PSY 311
Sensory Processing

Ibadan Distance Learning Centre Series

PSY 311
Sensory Processing

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Vice-Chancellor's Message

I congratulate you on being part of the historic evolution of our Centre for External Studies into a Distance Learning Centre. The reinvigorated Centre, is building on a solid tradition of nearly twenty years of service to the Nigerian community in providing higher education to those who had hitherto been unable to benefit from it.

Distance Learning requires an environment in which learners themselves actively participate in constructing their own knowledge. They need to be able to access and interpret existing knowledge and in the process, become autonomous learners.

Consequently, our major goal is to provide full multi media mode of teaching/learning in which you will use not only print but also video, audio and electronic learning materials.

To this end, we have run two intensive workshops to produce a fresh batch of course materials in order to increase substantially the number of texts available to you. The authors made great efforts to include the latest information, knowledge and skills in the different disciplines and ensure that the materials are user-friendly. It is our hope that you will put them to the best use.

Professor Olufemi A. Bamiro, FNSE
Vice-Chancellor

Foreword

The University of Ibadan Distance Learning Programme has a vision of providing lifelong education for Nigerian citizens who for a variety of reasons have opted for the Distance Learning mode. In this way, it aims at democratizing education by ensuring access and equity.

The U.I. experience in Distance Learning dates back to 1988 when the Centre for External Studies was established to cater mainly for upgrading the knowledge and skills of NCE teachers to a Bachelors degree in Education. Since then, it has gathered considerable experience in preparing and producing course materials for its programmes. The recent expansions of the programme to cover Agriculture and the need to review the existing materials have necessitated an accelerated process of course materials production. To this end, one major workshop was held in December 2006 which have resulted in a substantial increase in the number of course materials. The writing of the courses by a team of experts and rigorous peer review have ensured the maintenance of the University's high standards. The approach is not only to emphasize cognitive knowledge but also skills and humane values which are at the core of education, even in an ICT age.

The materials have had the input of experienced editors and illustrators who have ensured that they are accurate, current and learner friendly. They are specially written with distance learners in mind, since such people can often feel isolated from the community of learners. Adequate supplementary reading materials as well as other information sources are suggested in the course materials.

The Distance Learning Centre also envisages that regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks will find these books very useful. We are therefore delighted to present these new titles to both our Distance Learning students and the University's regular students. We are confident that the books will be an invaluable resource to them.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.

Professor Francis O. Egbokhare
Director

General Introduction and Course Objectives

Basic survival of an organism relies upon knowing the world that surrounds it. The fundamental system that underlies this knowing is what "Sensory Processes" is all about. Perhaps, it may not be an exaggeration to state that in sensory processing, one sees the 'constant endeavour' of human consciousness to explore the world around through the study of sense organs. These organs enable us to see, hear, taste, touch, balance, and experience such feelings as body stiffness, soreness, fullness, warmth, pleasure, pain and movement.

The processes involved in each organ may seem straightforward, but in reality a complex chain of receiving, transmitting, and interpreting sensory information are involved.

The course is therefore prepared to introduce the students' psychologists to concept of sensory processing and the mechanisms involved. More so, it is to explain in detail, the functioning of the sense organs and the important roles they play in understanding the world around us. Through this course, the students will gain a better idea of how our senses work and how this information is organised and interpreted.

At the end of this course, the students should be able to:

1. demonstrate full understanding of sensory processing;
2. mention and explain the different types of sensory receptors;
3. highlight the different types of sense organs and their functioning; and
4. explain the mechanisms associated with the organs

LECTURE ONE

Introduction to Sensory Processing

Introduction

The brain has a lot of work to do throughout the day. There is a continuous flow of information available from all the sensory systems, and the brain must sort through the information, prioritise and emphasize components; it has to decide both how to understand what is going on and what you will do, based on the information available. In this chapter, the major highlights are sensory processing neurological thresholds, self -regulation strategies, and other terms involved in sensory processing.

Objectives

At the end of this lecture, you should be able to:

1. explain the meaning of concepts such as sensory processing, neurological thresholds, habituation, sensitisation, and self -regulation strategies, passive and active strategies for self-regulation;
2. demonstrate mastering by discussing each of the above concepts thorough; and
3. discuss the different levels of threshold and types of responsiveness.

Pre-Test

1. What do you understand by sensory processing, neurological threshold and self-regulation?
2. Define self -regulation strategies, passive and active strategies for self-regulation.

3. What is the difference between self-regulation and self -regulation strategies?

CONTENT

Sensory Processing

Sensory processing is a complex set of actions that enable the brain to understand what is going on both inside your own body and in the world around you. It is an overarching term that refers to the method the nervous system uses to receive, organise and understand sensory input. Sensory processing is considered an internal process of the nervous system that enables people to figure out how to respond to environmental demands based on the sensory information that was available to make the person aware of what is going on both around the person (e.g., from auditory and visual input) and from within the person's body (e.g., from touch, joint receptors). Two primary factors that contributed to our understanding of the overall concept of sensory processing are neurological thresholds and self-regulation strategies.

Neurological thresholds: This refers to the amount of stimuli required for a neuron or neuron system to respond. When the nervous system responds really quickly to a sensory stimulus, we say there is a low threshold and when the nervous system responds more slowly than expected, we say there is a high threshold for responding. All of us need a balance between low and high thresholds so that we notice just enough things to keep us aware and attentive, but not so many things that we become overloaded with information and feel distracted.

At the extreme ends of the neurological threshold are habituation (related to high thresholds) and sensitisation (related to low thresholds).

Habituation refers to the process of recognizing familiar stimuli that do not require additional attention (Dunn, 2000). For young children, habituation is essential so they might focus their attention on the activity at hand. Without this process, children would be constantly distracted by the variety of stimuli that are present in the environment.

Sensitization is the process that enhances the awareness of important stimuli. It is significant to development because it allows the child to remain attentive to the environment while engaged in play or other learning. The ability to modulate responses of the nervous system permits the young child to generate appropriate responses to stimuli in the environment.

Self-Regulation Strategies: These are ranges of behavioural responses to sensory input that reflect the child's self-regulation strategies. At one end of this continuum are passive self-regulations strategies in which the person lets sensory events occur. Passive self-regulation can mean that persons miss things, or feel overtaken by things that are happening around them. For example, a person with passive self-regulation might miss the visual input of facial expressions or gestures during socialisation. Conversely, a person with passive self-regulation might notice everyone fidgeting in a class, and this input could compete with the teacher's lecture.

At the other end of this continuum is active self-regulation strategies, people with active strategies select and engage in behaviours to control their own sensory experiences. Active self-regulation can yield more or less sensory input. For example, a person might hum or whistle while playing cards to add sensory input to keep attentive to the game. Conversely, a person might move to a quiet room while studying as a means of controlling auditory input to increase concentration. Both passive and active strategies for self-regulation can be useful and helpful to the person, or can interfere with the ability to participate in daily life.

Other terms in sensory processing

High Thresholds

This refers to the end of the 'neurological thresholds' continuum. It reflects a condition in which it takes a lot of sensory input to activate a response. We refer to this as hypo responsiveness or hypo reactivity to indicate less responding than would be expected.

Low Thresholds

This end of the 'neurological thresholds' continuum reflects a condition in which it takes very little sensory input to activate a response. We refer to this as hyper-responsiveness or hyper-reactivity to indicate more responding than would be expected.

Within this perspective, we talk about **Responsiveness** to refer to the way that you respond to demands in your life. Many things can affect your responsiveness, including the demands of an activity, the characteristics of the environment or the way that a person's self-regulation strategies affect his daily life. When your nervous system is responding too much, we call it hyper-responsive (or over responsive), and when you are responding too little, we call it hypo-responsive (or under responsive).

Hyper Responsiveness/Hyper Responsivity/Over responsiveness

The nervous system acts based on excitation and inhibition. Under typical circumstances, the nervous system receives both excitatory and inhibitory messages, and must balance these competing inputs to determine an appropriate and adaptive response. Sometimes, the nervous system responses are out of balance. When those responses are larger than we would normally expect in a particular situation, it is referred to as 'hyper responsive'. We hypothesize about a person's hyper responsiveness by observing behaviour in a particular context.

Hypo Responsiveness/ Hyposensivity

The nervous system acts based on excitation and inhibition. Under typical circumstances, the nervous system receives both excitatory and inhibitory messages, and must balance these competing inputs to determine an appropriate and adaptive response. Sometimes, the nervous system responses are out of balance. When those responses are smaller than we would normally expect in a particular situation, it is referred to as 'hypo responsive'. We hypothesize about a person's hypo responsiveness by observing behaviour in a particular context. For example, a child who seems oblivious to her family's activities during family fun night may be exhibiting hypo responsiveness to the movement, sounds and visual stimuli of the family activities.

In addition to considering these patterns of sensory processing, you have to also consider how each of your sensory systems responds. You probably won't have the same responses with each sensory system. For example, you might have sensitivity for sounds, and yet not notice visual or touch stimuli. Although we might identify with one pattern of sensory processing, the truth is that each person has an amount of each pattern of sensory processing. You might see yourself as primarily a sensation seeker, and still have some sensitivity to certain sensations. For example, you might really enjoy movement, visual experiences and textures, and be very sensitive to sounds.

Summary

In this lecture, we have learnt that sensory processing; neurological thresholds, self -regulation strategies are very important aspects that shape information processing in the brain. We also noted that the extreme ends of the neurological threshold are habituation (related to high thresholds) and sensitization (related to low thresholds). Other terms involved in sensory processing were also learnt, such as hyper responsiveness and hypo responsiveness

Post-Test

1. Differentiate between neurological threshold and self-regulation.
2. Briefly discuss sensory processing.

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LECTURE TWO

Patterns of Responding to Sensory Events

Introduction

Apart from the two major factors (neurological thresholds and self regulation strategies) associated with our understanding of the overall concept of sensory, we can identify four basic patterns of responding to sensory events in everyday life. In this lecture, the highlights include low or poor registration, sensation seeking, sensation avoiding, and sensation sensitivity.

Objectives

At the end of this lecture, you should be able to:

1. discuss the patterns of responding to sensory events; and
2. demonstrate your understanding of sensation seeking, sensation avoiding, sensation sensitivity and low or poor registration

Pre-Test

1. What do you understand by sensation seeking?
2. Define low registration
3. What is sensation avoiding?
4. What is sensation sensitivity

CONTENT

Low Registration/ Poor Registration

Low registration refers to a pattern of sensory processing that is characterized by high sensory thresholds and a passive self regulation strategy (Dunn, 1997). When people have a low registration pattern of sensory processing, they notice sensory stimuli much less than others. The sensory profile measures cover the life span, and use informant report to evaluate a person's ability to register sensory input. People who have low registration patterns seem uninterested, self absorbed and sometimes dull in affect. They do not notice what is going on around them, and miss cues that might guide their behaviours. We hypothesize that most events in daily life do not contain a sufficient amount of intensity to meet these children's thresholds; their passive strategies lead to their being somewhat oblivious to activities. Dunn and colleagues have conducted national studies of infants, children and adults with and without disabilities, and have found that persons without disabilities of all ages notice and register sensory input most of the time, and that people with disabilities such as autism and schizophrenia are significantly more likely to experience low registration. When a person has low registration patterns, interventions are directed at increasing the intensity of sensory input to improve the chances for noticing and responding to environmental demands.

Sensation Seeking

Sensation seeking refers to a pattern of sensory processing that is characterized by high sensory thresholds and an active self regulation strategy (Dunn, 1997). When people have sensation seeking patterns of sensory processing, they enjoy and generate extra sensory input for themselves. *The Sensory Profile measures cover the life span, and use informant report to evaluate a person's ability to register sensory input*. Children who have Sensation Seeking patterns are very active, continuously engaging and excitable. We hypothesize that they are engaging in active strategies to increase input as a means to meet high thresholds. Dunn and colleagues have conducted national studies of infants, children and adults with and without disabilities, and have found that persons without disabilities of all ages seek and derive pleasure from sensory experiences. Sensation seeking becomes a problem when seeking behaviours keep the person from continuing in a desired activity. When a person has difficulty with sensation seeking, interventions are directed at providing more opportunities for the desired sensory input within daily life activities.

