new information that is inconsistent with previously learned information.
- Source confusion occurs when we either don't remember or misidentify the source of a memory.
- The misinformation effect, schema distortion and source confusion can contribute to inaccuracies in eyewitness testimony.
- Memory tends to be fairly accurate for the general gist of experiences.
- Distorted or false memories can be just as vivid as accurate memories.

15.6 Keywords

Schema : An organized cluster of information about a particular topic.

Source Confusion: A memory distortion that occurs when the true source of the memory is forgotten.

Eyewitness Testimony: Information provided by witnesses to crimes or accidents.

Misinformation Effect: A memory-distortion phenomenon in which a person's existing memories can be altered if the person is exposed to misleading information.

15.7 Check Your Progress

1. Define Schemas.

2. What are the contributions of Elizabeth Loftus to memory?

3. What is a false memory?

4. Define source confusion.

5. Who is an eyewitness?

15.8 Answers To Check Your Progress

1. Refer in text content : 15.2
2. Refer in text content : 15.4
3. Refer in text content : 15.3
4. Refer in text content : 15.3
5. Refer in text content : 15.4

15.9 Model Questions

1. Discuss memory as a constructive process in detail.
2. Elaborate on the role of schemas on memory distortions.

LESSON : 16

FORGETTING AND STRATEGIES TO IMPROVE MEMORY

Preview

In the previous chapter we considered the concept of constructing memories. Also varied aspects like, schemas and source confusion that often leads to false memories was also discussed. Emphasis was also given to understanding the causes of distortions in eyewitness testimony with regards to memory. In this chapter we will consider the concept of forgetting. We will also explore on the various factors that influence forgetting. In conclusion varied strategies to improve memory will be considered.

Learning Objectives

After studying this chapter you will be able to:

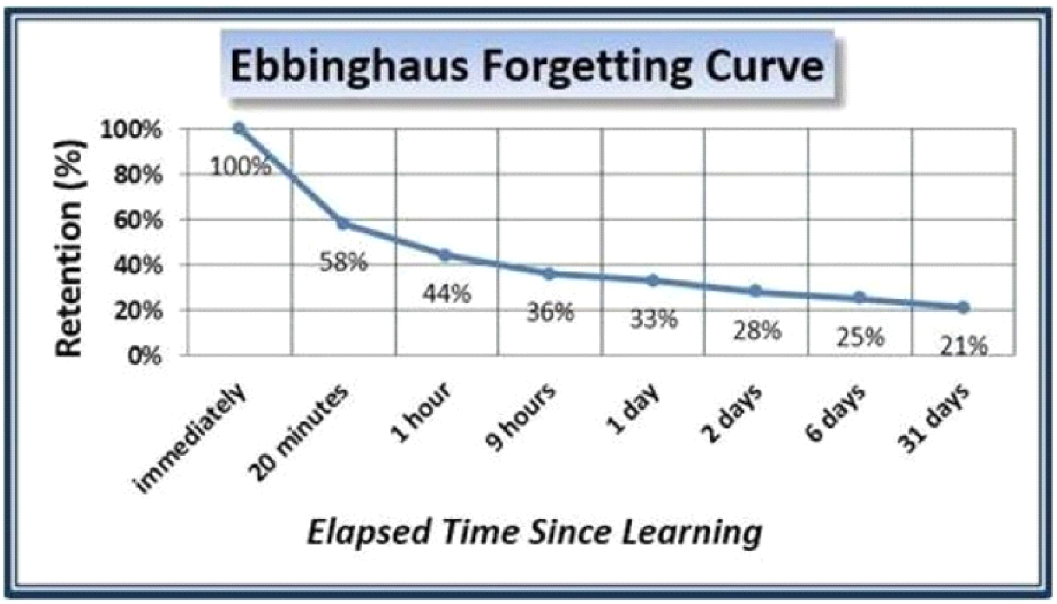
- Understand the concept of forgetting.
- Understand the factors that influence forgetting.
- Illustrate the strategies to improve memory.

Plan of Study

16.1 Introduction To Forgetting

Forgetting is the inability to recall information that was previously available. Forgetting is so common that our lives are filled with automatic reminders to safeguard forgetting important information. Sometimes, of course we want to forget. From the standpoint of a person's psychological well-being, it's probably just as well that we tend to forget the details of unpleasant memories, such as past failures, social embarrassments and unhappy relationships. Even more generally, our minds would be cluttered with mountains of useless information if we remembered every television program, magazine article, billboard or conversation we have ever experienced. So forgetting does have some adaptive values.