Sensation Avoiding

Sensation avoiding refers to a pattern of sensory processing that is characterized by low sensory thresholds and an active self regulation strategy (Dunn, 1997), when people have a sensation avoiding pattern of sensory processing; they are bothered by input more than others. The sensory profile measures cover the life span, and use informant report to evaluate a person's sensation avoiding tendencies. Children who have sensation avoiding patterns are rule bound ritual driven and uncooperative. They engage in behaviours to limit the sensory input they must deal with. We hypothesize that they limit sensory opportunities because unfamiliar sensory input is difficult to understand and organize, or might even be "threatening" to the nervous system. Ritual behaviour provides a high rate of familiar sensory input, while simultaneously limiting the possibility of unfamiliar input. Dunn and colleagues have conducted national studies of infants, children and adults with and without disabilities, and have found that persons without disabilities of all ages seldom engage in sensation avoiding behaviours, and that people with disabilities such as autism and schizophrenia are significantly more likely to engage in a high amount of sensation avoiding patterns. When a person has sensation avoiding patterns, interventions are directed at making input less available, so that the person does not become overwhelmed and want to withdraw from participation in everyday life.

Sensory Sensitivity

Sensory sensitivity refers to a pattern of sensory processing that is characterized by low sensory thresholds and a passive self regulation strategy (Dunn, 1997); when people have a sensory sensitivity pattern of sensory processing, they detect more input than others. The sensory profile measures cover the life span, and use informant report to evaluate a person's sensory sensitivity tendencies. Children who have sensory sensitivity patterns are distractible, hyperactive and can be complainers. They notice many more sensory events than others do, and comment about them with regularity. We hypothesize that they have low thresholds that enable them to have a high rate of noticing what is going on around them. These children use passive strategies in that they allow things to happen and comment rather than removing themselves (as a sensation avoider is likely to do). Dunn and colleagues have conducted national studies of infants, children and adults with and without disabilities, and have found that persons without disabilities of all ages seldom engage in sensory sensitivity behaviours, and that people with disabilities such as autism, Asperger syndrome and ADHD are significantly more likely to engage in a high amount of sensory sensitivity patterns. When a person has sensory sensitivity patterns, interventions are directed at providing more structured input, so that the person does not become overwhelmed in everyday life.

Summary

In this lecture, we have discussed the basic patterns of responding to sensory events. The contemporary conception of low and high registration, sensory sensitivity, sensation seeking, and avoiding were discussed in details. In the process, the distinctions among the terms were equally made.

Post-Test

1. How can you relate sensation seeking, low registration, sensation avoiding, and sensation sensitivity to your understanding of sensory processing?
2. Briefly discuss the patterns of sensory processing

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LECTURE THREE

Introduction to Sensory Receptors

Introduction

This lecture will introduce you to the concept of sensory receptors in terms of functions, kinds and the general meaning as used by scientific researchers.

Objectives

At the end of this lecture, you should be able to:

1. show a good understanding of sensory receptors; and
2. highlight and explain the different sensory receptors.

Pre-Test

1. Define a sensory receptor
2. Enumerate the different types of sensory receptors you know
3. What do you understand by processing, neurological threshold and self-regulation?
4. Define self -regulation strategies, passive and active strategies for self-regulation.

CONTENT

Sensory receptors account for our ability to see, hear, taste, and smell, and to sense touch, pain, temperature, and body position. They also provide the unconscious ability of the body to detect changes in blood volume, blood pressure, and the levels of salts, gases, and nutrients in the blood. These specialised cells are exquisitely adapted for the detection of particular physical or chemical events outside the cell. They are connected to nerve cells, or are themselves nerve cells. Many of them are enclosed in sense organs. Others are the endings of nerve fibers that ramify within the skin, the muscles, bones, and joints and the other organs of the body. Yet others are nerve cells within the brain that are sensitive temperature, to dissolved gases, salts, and other substances in the fluid around them.

In human beings there are just four basic types of sensory receptor-sensitive to mechanical stimulation, light, chemicals, and temperature-but they vary enormously in their form. The particular kind of stimulus to which they respond is largely determined by the structure of the sense organ around them or by their location in the body. Some animals have receptors sensitive to magnetic fields or to electrical fields. All sensory receptors in the human body operate on the same general principles. Their membranes contain particular protein molecules that are activated and change their shape when the appropriate physical force or chemical substance comes into contact with them. For instance, light falling on the retina causes rotation of a small part of molecules called photo-pigments, which lie within the internal membranes of the rod and cone receptor cells.

Olfactory neurons in the nose have fine hairs covered in a huge variety of protein molecules to which inhaled odorant molecules attach in a ‘lock-and-key’ fashion. Specialised proteins in the membranes of hair cells in the cochlea and the vestibular apparatus of the inner ear are sensitive to the mechanical forces caused by sound or movements of the head, respectively. Other types of mechano-receptive nerve endings that detect touch and vibration of the skin, movements and stretch of muscles, tendons, and joints, and the pressure of blood in the blood vessels and heart, employ similar stretch-sensitive proteins in their membranes.

Activation of the specific protein receptors in the cell membrane is followed by a sequence of reactions, collectively called transduction, leading to the initiation of nerve impulses (action potentials), which are transmitted along a fibre towards (or within) the central nervous system. The essential step, resulting directly or indirectly from the activation of the receptor molecules, is the opening or closing of tiny pores (ion channels) in the cell membrane. This causes a change in the movement of charged ions (usually sodium ions), which alters the voltage inside the receptor cell. The amplitude of this receptor potential varies with the intensity of the stimulus. This then leads to the firing of nerve impulses, either in the sensory cell itself or in an adjacent nerve cell. The sensory stimulus is thus translated into a train of impulses whose frequency varies with the stimulus strength.

The sensitivity of a sensory receptor usually depends on how much it has recently been stimulated. Hence, if a receptor (say a nerve fibre in the skin) is exposed to a constant stimulus (such as pressure on the skin), the rate of nerve impulses quickly falls to a much lower level, or even ceases altogether. This phenomenon, called adaptation, leads receptors to be more sensitive to changing than to steady stimulation. Hence they usually measure the stimulus as a percentage of its deviation from the background signal, rather than signaling its absolute intensity. This means that our sensory receptors are sensitive to small changes in signal strength but tune out constant signals. Everyone is familiar with this effect: it is the reason you cease to notice a constant background noise, quickly desensitize to strong smells, and are gradually able to see in a darkened room after leaving one that is brightly lit. It is one example of the way in which our sensory systems 'economise' in their use of nerve impulses.

Summary

In this lecture, we have examined sensory receptors and how they account for our ability to see, hear, taste, and smell, and to sense touch, pain, temperature, and body position. We also learnt that in human beings there are just four basic types of sensory receptor, sensitive to mechanical stimulation, light, chemicals, and temperature but they vary enormously in their form. The principles underlying the receptors were discussed too.

Post-Test

1. Examine the sensory receptors indicated in this chapter.
2. Differentiate between any of the two mentioned above.
3. Identify the major concepts in this chapter and relate them to the functioning of sensory receptors
4. Write short note on your conception of sensory receptor

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LECTURE FOUR

Sense and Sensory Awareness

Introduction

This lecture introduces pupils' psychologists to the meaning of awareness of outside and the internal world of our own bodies through the study of sensation, perception, stimulus and the sense.

Objectives

At the end of this lecture, you should be able to:

1. explain the concepts of sensation, perception and stimulus as used in the field of psychology; and
2. discuss the relationship existing between sensation and perception

Pre-Test

1. What is a sense?
2. What is sensation?
3. Provide brief explanation of your understanding of perception and stimulus.

CONTENT

Definition of Sense

There is no firm agreement among neurologists as to the number of senses because of differing definitions of what constitutes a sense. One definition states that an exteroceptive sense is a faculty by which outside stimuli are perceived. The traditional five senses are sight, hearing, touch, smell, taste: a classification attributed to Aristotle. Humans also have at least six additional senses (a total of eleven including interoceptive senses) that include: nociception (pain), equilibrioception (balance), proprioception & kinesthesia (joint motion and acceleration), sense of time, thermoception (temperature differences), and in some a weak magnetoception (direction)

One commonly recognised categorisation for human senses is as follows: chemoreception; photoreception; mechanoreception; and thermoception. Indeed, all human senses fit into one of these four categories.

Different senses also exist in other animals, for example electroreception.

A broadly acceptable definition of a sense would be "a system that consists of a group of sensory cell types that responds to a specific physical phenomenon, and that corresponds to a particular group of regions within the brain where the signals are received and interpreted." Disputes about the number of senses typically arise around the classification of the various cell types and their mapping to regions of the brain.

Senses

Sight

Sight or vision: is the ability of the brain and eye to detect electromagnetic waves within the visible range (light) interpreting the image as "sight." There is disagreement as to whether this constitutes one, two or three senses. Neuroanatomists generally regard it as two senses, given that different receptors are responsible for the perception of colour (the frequency of photons of light) and brightness (amplitude/intensity - number of photons of light). Some argue that stereopsis, the perception of depth, also constitutes a sense, but it is generally regarded as a cognitive (that is, post-sensory) function of brain to interpret sensory input and to derive new information. The inability to see is called blindness.

Hearing

Hearing or audition: is the sense of sound perception. Since sound is vibrations propagating through a medium such as air, the detection of these vibrations, that is the sense of the hearing, is a mechanical sense akin to a sense of touch, albeit a very specialised one. In humans, this perception is executed by tiny hair fibres in the inner ear which detect the motion of a membrane which vibrates in response to changes in the pressure exerted by atmospheric particles within a range of 20 to 22000 Hertz, with substantial variation between individuals. Sound can also be detected as vibrations conducted through the body by tactition. Lower and higher frequencies than that can be heard are detected this way only. The inability to hear is called deafness.

Taste

Taste or gustation: is one of the two main "chemical" senses. There are at least four types of tastes that "buds" (receptors) on the tongue detect, given that each receptor conveys information to a slightly different region of the brain. The inability to taste is called ageusia.

The four well-known receptors detect something sweet, salt, sour, and bitter, although the receptors for something sweet and bitter have not been conclusively identified. A fifth receptor, for a sensation called umami, was first theorized in 1908 and its existence confirmed in 2000. The umami receptor detects the amino acid glutamate, a flavour commonly found in meat and in artificial flavourings such as monosodium glutamate.

Note that taste is not the same as flavour; flavour includes the smell of a food as well as its taste.

Smell

Smell or Olfaction: is the other "chemical" sense. Unlike taste, there are hundreds of olfactory receptors, each binding to a particular molecular feature. Odour molecules possess a variety of features and thus excite specific receptors more or less strongly. This combination of excitatory signals from different receptors makes up what we perceive as the molecule's smell. In the brain, olfaction is processed by the olfactory system. Olfactory receptor neurons in the nose differ from most other neurons in that they die and regenerate on a regular basis. The inability to smell is called anosmia. Some neurons in the nose are specialised to detect pheromones.

Touch

Touch, also called mechanoreception or somatic sensation, is the sense of pressure perception, generally in the skin. There are a variety of nerve endings that respond to variations in pressure (e.g., firm, brushing, and sustained). The inability to feel anything or almost anything is called anesthesia. Paresthesia is a sensation of tingling, pricking, or numbness of a person's skin with no apparent long term physical effect.

Balance and acceleration

Balance, Equilibrioception, or vestibular sense, is the sense which allows an organism to sense body movement, direction, and acceleration, and to attain and maintain postural equilibrium and balance. The organ of equilibrioception is the vestibular labyrinthine system found in both of the inner ears. Technically this organ is responsible for two senses, angular momentum and linear acceleration (which also senses gravity), but they are known together as equilibrioception.

The vestibular nerve conducts information from the three semicircular canals, corresponding to the three spatial planes, the utricle, and the saccule. The ampulla, or base, portion of the three semicircular canals each contains a structure called a crista. These bend in response to angular momentum or spinning. The saccule and utricle, also called the "otolith organs", sense linear acceleration and thus gravity. Otoliths are small crystals of calcium carbonate that provide the inertia needed to detect changes in acceleration or gravity.

Temperature

Thermoception is the sense of heat and the absence of heat (cold) by the skin and including internal skin passages. The thermoceptors in the skin are quite different from the homeostatic thermoceptors in the brain (hypothalamus) which provide feedback on internal body temperature.

Kinesthetic sense

Proprioception, the kinesthetic sense, provides the parietal cortex of the brain with information on the relative positions of the parts of the body. Neurologists test this sense by telling patients to close their eyes and touch the tip of a finger to their nose. Assuming proper proprioceptive function, at no time will the person lose awareness of where the hand actually is, even though it is not being detected by any of the other senses. Proprioception and touch are related in subtle ways, and their impairment results in surprising and deep deficits in perception and action.

Pain

Nociception (physiological pain) signals near-damage or damage to tissue. The three types of pain receptors are cutaneous (skin), somatic (joints and bones) and visceral (body organs). It was believed that pain was simply the overloading of pressure receptors, but research in the first half of the 20th century indicated that pain is a distinct phenomenon that intertwines with all of the other senses, including touch. Pain was once considered an entirely subjective experience, but recent studies show that pain is registered in the anterior cingulate gyrus of the brain.

Sensation and Awareness

Sensation is the process of receiving, translating, and transmitting messages from the outside world to the brain (Lahey, 2004); Sensation is equally defined as the immediate experience of basic properties of an object of event that occurs when a receptor is stimulated. Sensory receptor cells are cells inside sense organs, which receive outside forms of energy and translate them into neural impulses that can be transmitted to the brain for interpretation. When enough physical energy strikes a receptor cell, the cell sends neural impulses to the brain. It is the signals sent by these receptors that cause us to become aware of the outside world. Perception, on other hand, is derived from an English word "perceive" that is, to become aware of something through the senses, to comprehend or grasp a stimulus. Perception arises from the subjective experiences of objects or events that ordinarily results from stimulation of receptor organs of the body. The definition has taken different perspectives to mean insight, intuition and knowledge gained by perceiving. Perception also is the act, process, faculty of perceiving, organizing, and interpreting sensory input as signaling a particular object or event. More so, perception involves the neurological processes by which recognition and interpretation are affected. By specialised receptors, the stimulation is transformed or encoded into neural activity. A key conception in understanding sensation and perception is stimulus. The term 'stimulus' comes from the action of sensory receptor cells, and it refer to any aspect of the outside world that directly influences our behaviour or conscious experience. Psychologists call the registration of sensation when a physical event excites the appropriate receptors early processing, but this not yet perception. Perception includes two major phases: immediate processing and late processing. By immediate processing, the input is organised into coherent units, while in late processing the perceptual system interprets the meaning.

Early, immediate and late processing seems to indicate a simple sequential process, but more is happening. Processing may be “bottom up” initiated by stimulus or “top down” guided by knowledge, expectation, or belief. The two sorts of processes could be in play at the same time.

Summary

In this lecture, we learnt that our brains are not in direct contact with the outside world. But sensory receptor cells have the ability to transduce physical energy into coded neural messages that are sent to the brain (sensation), where they are interpreted (perception). We realised that not all forms of physical energy could become part of our perception of the world. We must have sensory receptor cells that can transduce that form of energy and the stimulation must be strong enough to exceed the sensory threshold. Our perception of external reality is complicated because there is no simple and direct relationship between the properties of physical stimuli and our conscious sensations. Finally we learnt that external stimuli could only be perceived through the senses.

Post-Test

1. What differences exist between the above-mentioned senses?
2. Briefly examine the sensory receptors mentioned in this chapter.
3. Write short notes on your conception of sensation and perception.

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LECTURE FIVE

Vision I: Introduction, Eye-ball, Refractory media, and Disorders of the Eye

Introduction

As far back as the 1760's, the famous philosopher Immanuel Kant proposed that our knowledge of the outside world depends on our modes of perception. In order to define what is "extrasensory" we need to define what is "sensory". Traditionally, there are five senses: sight, smell, taste, touch, and hearing. The sense of vision (sight) is one of the five classical senses, which assume greater importance than any other sensory system. Each of the senses consists of specialized cells that have receptors for specific stimuli. These cells have links to the nervous system and thus to the brain. Sensing is done at primitive levels in the cells and integrated into sensations in the nervous system.

Sight is probably the most developed sense in humans, followed closely by hearing. The highlights in this study include the eyeball, the eye as refractive media, errors of refraction and accommodation

Objectives

At the end of this lecture, you should be able to:

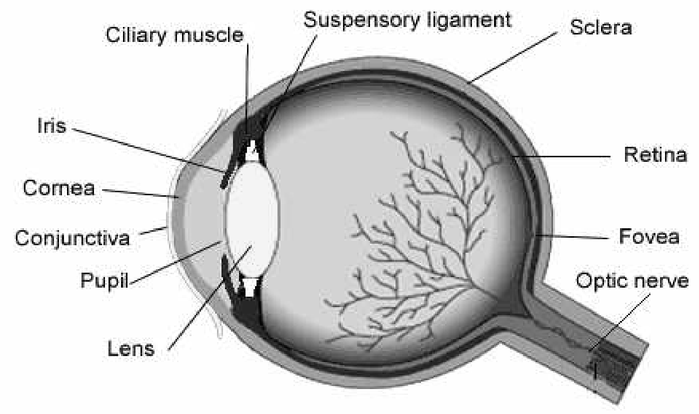
1. describe the anatomy of human eye;
2. label the parts of the eye, indicating their functions; and
3. explain the mechanism of refraction.

Pre-Test

1. What is vision?
2. Identify the functional parts of the human eye
3. Describe the physiology of human sight

CONTENT

Eye-ball



The eye is the organ of vision, situated in the eye sockets of the skull. It is almost spherical in shape and is about 2.5cm in diameter. The adipose/fatty tissue occupies the space between the eyes and the orbital cavity. The delicate eye is protected from injury by the bony wall of the orbit and the surrounding fat.

The eye has three layers, the outer layer, the middle layer and the inner layer. The outer fibrous layer is made of sclera and the cornea. The middle vascular layer is made of the choroids, ciliary body and iris. The inner nervous tissue is made up of retina. The structures inside the eyeball are the lens, aqueous fluid/humor and vitreous fluid/humor.

Cornea is convex in shape and transparent as glass, it is found in the front of the eye. The continuation of cornea seen in white colour is called sclera. It is the outermost layer of the eye. It gives shape to the eyeball. The sclera or white of the eye forms the outermost layer of tissue of the posterior and lateral aspects of the eyeball and is continuous interiorly with the transparent cornea. It preserves the eyeball and also protects the delicate inner layers. The transparent cornea in front allows the passage of light rays to focus on the retina. The extrinsic muscles attached to the sclera permits and limits movements of the eyeball within the orbit.

The choroid is very rich in blood vessels, deep chocolate brown in colour and lines in the posterior $5/6^{th}$ of the inner surface of the eye. Melanin is the pigment, which gives dark coloration to the choroids. It absorbs excess light that enters the eye. Numerous capillaries are present in the choroids. They bring oxygen and nutrients required for the eye. When light enters the eye through the pupil, it stimulates the nerve endings in the retina and is then absorbed by the choroids.

The Cilliary body is the anterior continuation of the choroids. It consists of ciliary muscles and secretory epithelial cells and gives attachment to the suspensory ligament. Contraction and relaxation of the ciliary muscle changes the thickness of the lens, refracts light rays entering the eye to focus them on the retina. The epithelial cells also secrets aqueous fluid into the anterior chamber of the eye.

The Iris is the visible coloured part of the eye, which extends anteriorly from the ciliary body, lying behind the cornea in front of the lens. It is a circular body composed of pigment cells and two layers of smooth muscle fibers. It divides the anterior segment into the anterior and posterior chambers, which contain aqueous fluid secreted by the ciliary body. At the center of the iris is the pupil. Parasympathetic stimulation constricts the pupil and sympathetic stimulation dilates it. The amount of pigment cells in the iris is genetically determined. This determines the colour of the iris. Albinos have no pigment cells, and people with blue eyes have fewer pigment cells than people with brown eyes.

The lens is a highly elastic, circular bi- convex body lying immediately behind the pupil. It consists of fibers enclosed within a capsule. It is suspended from the ciliary muscle by the suspensory ligament. The ciliary muscle through the suspensory ligament controls its thickness. The lens bends (refracts) light rays reflected by the objects in front of the eyes. The nearer the object to be viewed is, the thicker the lens becomes to allow focusing.

The eye has a complex structure consisting of a transparent lens that focuses light on the retina. The retina is covered with two basic types of light-sensitive cells, the cells-rods and cones. The cone cells are sensitive to color and are located in the part of the retina called the fovea, where the light is focused by the lens. The rod cells are not sensitive to color, but have greater sensitivity to light than the cone cells. These cells are located around the fovea and are responsible for peripheral vision and night vision. The eye is connected to the brain through the optic nerve. The point of this connection is called the "blind spot" because it is insensitive to light.

The Eye as a refractory media

As light rays enter the eye, the biconvex lens bends and focuses light rays on the retina. Before reaching the retina, light rays pass successively through the conjunctiva, cornea, aqueous fluid, lens and vitreous body. To increase the refractory power, the ciliary muscle contracts, releasing its pull on the suspensory ligament and the anterior surface of the lens bulges forward, increasing its convexity this focuses light rays on the retina. When the ciliary muscle relaxes, it slips backwards, increasing its pull on the suspensory ligament, making the lens thinner. This focuses light rays from distant objects on the retina.

Disorders of the eye

As we grow old, the elasticity of the lens decreases. This state is known as presbyopia. The transparency of the lens is lost. This is common in aged people and in some persons affected by diseases. This disorder is known as cataract.

Myopia (Short sight)

The elongation of the eyeball results in myopia. The image of the object is formed in front of the retina. People having such errors are not able to see distant objects clearly.

Hypermetropia (Long sight)

In this case, the eyeball shortens leading to the formation of the image behind the retina. Such people cannot see near objects clearly, though they are able to see distant objects.

Astigmatism

Like the shape of the eyes, any disorder in the curvature of the cornea or lens affects the vision. This results in the formation of incomplete and blurred images of objects. This state is known as astigmatism. This disorder is rectified using suitable cylindrical lenses.

Summary

In this lecture, we learnt of the structure of the eye. We are meant to understand that the eye is much like a human camera. The lens focuses a visual image on the retina of the eye, which contains two kinds of sensory receptor cells, the rods and the cones. These transduce the light waves into neural messages. The two kinds of receptor cells perform their jobs somewhat differently. Cones work best in intense light; provide good visual acuity, and transducer information about colour. We also learnt of the disorders of the eye caused by changes in the elasticity of the lens.

Post – Test

Draw and label the eye and illustrate the mechanism of the eye.

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LECTURE SIX

Vision II: Image Formation, Accommodation, and Visual Pathway

Introduction

In this lecture, you would learn how images are formed in the eye. The mechanisms underlying the constriction of the pupils, convergence of the eyeballs and changing the power of the lens (regulates the intensity of the light) would equally be demonstrated

The highlights involve the concept of accommodation, retinal projection and the visual pathway.

Objectives

At the end of this lecture, you should be able to:

1. describe the physiology of vision by human eye;
2. illustrate the functioning of the cones and rods in the regulation of light; and
3. explain the mechanism of image formation and accommodation.

Pre-Test

1. What do you understand by accommodation?
2. How is image formed in the human eye?
3. Describe the physiology of human sight
4. What is binocular vision?

CONTENT

How image is formed

The light gets refracted when it passes through cornea, aqueous humour, lens and vitreous humour. As a result of this, the image falls on the retina. But when we look at a near object, its image will be formed behind the retina. Here the curvature of the lens is increased by the contraction of the ciliary muscles, so that the image is formed on the retina. Thus depending upon the distance of the object from the eye, its ability to focus the image on the retina by altering the convexity of the lens is called the power of accommodation. In addition to the contractions of the ciliary muscles, the curvature of the cornea, shape of the pupil and the fluids in the eye also help in this process.

Accommodation

The constriction of the pupils, convergence of the eyeballs and changing the power of the lens assists accommodation by reducing the width of the beam of light entering the eye so that it passes through the central curved part of the lens. In a bright light, the pupils are constricted. In a dim light they are dilated. If the pupils were dilated in a bright light, too much light would enter the eye and damage the sensitive retina. In a dim light, if the pupils were constricted, insufficient light would enter the eye to activate the photosensitive pigments in the rods and cones, which stimulate the nerve endings in the retina. Contraction of the circular muscles of the iris constricts the pupil, and contraction of the radiating muscles of the iris dilates it. Sympathetic stimulation dilates the pupils and the parasympathetic stimulation causes constriction.