16.1.1 Hermann Ebbinghaus : The Forgetting Curve



German psychologist Hermann Ebbinghaus began the scientific study if forgetting over a century ago. His goal was to determine how much information was forgotten after different lengths of time. But he wanted to make sure that he was studying the memory and forgetting of completely new memory. To solve this problem, Ebbinghaus (1885) created new material to memorize : thousands of nonsense syllables. A nonsense syllable is a three-letter combination, made up of two consonants and a vowel, such as WIB or MEP. It almost sounds like a word, but it is meaningless. This study was conducted on himself, and he carefully noted how many times he had to repeat a list of 13 nonsense syllables before he could recall the list perfectly.

Once he had learned the nonsense syllables, Ebbinghaus tested his recall of them after varying amounts of time, ranging from 20 minutes to 31 days. He plotted his results in the now-famous Ebbinghaus forgetting curve.

The Ebbinghaus forgetting curve reveals two distinct patterns in the relationship between forgetting and the passage of time. First, much of what we forget is lost relatively soon after we originally learned it. How quickly we forget material depends on several factors such as how well the material was encoded in the first place, how deeply it was processed, and how often it was rehearsed.

Second, the Ebbinghaus forgetting curve shows that the amount of forgetting eventually levels off. The information that is not quickly forgotten seems to be remarkably stable in memory over long periods of time.

16.2 Factors That Influence Forgetting

Research on forgetting, both in the laboratory and in everyday life, has identified four potential causes of forgetting: encoding failure, interference, motivated forgetting, and decay. Let’s consider how each of these causes can help explain instances of forgetting.

16.2.1 Encoding Failure

One of the most common reasons for forgetting is that we never encoded the information into long-term memory in the first place. This phenomenon is called encoding failure. Encoding failure explains why you forget where you put your car keys or a person’s name five minutes after meeting her. The information momentarily entered your short term memory, but it was never encoded into long term memory.

16.2.2 Interference Theory

A second reason for forgetting is that memories an interfere with one another. According to the interference theory of forgetting, forgetting is caused by one memory competing with or replacing another memory. the most critical factor is the similarity of the information. The more similar the information is in two memories, the more likely it is that interference will be produced.

There are two basic types of interference. Retroactive interference occurs when a new memory (your new phone number) interferes with remembering an old memory (your old phone number). Proactive interference is the opposite of retroactive interference. It occurs when an old memory interferes with a new memory. This is a relatively common experience. For example, proactive interference can occur when you get a new car or borrow someone else's car. You want to switch on the headlights, but you keep turning on the windshield wipers. The old memory (the switch's location in your car) interferes with the more recent memory (the switch's location in the new car).

16.2.3 Motivated Forgetting

Motivated forgetting refers to the idea that we forget because we are motivated to forget, usually because a memory is unpleasant or disturbing. In one form of motivated forgetting called suppression, a person makes a deliberate, conscious effort to forget information. Although the person remains aware that a particular event did occur, he or she consciously chooses not to think about it.

There is another form of motivated forgetting that is much more controversial. Repression is motivated forgetting that occurs unconsciously. With repression, all memory of an event or experience is blocked from conscious awareness. Thus, repression is fundamentally different from suppression, in which people know that a particular event happened but intentionally avoid thinking about it.

16.2.4 Decay Theory

According to decay theory , we forget memories because we don't use them and they fade away over time as a matter of normal brain processes. The idea is that when a new memory id formed, it creates a memory trace- a distinct change in brain structure of chemistry. Through disuse over time, the normal metabolic processes of the brain are thought to erode the memory trace. The gradual fading of memories, then, would be similar to the fading of letters on billboards or newsprint exposed to environmental elements such as sunlight.

16.3 Strategies to Improve Memory

1. Focus your attention

Problems in absorbing new information arise when distracting thoughts, background noise and other interruptions sidetrack your attention. It will thus be effective to locate a quiet study space that is free from distractions so you can focus your attention.

2. Commit the necessary time

The more time you spend learning material, the better you will understand it and the longer you will remember it. So don't rely on skimming material the night before a test. Budget enough time to read the assigned material carefully. If you read material faster that you can comprehend it, you not only won't understand the material, you also won't remember it.

3. Space your study sessions:

Distributed practice means that you learn information over several sessions, which gives you time to mentally process and incorporate the information. It's also been shown that sleep, particularly REM sleep, helps consolidate new memories. All-night cram sessions just before an exam are one of the least effective ways to learn new material.