The pupil constricts in bright light and dilates in dimlight. When the circular muscles contract, the pupil decreases in size. The lens is made of a substance, which has elasticity. The lens is connected to the ciliary muscles with the help of ligaments. The lens in the eye is convex.

The chemistry of vision

Image of the objects are formed in the eye. Photoreceptors such as rod cells and cone cells are present in the retina. Rod cells get stimulated in dimlight. Thus it helps the vision in dimlight. But cone cells get stimulated only in bright light. The cone cells help to distinguish colours and to see the objects in bright light. The pigment seen in the rod cells is rhodopsin.

When light falls on it, rhodopsin dissociates resulting to chemical changes. The impulses formed as a result are received as a stimulus by the nerve cells. Retinine, which is the part of the rhodopsin, is synthesized from Vitamin A. Now it is clear that the deficiency of vitamin A causes night blindness. There are different types of cone cells to recognize the primary colours namely, blue, green and red. They contain different types of a pigment called iodopsin, which helps us to recognize the primary colours. Damages in any of these cone cells may cause inability to distinguish colours. This is called colour blindness.

The blind spot and the yellow spot

The part of the retina where the optic nerve begins lacks rod cells and cone cells. This part is called blindspot. The part, which is seen almost in the centre of the retina, is called yellow spot. More cone cells are present here. There are no rod cells. It is the point of highest vision. When we concentrate on small objects the image is formed here.

The physiology of vision

You have understood that the light that falls on the photoreceptors causes a chemical change. This stimulus creates impulses that travel through the optic nerve, which is formed by the clustering of axons of the photoreceptors, reaches the cerebrum. The process involves refraction of light rays, changing the size of the pupils and accommodation of the eyes. Though the image formed in the retina is inverted, it is the cerebrum that makes the vision a reality.

Binocular vision

Though the image of an object is formed in both the eyes, we do not feel it as two separate images. It is the cerebrum, which coordinates the images formed in both the eyes. The binocular vision helps us to calculate the distance from objects correctly. This is not possible for all animals. Binocular vision is obtained since it is possible to concentrate both eyes on a single object. The balanced movement of the two eyes is made possible by the muscles of the eyeball. If the balanced movement of the muscles is not possible, the condition is called squint. Early detection of this disorder can be rectified by a careful surgery.

Glaucoma

We have understood that the production and re absorption of the aqueous humour is a continuous process but where reabsorption is prevented the pressure inside the aqueous chamber is increased. The increase in pressure in the eyeball results in glaucoma. The curvature of the cornea changes due to the increase in pressure. The patient gets pain in his eyes and he sees colour rings around a flame. As this continues, the extraordinary pressure causes the receptor cells to disintegrate.

Protection within the eye

The position of the tear gland is very important in the protection of the eye.

The tears produced by these glands enter into the nose. An enzyme called lysozyme present in tears prevents infection of the eye. Conjunctiva is a membrane, which covers the conjuctivitis.

Summary

In this lecture, we have learnt that images are formed on the retina depending upon the distance of the object from the eye, its ability to focus the image on the retina and by altering the convexity of the lens. Also, photoreceptors such as rod cells and cone cells are present in the retina and relevant in distinguishing colours. We equally learnt that physiology of vision involves refraction of light rays, changing the size of the pupils and accommodation of the eyes. The binocular vision helps us to calculate the distance from objects correctly. Lastly, the increase in pressure in the eyeball results in glaucoma.

Post-Test

1. Describe how different parts of the eye work together to produce vision
2. Discus the chemistry behind the glaucoma.

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LECTURE SEVEN

Vision III: Transduction, Sensory Limits, Dark and Light Adaptation

Introduction

In this lecture, we shall discuss the concept of transduction, sensory limits, dark and light adaptation. The mechanisms underlying these concepts are also examined. The concept of accommodation, retinal projection and the visual pathway also form part of the discussion.

Objectives

At the end of this lecture, you should be able to:

1. explain the concept of transduction, sensory limits and adaptation;
2. demonstrate the understanding of light and dark adaptation; and
3. differentiate between transduction, and adaptation of light.

Pre- Test

1. Define transduction
2. Briefly explain sensory limits?
3. How does the eye adapt to light and dark environments?

CONTENT

Transduction

Energy from stimuli cannot go directly to the brain. Light, sound, and other kinds of energy from the outside world are not able to travel through the nerves, and the brain cannot "understand" what they mean. To be useful to the brain, sensory messages must be translated into neural impulses that the neurons carry and the brain understands. The translation of one form of energy into another is called transduction. Sense organs transduce sensory energy into neural energy. This is accomplished in the sense organ by the sensory receptor cells. As stated earlier, sensory receptor cells are specialised neurons that are excited by specific kinds of sensory energy and give off neural impulses from their axons. Some sensory receptor cells are sensitive to sound, some to light, some to chemicals, and so on. But in every case, the receptor cells give off coded neural impulses that carry the transduced sensory message to one of the sensory areas of the brain. The sense organs themselves (such as the ear, eye, nose etc) are constructed in special ways that expose the receptor cells to sensory energy and help them transduce it into neural impulses. At the centre of every sense organ are receptor cells that do the transducing

Sensory Limits

Even when we have receptor cells that can transduce a kind of sensory message, not every message will be strong enough to be detected. The term threshold refers to the lower limits of sensory experience. The primary kinds of threshold are; the smallest magnitude of a stimulus that can be detected, and the smallest difference between two stimuli that can be detected.

The absolute threshold is the smallest magnitude of the stimulus that can be detected. Measuring such thresholds is not a simple matter. People differ considerably in their sensitivity to weak stimuli, and the sensitivity of each of us differs from time to time. For this reason, absolute thresholds are defined as the magnitude of a stimulus that subjects can detect half a time. The smallest difference between two stimuli that can be detected half the time is called the difference threshold. For example, the smallest change in intensity of your stereo that you can distinguish as “louder’ 50 percent of time is your difference threshold for that stimulus. Detailed knowledge of absolute and difference thresholds has, in fact, been used by the electronics industry to design better stereo system.

Dark and light Adaptation

When you walk into dark movie theatre from the daylight, you are “blind” at first; your eyes can pick a very little visual information. On spending about 5 minutes however, your vision in the darkened room considerably improves slowly until you can see fairly well. When you exit the theatre from the matinee performance, you have the opposite experience. At first, the intense light “blinds” you. You squint and block out the painful light, but in a little while you can see normally again. What in fact, is going on? How can you be sighted one moment and blind the next moment just because the intensity of light has suddenly changed? The phenomena are called dark adaptation and light adaptation.

Here is what happens in the retina during dark adaptation. In a lighted room, the rods and cones are being used frequently, so they are not very sensitive. When we enter darkness, the rods and cones are not sensitive enough to be stimulated by the low-intensity light. This gives the receptors a “rest”, so they begin to gain sensitivity by making a fresh supply of the chemicals used in light reception, which have been literally “bleached out” by the intense light.

At first, both the rods and the cone are recovering their sensitivity, so improvement is fairly rapid. But the cones become fully sensitive (remember, they are not very sensitive in weak light) within about 5 minutes, so the rate of improvement slows after that. The rods continue to improve in sensitivity slowly, reaching a level of sensitivity to light that is an amazing 100,000 times grater than the bright illumination after about 30munites in the dark.

In light adaptation

The eye is much like a human camera. The lens focuses a visual image on the retina of the eye, which contains two kinds of sensory receptor cells, the rods and the cones. The wavelengths, amplitude, and complexity of the light waves are tranduce into neural messages. These two kinds of receptor cells perform their jobs somewhat differently. Cone work best in intense light; provide good visual acuity, and transduce information about colour. Rods work well in weak light, do not provide good acuity, and do not code information about colour. The eye does not function well when the intensity of light suddenly changes, but it quickly regains its sensitivity through the processes of light and dark adaptation. There are two major theoretical explanations of how the visual systems tranduces colour. One states that three different kinds of cones are most sensitive to light of different wavelengths. The other suggests that two kinds of colour-processing mechanisms in the visual system process complementary colours. Each theory is "correct" at different stages of the information processing about the wavelength of light.

Summary

In this lecture, we have learnt that the concept of transduction. We noted that energy from the stimuli must be translated into neural impulses that the neurons carry and the brain understands. This is accomplished in the sense organ by the sensory receptor cells. Sensory Limits in the term threshold are also learnt. Cultural orientations in terms of group ideology, individualism and collectivism shape the behaviour of people in social setting. An individualistic culture considers the interest of individuals to be above the group interest while the collectivist culture emphasizes that the group's interest takes priority over individual's interest.

Post Test

1. Describe the roles played by the rods and cones in both dark adaptation and light adaptation
2. Explain the role of accommodation in vision.

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LECTURE EIGHT

Vision IV: Colour Vision, Visual Perception and Depth Perception

Introduction

Sensations that are transmitted to the brain have little “meaning” of their own. They are in the form of raw neural energy that must be organised and interpreted in the process we call perception. However, some aspects of perception are unique to members of different cultures. The specific learning experiences, memories, motives, and emotions of the individual also can influence perception. For example, we all perceive the stimuli of knife in pretty much the same way because of the inborn ways we organise visual information. But a knife also has unique perceptual meaning to each individual, depending on whether the person has been cut by a similar knife.

Objectives

At the end of this lecture, you should be able to:

1. describe the visual perception and depth perception; and
2. explain the mechanism of colour vision

Pre-Test

1. What is colour vision?
2. Define visual perception
3. What do you understand by perception?
4. Briefly explain visual and depth perception

CONTENT

Colour Vision

Energy of any wavelength within the spectrum of visible light evokes a sensation of colour when it stimulates the human visible system. Light energy is that energy which has no colour of its own. Colour is the conscious expectation experience that results from the processing of light energy by the eye and nervous system. It's obviously useful to be able to discriminate among lights of different wavelengths. It has taken psychologists and other scientists more than a hundred years to reach the current understanding of the complex mechanisms of colour.

In the early 1800s, Thomas Young and Hermann von Helmholz made the observation that any colour can be created by shinning different combinations of the wavelengths of light for red, blue, and green on a single spot. For example, as the combination of red and green light produces yellow. Based on this observation, Young and Helmholz guessed that there are three kinds of cones in the retina that respond mostly to light in either the red, green or blue range of wavelengths. Their theory is referred to as the trichromatic theory of colour vision. According to this theory, alls sensations of colours results from different levels of stimulation of the red, green, and blue receptors.

Over the years studies have confirmed that the there are indeed three kinds of cones. Each kind of cone contains pigments that mostly absorb light of the wavelengths that correspond to red, green, and blue receptors.

After the trichrometric theory other scientists pointed out that it could not explain three intriguing phenomena, complimentary colour, colour afterimage and partial colour blindness; hence, the opponent -process theory to provide explanations.

The opponent–process theory is the theory of colour vision contending that the visual system has two kinds of colour processors, which respond to light in either the red-green or yellow-blue ranges of wavelengths

Visual Perception

Visual perception begins in the complex neural structures of the eye before sensory messages are transmitted to the brain (Hochberg, 1988). The distinction between sensation and perception, then, is largely an arbitrary one, but it makes our discussion of information processing by the sense organs and brain easier to understand. The major ways, in which sensory information is interpreted into meaningful perceptions, including both those that are common to us all and those that are unique to each individual are discussed.

Raw visual sensations are like the unassembled parts of a washing machine; they must be put together in an organized way before they are useful to us. Gestalt psychologists in their pioneering writings described some of the fundamental ways in which the eye and brain organize visual sensations on perceptions, though worthy of attention (Palmer, 2002).

The following are the five Gestalt principle of perception.

Figure–ground: When we perceive a visual stimulus, part of what we see is the centre of our attention, figure and the rest is the indistinct ground. This principle of perception is very useful in showing us that what we perceive is often based more on what goes on in our brain than what is in front of our eyes.

Continuity: We tend to perceive lines of patterns that follow a smooth contour as being part of a single unit. We do not naturally organize sensations in this way; however, we tend to perceive continuity in lines and patterns.

Proximity: Things that proximal (close together) are usually perceived as belonging together.

Similarity: On this particular fundamental principle, similar things are perceived as being related.

Closure: incomplete figures of familiar things tend to be perceived as complex wholes. Again, we fill in missing sensory information to create complete and whole perceptions.

Depth Perception

The retina has a two-dimensional surface. It has an up and down, and a left and a right, but no depth. The eye and brain accomplish this remarkable feat by using a number of two-dimensional cues to create a perceptual distance.

The eight monocular cues are:

Texture gradient: The texture of objects is larger and more visible up, close and smaller when far away. On curved surfaces, the elements of texture are also more slanted when they are farther away.

Linear perspectives: Objects cast smaller images on the retina when they are more distant. As a result, parallel lines, such as railroad tracks, appear to grow closer together the farther away they are from us. In paintings, therefore, objects with larger relative size will appear to be closer than will objects with smaller relative size.

Superposition: Closer objects tend to be partially in front of, or partially cover up, more distant objects.

Shadowing: the shadows cast by objects suggest their depth.

Speed of movement: Objects farther away appears to move across the field of vision more slowly than do closer objects. For example, a dog running through a distant field appears to move slowly, but it moves quickly when the dog runs right in front of us.

Aerial perspective: Water vapour and pollution in the air scatter light waves, giving distant objects a bluish, hazy appearance compared with nearby objects.

Accommodation: In accommodation, the shape of the lens of the eye must change to focus the visual image on the retina form stimuli that are different distances from the eye. This process is called accommodation. Kinaesthetic receptors in the ciliary muscle, therefore, provide a source of information about the distance of different objects. This information is useful, however, only for short distances up to about 4 feet.

Vertical position: When objects are on the ground, the farther they appear to be below the horizon, the closer they appear to be to us. For objects in the air, however, the farther they appear to be above the horizon, the closer they appear to be to us.

Summary

In this lecture, we have learnt that colour is the conscious expectation experience that results from the processing of light energy by the eye and nervous system. We also noted that it has taken psychologists and other scientists more than a hundred years to reach the current understanding of the complex mechanisms of colour. The contributions of Young and Helmholz to the trichromatic and opponent–process theory of colour vision were equally learnt. The five Gestalt principles of perception and the eight monocular cues of perception were also examined.

Post Test

1. Write short notes on visual perception and depth perception
2. Compare and contrast the trichromatic theory and the opponent-process theory of colour vision.

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LECTURE NINE

Audition I: External, Middle and Inner Ear Cochlear Microphonics

Introduction

The ear is the organ of hearing. One of the stimuli that the nervous system is sensitive to is sound. The outer ear protrudes away from the head and is shaped like a cup to direct sounds towards the tympanic membrane. The tympanic membrane transmits vibrations to the inner ear through a series of small bones to the brain upon which appropriate responses are made by the nervous system.

This chapter describes the three parts of the human ear, the outer ear, middle ear and inner ear.

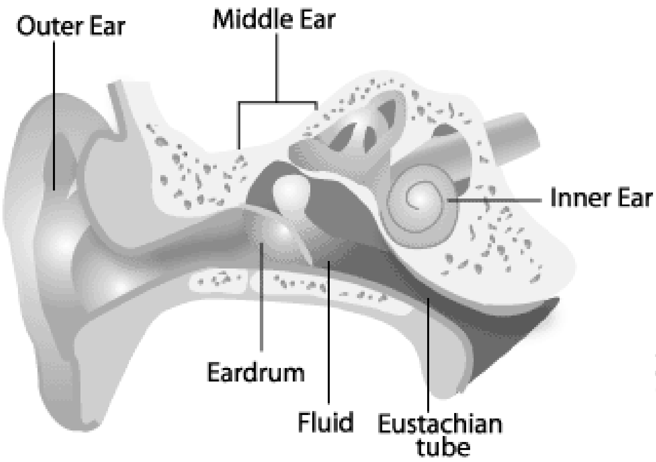
Objectives

At the end of this lecture, you should be able to:

1. describe the parts of the human ear; and
2. explain the physiology of hearing

Pre-Test

1. Describe the human ear
2. Mention the functions of specific parts of the human ear.



CONTENT

Hold the fingers of your palm close to each other and place it behind the pinna. Then try to concentrate on a particular sound continuously having the same frequency. Remove the palm and try to concentrate on the same sound again. What difference do you feel?

If you snap your fingers, you will hear a crack. This sound comes from waves of air that were compressed and expanded by the quick movement of your fingers. If you could see sound waves, you might compare them to the ripples on a lake. Each ripple that is made each time air is compressed and expanded is called a cycle. You can tell the difference between low and high sounds by their pitch. The pitch is determined by the number of cycles that occur per second. The low-pitched sound of a bass has fewer cycles per second than the high pitch of a doorbell. The term frequency is used to express the number of cycles per second. The average person hears frequencies from 20 to 20,000 cycles per second. With normal aging, we lose the ability to detect the very highest of these frequencies, such that by age seventy, many people have trouble hearing sounds above 6,000 cycles. The loudness of a sound is determined by the height or amplitude of the sound wave and is measured in units called decibels. A whisper is about 30 decibels whereas the usual live band blasts about 110 decibels. The higher the decibel level, the more intense the sound would be, and the greater the danger of damaging the organs of hearing. This is why people that work near noisy equipment are always advised to wear ear-protecting equipment.

External Ear

The external ear consists of pinna, auditory canal and ear drum. Pinna helps to direct the sound waves into the auditory canal. Ceruminous glands are special glands, which are found in the walls of the auditory canal, which is the continuation of the pinna. The wax produced by these glands and the hairs in the auditory canal protect the ear from small insects, germs and dust. In additions to this, they help to maintain the temperature and dampness of the auditory canal. The auditory canal ends in the ear drum. It is clear from the diagram that this thin membrane separates the external ear from the middle ear. This membrane capable of vibration is connected to the ossicles of the middle ear.

The Middle Ear

The middle ear is a chamber with air circulation. Within the chamber are three tiny bones, the malleus (hammer), incus (anvil) and the stapes (stirrups). The bones are differently shaped and serve specific functions. When sound waves strike the ear drum, it causes it to vibrate. Each of these act as a lever increasing the pressure on the next, until the pressure exerted by the stirrup is many times greater than what the hammer exerts. The stirrups press against a membrane called the oval window, which lies at the end of the middle ear. The oval window separates the middle ear from the inner ear. The bones of the middle ear are connected to each other by ligaments and are capable of vibrating in a peculiar way. Because the oval window is much smaller than the ear drum, and because of the lever effects that the three tiny bones create, the oval window receives much more pressure per square millimeter than the ear drum does. This increased pressure is needed to move the fluid in the next chamber of the ear. The eustachian tube connects the middle ear to pharynx. This tube helps to regulate the air pressure on both sides of the ear drum (tympanum).

Inner Ear

The inner ear or labyrinth contains the organ of hearing and balance. It is generally described in two pans, the bony labyrinth and the membranous labyrinth. The bony labyrinth is larger than, and encloses the membranous labyrinth of the same shape, which fits into it, like a tube within a tube. In the bony and membranous labyrinths there is a layer of watery fluid called the perilymph and within the membranous labyrinth, there is the endolymph. The bony labyrinth consists of: 1 vestibule, 1 cochlear and 3 semi circular canals. The vestibule contains the oval and round windows in its fill wall. The cochlear resembles a snail's shell. The semi circular is three tubes arranged so that one is situated in each of the three planes of space. They are continuous with the vestibule. The membranous labyrinth lies in the bony labyrinth. It contains endolymph and comprises of the vestibule, cochlear and the three circular canals.

Running almost the entire length of the cochlea are several layers of membranes (the scala vestibule, the scala media and the seal a tympani) that separate the two tubes. The lower membrane, called the basilar membrane, forms a floor on which the ear's sensory receptors sit. Hairlike receptor cells are contained in the organ of corti. Vibration in the cochlear fluid set the basilar membrane in motion. This movement, in turn, moves the organ of corti and stimulates the receptor cells it contains. These receptors transduce the sound waves in the cochlear fluid into coded neural impulses, which are sent to the brain.

Summary

The ear consists of external ear, middle ear (tympanic cavity), and the inner ear. The external ear consists of the auricle (pinna) and the external acoustic meatus. The middle ear contains the oval window, round window and the auditory ossicles. When sound waves strike the ear drum, it causes it to vibrate. The wave sets in motion three tiny bones, the malleus (hammer), incus (anvil) and the stapes (stirrups)

The inner ear or labyrinth contains the organ of hearing and balance, generally described in two parts, the bony labyrinth and the membranous labyrinth. The auditory receptors combine forming the cochlear (auditory) part of the vestibule cochlear nerve, to the hearing area in the cerebrum where the sound is perceived.

Sound waves have properties of pitch and volume, or intensity. Pitch is determined by the frequency of the sound waves while volume depends on the amplitude of the sound waves. Essentially, very loud noise is damaging to the ear.

Post-Test

1. Draw the ear and show the functional areas
2. Classify the ear into three structural parts
3. Describe the middle ear
4. Explain the process of hearing.

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LECTURE TEN

Audition II: Mechanism of hearing, auditory pathway and Sound localization

Introduction

In this chapter, the major issues underlying audition are discussed in relation to mechanism of hearing, auditory pathway and sound location. This includes the technique on how the ear controls the intensity of sounds, frequencies of pith to produce audition. How the brain combines the input of our two ears to determine the direction and distance of sounds was also discussed.

Objectives

At the end of this lecture, you should be able to:

1. describe mechanisms of the human ear;
2. label the parts of the ear, indicating their functions; and
3. explain the mechanism of hearing.

Pre-Test

1. Mention the parts of the ear
2. Identify the functional parts of the human eye
3. Describe the physiology of human sight

CONTENT

Mechanism of Hearing

The ear is the organ of hearing. The outer ear protrudes away from the head and is shaped like a cup to direct sounds toward the tympanic membrane, which transmits vibrations to the inner ear through a series of small bones. The inner ear, or cochlea, is a spiral-shaped chamber covered internally by nerve fibers that react to the vibrations and transmit impulses to the brain via the auditory nerve. From there, the sounds travel to the thalamus and then to the primary auditory area located in the temporal bone of the cortex. The brain combines the input of our two ears to determine the direction and distance of sounds. More so, because of the structure of the inner ear, sounds of different frequencies stimulate the basilar membrane at different places along its length allowing discrimination of pitch. Additionally, the greater the amplitude of the wave created in the endolymph, the greater the stimulation of the auditory receptors in the hair cells in the spiral organ, enabling perception of volume.

The human ear can perceive frequencies from 16 cycles per second, which is a very deep bass, to 28,000 cycles per second, which is a very high pitch. In addition, the human ear can detect pitch changes as small as 3 hundredths of one percent of the original frequency in some frequency ranges. Some people have "perfect pitch", which is the ability to map a tone precisely on the musical scale. Bats and dolphins can detect frequencies higher than 100,000 cycles per second.

Auditory pathway and Sound localisation

The intensity of a sound wave is coded by the number of receptors in the organ of corti that fire. Low intensity sounds stimulate only a few receptors, high intensity sounds stimulate many receptors.

The frequency of the sound wave is apparently coded in at least two ways. First, sound waves of different frequencies stimulate receptor cells at different places along the organ of corti. Higher frequency waves stimulate the organ of corti close to the oval window; lower frequency waves stimulate it farther along the cochlea (except for very low frequencies).

Second, the frequency of the sound waves is duplicated to some extent in the frequency of the signals sent to the brain by the auditory receptors. Only at lower frequencies is each neuron able to signal at the same frequency the sound wave. At higher frequencies, the coding of frequency is achieved by volleys of neural impulse by different groups of neurons, which reflect the frequency of the sound wave.

Not all sounds travel this complete route from outer ear to cochlea. Some sounds are transmitted through the bones of the head directly to the cochlear fluid. We hear ourselves speak (and eat) largely through bone conduction hearing.

This is an important consideration in diagnosing heating problems. People who have suffered damage to the hearing apparatus of the middle ear can hear bone- conducted sounds fairly well, but not airborne sounds. People with damage to the auditory nerve (nerve deafness) have difficulty hearing either type of sound.

World without sound (Soundless world)

Deafness is a state in which hearing is not possible. The defect of the following parts in the ear may cause deafness (ear drum, cochlea, ear ossicles, and auditory nerve) Have you thought of the reasons for the disorders of these organs?

Any infection in eustachian tube will spread to the middle ear. The ear drum may become damaged too by an infection in the auditory canal. In many instances this results in damages in the middle and external ear leading to deafness. How does excessive noise, strong blows on the cheek, pointed objects entering the auditory canal and attack from insects affect hearing? Defects in the brain, auditory nerve, and cochlea are also reasons for deafness. How will you save the ear from deafness?