4. Organize the information

We have a strong natural tendency to organize information in long term memory into categories. You can capitalize on this tendency by actively organizing information that you want to remember. Use the chapter headings and subheadings as categories. Under each category, list and describe the relevant terms, concepts and ideas. This strategy can double the amount of information you can recall.

5. Elaborate on the material

In order to remember the information that you study you need to engage in elaborative rehearsal and actively process the information for meaning actively question ne information and think about its implications. Form memory associations by relating the material to what you already know. Try to come up with examples that relate to your own life. React to what you read by writing your comments or questions in the margin of the textbook. Create sentences that accurately use the concept or term.

6. Use visual imagery

Much of the information in this text easily lends itself to visual imagery. Use the photographs and other illustration to help form visual memories of the information. A simple way to make text information visually distinct is to highlight different concepts in different colors.

7. Explain it to a friend

Memory research clearly supports the benefits of explaining new material out loud. After you read a section of material, stop. Summarize what you have read in your mind. When you think you understand it, try to explain the information to a friend or a family member.

8. Reduce interference within a topic

To minimize memory interference for related information, first break the chapter into manageable sections, then learn the key information one section at a time. As you encounter new concepts, compare them with previously learned concepts, looking for differences and similarities. By building distinct memories for important information as you progress through a topic, you are more likely to distinguish between concepts so they don't get confused in your memory.

16.4 Summary

- Forgetting refers to the inability to recall information that was previously available.
- Encoding failure is one cause of forgetting.
- According to interference theory, forgetting results from retroactive and proactive interference.
- Motivated forgetting can result from suppression and repression.
- Decay theory is another explanation for forgetting cause by disuse of information.

16.5 Keywords

Forgetting: The inability to recall information that was previously available.

Encoding failure: The inability to recall specific information because of insufficient encoding for storage in long term memory.

Interference theory: The theory that forgetting is caused by one memory competing with or replacing another.

Retroactive interference: Forgetting in which a new memory interferes with remembering an old memory, backward-acting memory interference.

Proactive interference: Forgetting in which an old memory interferes with remembering a new memory; forward-acting memory interference.

Motivated forgetting: The theory that forgetting occurs because an undesired meory is held back from awareness.

Suppression: Motivated forgetting that occurs consciously.'

Repression: Motivated forgetting that occurs unconsciously.

Decay theory: The view that forgetting is due to normal metabolic processes that occur in the brain over time.

16.6 Check Your Progress

PART : A

Circle the letter of the correct answer

1. Renee asked her husband what his secretary had worn to the office party, and he could not remember. The most likely explanation is:

   a. suppression

   b. encoding failure

   c. the interference effect

   d. he was lying

2. Professor Daniel has many vivid memories of her students from last semester and can recall most of their names. Because of _________________________, she is having problems remembering her new students' names this semester.

   a. retroactive interference

   b. proactive interference

   c. decay

   d. suppression.

PART : B

Write short notes:

3. Highlight on the contributions of Hermann Ebbinghaus.

___

4. Name the two different types of motivated forgetting.

___

5. Define forgetting.

___

16.7 Answers To Check Your Progress

1. b
2. b
3. Refer in text content : 16.1.1
4. Refer in text content : 16.2.3
5. Refer in text content : 16.1

16.8 Model Questions

1. Define forgetting
2. Explain the factors that influence forgetting in detail.
3. Sketch out strategies to improve memory.

Model Question Paper

Advanced General Psychology- I

Max Marks: 80

Part A 10 x 2 = 20

Answer any TEN questions in 50 words each

1. Define cognitive neuroscience.
2. Mention any four subfields of psychology.
3. What is control group?
4. What is electrical gradience?
5. What do you mean by selective permeability?
6. Mention the names of common neurotransmitters.
7. What is receptor binding?
8. Define selective attention
9. Define learning.
10. What is negative reinforcement?
11. What are the different types of memory?
12. What is forgetting?

Part B 5 x 6 = 30

Answer any FIVE questions in 250 words each

13. Outline the emerging fields in psychology.
14. Bring out the similarities and differences between clinical and counselling psychology.
15. Explain saltatory conduction.
16. Bring out the structure and functions of spinal cord.
17. Trace out the approaches of perception.
18. Bring out the schedules of reinforcement.
19. Explain Observational learning in detail.

Part C 3 x 10 = 30

Answer any THREE questions in 500 words each

20. Discuss the experimental method of psychology.
21. Describe the structure of neuron.
22. Elucidate the process of neuro transmitter action.
23. Describe the structure and functions of forebrain.