Summary

In this lecture, we have learnt the mechanism of hearing, auditory pathway and sound localization in the field of sensation and awareness. That attribution theory seeks to understand how, and the process involved in arriving at inferences about the causes of behaviour. The covariation model embraces multiple observations relying, on consistency information, consensus information and distinctiveness.

Post Test

1. Deafness is a state in which hearing is not possible.
2. Differentiate between Auditory pathway and Sound localisation.

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LECTURE ELEVEN

Audition III: Vestibular Mechanisms and Sense of Posture

Introduction

Human beings, in common with other vertebrates, possess a set of sense organs that provide information to the brain concerning orientation and motion of the body. They reside in the inner ear and are collectively referred to as the vestibular system. They form a very small part of the human anatomy, the main components being no larger than 10 mm across. Most people are unaware of the vital role they play in everyday life — except when something goes wrong with one of the elements of this system. The vestibular system is deeply embedded in the temporal bone alongside the cochlea (which is responsible for hearing) and contains two distinct types of sensory organs (the semicircular canals and the otolith organs)

Objectives

At the end of this lecture, you should be able to:

1. explain the vestibular mechanism;
2. describe the sense of posture; and
3. illustrate how the ear maintain the balance of the body.

Pre-Test

1. Identify the functional parts of the vestibular system.
2. Describe the physiology of human sight.
3. How is visual and postural stability achieved by vestibular system?

CONTENT

The semicircular canals respond to rotational movements of the head, whether induced passively during activities such as running or riding a horse or a motorcycle, or actively, as it occurs when voluntary head movements are made during visual search. Each canal forms a cavity in the temporal bone and each contains a membranous duct filled with a viscous fluid (endolymph). There are three on each side of the head and the plane of each canal is perpendicular to the others, so that between all six of them they can provide information related to rotational acceleration of the head during movement around any axis. During such acceleration in the plane of a particular canal, the endolymph tends to remain stationary because of its inertia, so that there is relative motion of the endolymph within the duct. Motion of the endolymph is resisted by viscous friction at the fluid–duct boundary and by the elasticity of a gelatinous structure inside each canal, the cupula. The cupula contains sensory hair cells that consequently become deflected, causing stimulation of associated nerve fibres, leading to the transmission of signals to the brain.

The otolith organs respond to linear motion. They lie at the point at which all three semicircular ducts converge. There are two of them on each side of the head, and each contains sensory receptors in a structure known as a macula. With the head erect, the macula in each utricle is oriented horizontally, and in the saccule vertically. The base of each macula carries hair cells that project into a gelatinous substrate in which are embedded minute crystals of calcium carbonate (the otoconia) forming plaque with an area of only 1.5–2 mm^2; the otolith membrane separates this complex from the more fluid endolymph. When linear acceleration occurs in the plane of the macula, the inertia of this dense complex causes it — and therefore the hair cells within it — to be deflected in the direction opposite to that of the movement. These deflections set up trains of nerve impulses, with frequencies proportional to the extent of deflection. In the otolith organs hair cell clusters are tuned to different directions of motion, all directions of motion in the plane of the otolith being represented. The utricle can thus send signals to the brain representing a combination of fore–aft and lateral motion of the head, whereas the saccule principally conveys information about vertical motion.

Maintenance of visual and postural stability: In general, the function of the vestibular apparatus is (via connections in the brain) to generate activity in various muscle systems, which will compensate for the head and body motion, and result in the maintenance of visual and postural stability. The area in the brain stem (the vestibular nucleus) that receives the output of the canals and otoliths has direct connections with muscles controlling eye movements and with muscles of the neck and limbs. In the case of the eyes, the vestibulo–ocular reflex generates eye movements that compensate for head motion with a very short delay (around 10 milliseconds).

When we walk or run, the head generally bobs up and down. Stabilization of the eye prevents movement of visual images on the retina, which would otherwise cause images to be blurred. Individuals who have been unfortunate enough to lose the function of the vestibular system (through damage to the inner ear) often experience apparent motion of the visual world (oscillopsia) under these circumstances. Fortuitously, the vestibulo–ocular reflex, 'designed' to deal with maximum running speed, also allows modern man to view stationary objects in the outside world when traveling in high-speed vehicles, where there is often considerable linear and angular vibration. However, sometimes the reflex is inappropriate.

Reading a newspaper in a train is often difficult because, when looking at objects within the moving vehicle, the stabilizing reflex is no longer appropriate. To suppress the eye movements we rely largely on the ocular pursuit system, a mechanism that we normally use to track moving objects with the eyes when we are stationary. But ocular pursuit has a very limited range of operation and does not function at frequencies of vibration above about 2 cycles per second. Unfortunately, in moving vehicles frequencies of vibration are frequently much higher — between 2 and 20 cycles per second. Stabilization mechanisms similar to those for the eye operate for control of the head, limbs, and other postural systems, but they are necessarily more complex than those controlling the eye.

Perception of motion and orientation: As well as controlling actions within the body, vestibular stimulation also engenders powerful sensations of motion and orientation in space. Stimulation of the canals gives a sensation of turning, so that someone who is rotated on a swiveling chair will experience a sensation of rotation even in the absence of any other cues such as vision (i.e. with their eyes closed). However, because the canals are really responsive to angular acceleration, during a constant rate of angular rotation (constant angular velocity) the sensation gradually decays over 10–20 seconds. As rotation stops, the individual experiences rotation in the opposite direction, even though actual motion has ceased, because the fluid in the canal continues to move when the head has stopped. In everyday life, prolonged rotation is not often encountered, but it does occur frequently when flying. Pilots must therefore be aware that they cannot always rely on the sensation of motion, particularly in circumstances where there are no other reference cues such as sight of land (e.g. when flying in cloud).

Stimulation of the otolith organs also gives rise to sensations, but in this case they may be of either linear motion or of orientation with respect to the vertical. When linear acceleration is sustained it causes a continuous deflection of the otoconia. The most common situation in which this occurs is when the head is tilted, when gravitational acceleration causes the otoconia to be deflected in proportion to the degree of tilt. Consequently, application of sustained linear acceleration is usually interpreted as tilt, so that, when accelerating forward in a high-speed vehicle, a sensation of being tipped backwards is experienced. Again, this is particularly important when flying because, on take-off, an aircraft is normally accelerating and climbing at the same time. The combination of vehicle and gravitational accelerations gives rise to a sense of tilt that is greater than it should be, and the pilot must learn not to misinterpret this sensory information. When linear motion changes frequently, for example during vibration, a true sense of linear motion is normally experienced. This is most sensitive at frequencies close to those of natural head movements (around 2 cycles per second). In normal circumstances, linear and angular motion stimuli are combined, as when we bend down to tie a shoelace in a moving train. In such circumstances, the sensations can be complex and unexpected as a result of the coriolis components of acceleration that accompany motion in three dimensions. The individual may experience a disturbing sensation of tumbling in these circumstances, which may be sufficient to bring on motion sickness. Allied to the experience of real linear or angular body motion are similar sensations that may arise from motion of the visual world when the body itself is stationary. These sensations of self-motion are referred to as linear or angular vection respectively.

Disorders of the vestibular system

One of the major consequences of a failure of the vestibular system is the occurrence of vertigo, or dizziness, which is experienced by large numbers of individuals. Acute vertigo can occur when the vestibular system on one side of the head suddenly stops working effectively, which can be due to factors such as vestibular neuritis or haemorrhage in the cerebellum or brain stem. In such cases there is sudden onset of a strong sense of rotation, often accompanied by a flicking back and forth of the eyes (nystagmus). It generally disappears within hours or days. More persistent vertigo can occur, for example, as a result of the migration of calcite crystals from the otolith organs on to the cupula of the semicircular canal. The cupula then becomes inappropriately sensitive to gravity and a sensation of turning is brought on by a change of head position with respect to gravity. There are other examples of clinical problems arising from vestibular failure, many of which cause great disturbance to the sense of the body in space.

The ear and balance of the body

The semicircular canals and vestibule together help to maintain the balance of the body. The swollen end of the semicircular canal is called ampulla. Cupula containing sensory nerves found inside the ampulla can detect any movement of the head. The semicircular canal begins from the vestibule, goes around and rejoins in the vestibule. Small particles of calcium carbonate called otoliths are found near the haircells of the ampullae and vestibule. The movement of the head in any direction can be detected by the receptor hair cells. The nerve fibres coming from these two types of receptors reach the cerebellum through the auditory nerve.

Summary

In this lecture, we have learnt the vestibular mechanism and the sense of posture. We are able to identify the functional parts of the vestibular system, explain the mechanisms underlying the perception of motion and orientation, the visual and postural stability, and finally, the likely disorders that may occur the vestibular system.

Post-Test

1. How does the vestibular system function to maintain the visual and postural stability in the body?
2. Relate your knowledge of the ear with the general functioning of hearing and maintaining balance.

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LECTURE TWELVE

Somatosensations I: Structure of Skin and properties of Cutaneous Receptors, Dermatomes

Introduction

The skin is the sense organ of touch, and one of the means by which human beings respond to changes in the environment. Somatic sensation refers to sensations arising from the skin — such as touch, pressure, cold, warmth, and pain — and from the muscles, tendons, and joints — such as the position of the limbs and pain — are known as somatic sensations. The sense of touch is distributed throughout the body. Nerve endings in the skin and other parts of the body transmit sensations to the brain. Some parts of the body have a larger number of nerve endings and, therefore, are more sensitive. Four kinds of touch sensations can be identified: cold, heat, contact, and pain. Hairs on the skin magnify the sensitivity and act as an early warning system for the body. The fingertips and the sexual organs have the greatest concentration of nerve endings. The sexual organs have "erogenous zones" that when stimulated start a series of endocrine reactions and motor responses resulting in orgasm.

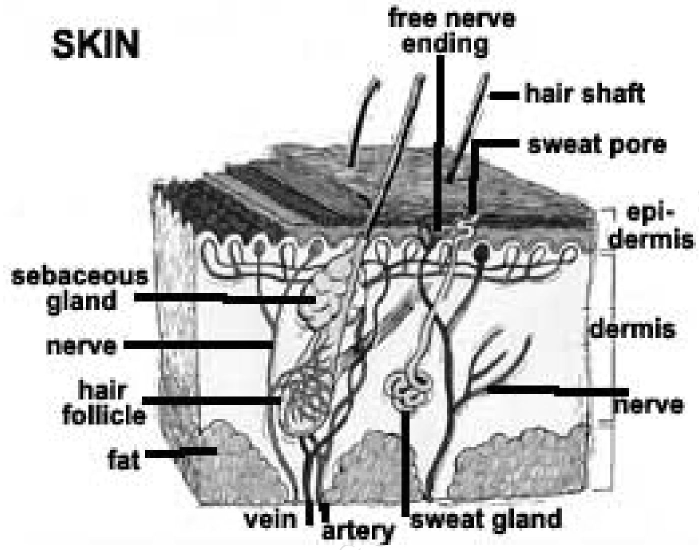
Objectives

At the end of this lecture, you should be able to:

1. describe the structure of the skin;
2. label the parts of the skin, indicating their functions; and
3. explain the mechanism of peripheral sensory apparatus.

Pre-Test

1. Identify the functional parts
2. Briefly describe the structure of the skin



CONTENT

The Greek word for body, 'Soma' refers to the whole of the body structure, apart from the germ cells (eggs and sperm). Sensations arising from the internal organs (the viscera), such as pain or the sense of fullness of the stomach or bladder, may therefore be included, although they are usually considered separately as visceral sensations. Pain arising from the viscera is often felt as though it comes from some part of the body surface or underlying tissue (referred pain).

All somatic sensations start with the excitation of sensory receptors located in the appropriate tissue — skin, muscle, joints etc. But we are not passive recipients of stimuli, and indeed the amount of information received in a passive way is severely limited. We, and other animals, actively explore objects to obtain information about them. Somatic sensation is intimately associated with movement (and also with resistance to movement). We use our fingers and also our tongue and lips to explore objects in order to identify their structure and form. Good examples of such 'active touch' include reading of Braille characters and the sorting and selecting of objects in a pocket, out of sight. Coins can be selected on the basis of size, shape, weight, and other distinguishing characteristics, such as the presence of a milled edge. Metal objects may be differentiated from non-metal ones on the basis of perceived temperature differences due to their different heat conducting properties, or by their weight relative to different their sizes. Modern experimental research on the mechanisms underlying somatic sensation (somato sensory mechanisms) began in the nineteenth century with psychophysical experiments on humans, supported by studies of the structure of sense organs in both human and animal tissues. Then, with the advent of electronic amplifiers, in the 1920s and 1930s the emphasis switched to animal experiments, where it continues to the present: electrical recordings of neural activity evoked by the stimulation of sensory receptors have been made from all parts of the nervous system concerned with somatic sensation. In the past thirty years, electrical recordings have also been made from peripheral nerves in conscious human subjects, and these important experiments have added enormously to our understanding. Most recently, advanced have been used to examine which parts of the brain are active during particular tactual tasks in awaken humans. The sensory receptors in the different tissues and organs are highly selective (or specific). Each type responds only to a particular stimulus, such as mechanical displacement, or cooling, or warming, or harmful stimuli, and not to more than one such kind of stimulus. These receptors, in turn, are connected through chains of nerve cells (neurons) to the somato-sensory areas of the brain's cerebral cortex in such a way that the specificity of the information is maintained — the ascending information travels along parallel pathways that may be considered as ‘pure lines’. The idea that sense organs are specific for particular stimuli and that their excitation leads to specific sensations was first clearly stated in 1811 by the Edinburgh anatomist Sir Charles Bell, but is more commonly attributed to Johannes Müller, who elaborated his Law of Specific Nerve Energies in 1826. Müller did not distinguish between the various sensations that can be elicited from the body, being more concerned with the special senses such as vision. Various workers established that cutaneous sensation (that arising from the skin) is punctate (spotty) in character, and attempts were made to identify particular structures (sensory receptors) at the sites of the sensory spots. These attempts were, at best, only partially successful, although the classical theory of von Frey (1852–1932) allots a particular type of receptor to each of the main cutaneous sensations (touch, cold, warmth, and pain). It was not until careful animal experiments were carried out that the situation clarified. The most important step forward was made by E. D. (later Lord) Adrian, the Cambridge physiologist who, in the 1920s, showed that there are specific sensory receptors in skin and muscle responding only to particular stimuli, and that these receptors transform the stimuli into trains of nerve impulses which are conducted into the central nervous system along peripheral nerve fibres. The analysis of the quality of a stimulus is therefore carried out by specific receptors, while information about stimulus intensity is carried by the frequency of the nerve impulses in the sensory nerve fibres. We now know that all mammalian species, including humans, have the same types of sensory receptors in skin, muscle, tendon, and joints.

Remarkable experiments initiated by the Swedish neurophysiologists, Hagbarth and Vallbo, in the late 1960s, in which electrical recordings were made from single peripheral nerve fibres in conscious human subjects, have confirmed that humans have the same sensory receptors as animals such as the cat. In addition, by electrically stimulating the individual nerve fibres from which recordings were made, they were able to determine the conscious experience (sensation), which results from activation of a particular receptor type. Thus, in the skin there are separate receptors responding to touch, light pressure, hair movement, vibration, cooling, warming, and harmful (painful) stimuli. In muscle and tendon there are receptors responding to muscle length, muscle tension, and harmful stimuli, and in the joint capsule there are receptors monitoring joint position and also responding to harmful events, these latter being exaggerated in inflammatory conditions, mimicking arthritic disease.

The peripheral sensory apparatus, consisting of the sensory receptors and the nerve fibres which connect them to the central nervous system, is therefore responsible for establishing which kinds of stimuli we can respond to, for setting the sensitivity of the system, and for determining the intensity of stimulation. Furthermore, it is also largely responsible for sensory acuity of the different parts of the body, because certain parts contain a higher density of receptors than others. There are very high densities of cutaneous receptors on the tips of the fingers, the lips, and the tongue: the parts of the body surface at which the greatest spatial resolution of sensation can be made, and the parts, which are actively used to explore objects.

The information carried by the peripheral nerve fibres enters the central nervous system either at the spinal cord or, for information from the head, at the brain stem. Here the various inputs from different receptors are distributed into separate sets of ascending channels (pathways or components of pathways) and passed on to the cerebral cortex. Because of the selective channelling of information from different receptor types into different ascending neuronal pathways, it is possible for damage to a particular pathway to produce a selective loss of sensations. For example, damage to part of the spinal cord (posterior or dorsal columns) leads to loss of vibration sense, whereas damage to another part (anterolateral columns) may lead to loss of temperature sense.

As the sensory information ascends to the cerebral cortex, considerable neuronal processing occurs at places where one set of nerve fibres connects with the next set of nerve cells in the chain, usually in clearly-defined parts of the nervous system called 'nuclei'. The processing extracts information from the input and performs analyses on it, such as the enhancement of contrasts (e.g. detection of edges), the orientation of linear stimuli, and the direction of movement of moving stimuli. At each processing station there is the opportunity for certain parts of the information to be suppressed, as would be necessary for selective attention. The nociceptive information — information concerning harmful events — that ultimately gives rise to the sensation of pain is commonly suppressed, especially during activities that are highly charged with emotion, such as during sports activities or in battle.

Each of the central processing stations, including those in the cerebral cortex itself (cortical somatosensory areas), are organized such that they contain a map of the body which can be revealed by recording from the nerve cells. Adjacent nerve cells are excited from adjacent parts of the body. In this way the nervous system locates the position at which a stimulus is acting on the body. Damage to part of one of these sensory maps, for example in the cerebral cortex, will produce sensory changes (a loss or reduction in a particular sensation or group of sensations) localized to a particular part of the body. It is therefore possible for a clinician to determine where brain damage might be located, by testing sensation. Similarly, with special averaging techniques it is possible to record, from the human scalp, the electrical and, more recently, the magnetic activity evoked in localized areas of the brain following localized stimulation of the body surface.

Initial processing in the cerebral cortex takes place in the somatosensory cortical areas. In order to allow for more subtle analysis by the brain, the information is then passed on to motor areas (since active motion is important in active touch) and also to other parts of the cortex (parietal cortex), where higher-order analysis takes place and where information from other senses is received as well. Here, the analysis of spatial relations is important, as is the co-ordination of eye and hand movements. Damage to the parietal cortex, especially on the side of the brain not concerned with language, leads to impairment in the ability to deal with extra personal space, and the patient may even deny that the opposite side of his body exists. Conversely, phantom sensations of movement may occur following amputations.

Summary

In this lecture, we have learnt that the skin is the sense organ of touch and one of the means by which human beings respond to changes in the environment. We equally learnt that the modern experimental research on the mechanisms underlying somatic sensation (somato sensory mechanisms) began in the nineteenth century with psychophysical experiments on humans, supported by studies of the structure of sense organs in both human and animal tissues. We noted also that the peripheral sensory apparatus, consisting of the sensory receptors and the nerve fibres which connect them to the central nervous system, and is responsible for establishing which kinds of stimuli we can respond to, for setting the sensitivity of the system, and for determining the intensity of stimulation.

Post Test

1. Briefly explain the contributions of Hagbarth and Vallbo, in contemporary conception of sensory receptors.
2. Draw and label the structure of the skin and the functioning parts.

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LECTURE THIRTEEN

Chemical Senses: I- Olfaction

Introduction

Chemical Perception of Taste and Smell

When we eat or drink we perceive a sensation that most people call ‘taste’. However, we all know that when the nose is blocked, for instance when one has a common cold, the sensation is considerably reduced. This is because it results from a combination of stimulation of chemical receptors (chemoreceptors) in the nose as well as the mouth. The chemoreceptors in the mouth are called gustatory receptors and those in the nose are olfactory receptors. The sensations that result from individual stimulation of these two types of chemoreceptors are respectively taste and smell. Chemoreceptors are not, however, the only sensory receptors involved in the appreciation and discrimination of food and drink. At least two other modalities of sensation affect the overall experience. The smoothness, texture and crunchiness of food are conveyed by mechanoreceptors on the tongue, and throughout the rest of the mouth, including the teeth, and in the pharynx. Thermoreceptors in the mouth also detect the temperature of solids and liquids. Just think of the combination of experiences – touch, fizziness, coolness, acidity and exquisite smells – that make up the experience of drinking champagne. Those who like spices in their food even derive pleasure from the stimulation of receptors normally involved in the sensation of pain (nociception). Chemicals found in common spices, such as Chili peppers, stimulate these nociceptors in the mouth and the resulting sensation is referred to as the common chemical sense.

The taste/smell system fulfils two separate physiological roles. Not only does it help us to identify ‘good’ food, containing essential nutrients (salts, carbohydrates, proteins and fats), but it also provides a warning of the unsuitability of harmful and potentially toxic substances by detecting them before they are ingested.

Objectives

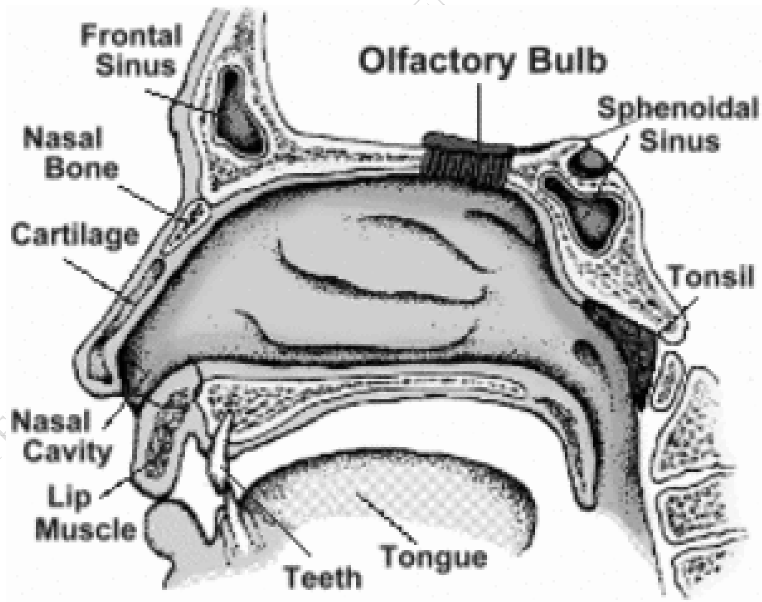
At the end of this lecture, you should be able to:

1. describe the chemical senses;
2. explain the perception of taste and smell; and
3. explain the mechanism of smell and olfaction.

Pre-Test

1. What is olfaction?
2. Identify the chemical senses.
3. Describe the functioning of the chemical senses.

Olfaction



Olfaction

The nose is the organ responsible for the sense of smell. The cavity of the nose is lined with mucous membranes that have smell receptors connected to the olfactory nerve. The smells themselves consist of vapors of various substances. The smell receptors interact with the molecules of these vapors and transmit the sensations to the brain. The nose also has a structure called the vomeronasal organ whose function has not been determined, but which is suspected of being sensitive to pheromones that influence the reproductive cycle. The smell receptors are sensitive to seven types of sensations that can be characterized as camphor, musk, flower, mint, ether, acrid, or putrid. The sense of smell is sometimes temporarily lost when a person has a cold. Dogs have a sense of smell that is many times more sensitive than man's.

Mechanism of Smell and the olfactory receptors

The human olfactory organ, the olfactory epithelium or mucosa, is a sheet of cells 100 –200mm thick, situated high in the back of the nose cavity and on the thin bony partition (the central septum) of the nasal passage. The olfactory system responds to airborne, volatile molecules that gain access to the olfactory epithelium with the in-and-out airflow through and behind the nose. The odour molecules are distributed over the receptor sheet in an irregular pattern by the turbulence of the airflow set up by the turbinate bones in the sidewalls of the nose. The molecules diffuse through the surface layer of mucus and stimulate the olfactory receptors. Hydrophilic (water-soluble) molecules dissolve readily in the mucus, but the diffusion of less soluble molecules is assisted by ‘odour binding proteins’ in the mucus. These odour binding proteins are also thought to assist in removing odour molecules from the receptor cells. The mucus layer moves across the surface of the olfactory mucosa at 10 to 60 mm per minute toward the nasopharynx (the continuous of the nasal cavity backwards and downwards to link to the pharynx. This flow of mucus (which is increased and becomes more watery in such conditions as infection of the nasal cavity and hay fever), also assists in the removal of odours after they have been sensed. The olfactory epithelium contains specialised, elongated nerve cells (olfactory receptors). These cells have very thin fibres that run upwards in bundles through perforations in the skull (the cribriform plate) above the roof of the nasal cavity, below the frontal lobes of the brain. These bundles of nerves constitute the 1st cranial nerve, the olfactory nerve. They extend only a very short distance, ending in the olfactory bulbs, which are a pair of swellings underneath the frontal lobes. The other end of each olfactory receptor, pointing down into the nasal cavity, is extended into a long process, ending in a knob carrying several hairs (cilia). These cilia are bathed in a thin layer of mucus, secreted by specialized cells in the olfactory epithelium, in which the molecules of odorous substances dissolve. In the membrane of the cilia are olfactory receptor proteins, which interact with the smelly molecules, and initiate a cascade reaction inside the cell that leads to a change in the rate of impulses (action potentials) passing along the nerve fibre. Human beings are able to distinguish 10,000 or more different odours. There have been valiant attempts to classify these into a smaller number (usually 10–20) basic or primary smells, comparable to the four or so primary tastes, but no scheme is universally accepted. The human nose (not to mention that of a sniffer dog) can be incredibly sensitive to very low concentrations of odorous substances. Certain male moths use similar receptor cells on their antennae to detect even single molecules of a pheromone secreted by female moths. Individual olfactory receptor neurons fire off spontaneously at between 3 and 60 impulses per second. When stimulated with particular odours, they increase their firing frequency. Each receptor cell responds, but not equally, to many different types of odour. As in the gustatory system, the successive nerve cells in the pathway become more selective, each responding to fewer odours. Interestingly, despite the poor selectivity of individual receptor cells, different regions of the olfactory sheet (consisting of hundred or thousands of receptor cells) are maximally responsive to particular odours. The overall pattern of activity in the olfactory epithelium can be mapped with electrical recording methods (electro-olfactogram) or other techniques for detecting active regions. Each distinctive odour produces its own ‘fingerprint’ of activity across the epithelium. This mapping is thought to reflect the patterns of expression (activation) of genes that make the receptor proteins in the receptor cell membranes. A huge family of odour receptor genes exists in the mouse, perhaps as many as 5% of all the genes. The spatial coding of odour quality is transmitted to the first relay of the olfactory pathway, the olfactory bulb. There is a loose topographical projection from the receptor sheet to the bulb, where the axons form synapses with neurons called mitral cells. The olfactory bulb contains a complex network of nerve cells and is responsible for a considerable amount of sensory processing.

Hence, neurons in the olfactory bulb respond with one distinct temporal pattern of impulses to one odour and different patterns to another smells. The mitral cells send their fibres into the olfactory tracts, which run backwards. Some end in the thalamus, which in turn sends fibres up to the olfactory cortex. The neurons of the olfactory cortex are still not highly specific for particular odours. Other fibres of the olfactory tract have direct connections to areas of the limbic system around the region of the hypothalamus. Since the limbic system is thought to be responsible for regulating emotions, this might explain the fact that smells can evoke strong feelings of enjoyment or aversion (the hedonic component of sensation).

Unlike other stimuli, olfactory stimuli are not very time-dependent. The effects of visual, tactile and auditory stimulation follow the stimulus immediately, whereas some olfactory stimuli, such as those left by animals when marking their territory, remain when the animal is long gone. In this way olfactory stimuli, and their behavioural and social effects, can have more lasting consequences.

The olfactory system occupies a smaller fraction of the brain in humans than in many other species, and this is part of the evidence for the commonly held belief that people are generally inferior in their sense of smell. Studies in other animals, from insects to hamsters to monkeys, have revealed the importance of olfaction for many aspects of behaviour, especially reproduction. For example, male rhesus monkeys use smell to sense the hormonal status of females (ovulating or not), with a marked effect on their level of sexual activity. But even in humans, there is growing evidence that olfaction (mainly unconscious) is important in such functions as sexual preference, and recognition of other people.

Summary

In this lecture, we have learnt of the olfactory system. The structure revealed that olfactory system is one of the most vital parts of the brain responsible for the sense of smell. In some animals, it is the primary mode of communication and influences many important functions, including reproduction and taste. The nose contains specialized sensory nerve cells, or neurons, which sends a nerve fiber called an axon to the olfactory bulb, a brain structure just above the nose. We also leant about the mechanism of smell and the olfactory receptors as well as how the spatial coding of odour quality is transmitted through the olfactory pathway.

Post-Test

1. Draw a labeled diagram of the nose to show the functional areas
2. Describe the olfaction mechanism.

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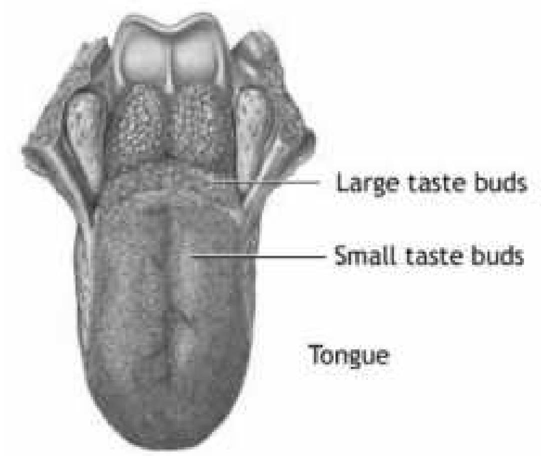
LECTURE FOURTEEN

Chemical Senses: II Gustation

Taste



The receptors for taste, called taste buds, are situated chiefly in the tongue, but they are also located in the roof of the mouth and near the pharynx. They are able to detect four basic tastes: salty, sweet, bitter, and sour. The tongue also can detect a sensation called "umami" from taste receptors sensitive to amino acids. Generally, the taste buds close to the tip of the tongue are sensitive to sweet tastes, whereas those in the back of the tongue are sensitive to bitter tastes. The taste buds on top and on the side of the tongue are sensitive to salty and sour tastes. At the base of each taste bud there is a nerve that sends the sensations to the brain. The sense of taste functions in coordination with the sense of smell. The number of taste buds varies substantially from individual to individual, but greater numbers increase sensitivity. Women, in general, have a greater number of taste buds than men. As in the case of color blindness, some people are insensitive to some tastes.

Mechanism of Taste and the Gustatory Receptors

The receptors involved in gustation are found in specialized 'end-organs' called taste buds, embedded in the epithelium that covers the surface of the tongue, soft palate, pharynx, larynx and epiglottis. However, they are not uniformly distributed in these regions. The taste buds on the tongue are associated with characteristic 'papillae' (from the Latin for pimples), whereas those in the other regions are found on the smooth epithelial surface. In humans, the number of taste buds varies considerably from person to person, with the majority having 2000 to 5000, distributed over the various regions. However, the number can be as low as 500 and as high as 20000 in some individuals.

The papillae in different regions of the tongue have distinctive shapes and characteristic numbers of taste buds associated with them. Scattered over the main body of the tongue are approximately 200, small, mushroom-shaped (fungiform) papillae, which have, on average, only three taste buds each. Larger (foliate) papillae are found at the back and sides of the tongue. They consist of up to nine folds of epithelium and have as many as 600 taste buds each. Eight to 12 larger mushroom shaped (circumvallate) papillae, each surrounded by a circular trough, lie at the back of the tongue in a V-shaped formation; these have on average 250 taste buds each. Scattered taste buds are also found in the epithelium of the soft palate, pharynx, larynx and epiglottis.

Each taste bud is contacted, at its base, by the terminals of sensory nerve fibres. These taste fibres belong to three different cranial nerves, connected to the brain. The nerve supply for most of the taste buds on the soft palate and towards the front of the tongue come from a division of the VIIth (facial) cranial nerve, called the chorda tympani, because its route to the brainstem passes close to the tympanic membrane in the ear. The IXth (glossopharyngeal) and Xth (vagus) nerves innervate taste buds in the back of the mouth and the pharynx respectively.

Each taste bud contains 50–150 neuroepithelial receptor cells arranged, like segments of an orange, to form a compact, pear-shaped structure. There is a small 2–10 mm opening in the epithelial surface called the taste pore, which allows direct contact between chemicals dissolved in the saliva and the tips of the receptor cells. These exposed parts of the receptor cells are made up of many long corrugated folds in the membrane called microvilli, which provide a greater surface area for contact with the saliva. It is difficult to taste food with a dry mouth. Saliva is essential for normal taste because it acts as both a solvent for the chemicals as well as a transport medium for those chemicals to reach the receptors. A layer of saliva extends into the taste pores and constantly bathes the receptors. The dissolved chemicals diffuse through this thin layer of saliva to reach the microvilli. Chewing, taste and smell, to varying degrees, stimulate reflex secretion of saliva from the salivary glands under the tongue and in the cheeks. As demonstrated in Ivan Pavlov classical experiments on dogs, the simple form of unconscious learning known as conditioning. The reflex secretion of saliva to the familiar signs of an impending meal, the sound of a dinner bell, the clatter of crockery, and the sight of the food.

The taste bud complex is a dynamic system in which the receptor cells are rapidly turning over. The life span of an individual receptor cell is about 10 days: cells are continually being born (through the division of epithelial stem cells within the bud), maturing, performing their gustatory function and eventually dying. Even though the receptor cell does not itself have an axon or fibre, the base of the cell has specialized regions that look like the terminals of nerve fibres. The cytoplasm in these regions is packed with tiny spherical vesicles, filled with a chemical transmitter substance, which is released when the potential inside the receptor cell becomes more positive (depolarization). In close association with these regions are the endings of the sensory nerve fibres, making an assembly like a synapse. Each taste bud is innervated by more than one nerve fibre and each single nerve fibre can connect to a number of receptor cells, taste buds and even papillae. This suggests a high degree of convergence of input from taste buds on to the sensory nerve fibres. Because of the rapid turnover of receptor cells, the connections between cells and nerve fibres are constantly changing. The nerves are continuously sprouting new processes, forming new synapses with young cells and retracting synaptic connections with dying cells. At any one time less than a third of the cells in the taste bud are innervated.

An intact nerve supply is necessary for the normal function of taste buds. If the nerves are damaged the taste buds degenerate and slough off, and following regeneration of the nerves, the taste buds reappear. Since the time of Aristotle (384–322 BC) there have been attempts to categorize taste into primary or basic tastes. Although many hundreds of different chemicals can stimulate activity in taste receptor cells, the four basic taste qualities of salt, sour, sweet and bitter have stood the test of time. However, there is still controversy as to whether combination of these four primary tastes adequately describes all gustatory experiences. Metallic and astringent tastes have, in the past, been suggested as primaries, and more recently Japanese researchers have proposed that the characteristic taste of monosodium glutamate (used as a taste enhancer by the food industry) is also a basic taste, with its own receptive mechanism. They have called it "umami" meaning "delicious taste"

Because of the dual role of gustatory receptor cells, detecting both nutrients and toxins, they must be able to respond, either individually or collectively, to a wide variety of chemicals. These chemicals range from simple ions such as sodium (salt) and hydrogen (sour) to the more complex compounds that give the sensations of sweet (e.g. sugar) and bitter (e.g. quinine). The mechanisms by which the chemical stimuli are translated into electrical events in the receptor cell (transduction) are numerous, varied and complex. The essential process depends on specific interactions between taste substances and specialized protein receptor molecules embedded in the membrane of the receptor cell, which trigger a series of chemical reactions, leading to a change in the flow of ions through pores in the membrane, and hence a change in the electrical potential inside the cell. However, there does not appear to be a unique mechanism for each of the basic tastes: each seems to use several different mechanisms. There may even be similarities of mechanism for different basic tastes. The way in which we can perceive many subtle tastes and distinguish between different compounds of the same basic taste category might be explained by the multiplicity and specificity of these mechanisms.

The evidence for a particular receptor mechanism is best for sweet sensation. First, certain drugs have specific effects on the detection of sweetness. For instance, after eating a West African fruit called miracle fruit, even quite acidic substances (such as lemon juice), which would normally be sour, taste extraordinarily sweet. Miracle fruit contains a substance that is thought to attach to the protein receptor molecules that detect sweet-tasting substances. A subsequent increase in acidity in the saliva is thought to alter the binding of this substance with the sweet receptor protein such that it stimulates the receptor, like a genuine sweet substance. In contrast, gymnemic acid, found in an Indian plant, Gymnema sylvestre, blocks the sweet receptor in some manner, and abolishes the sensation of sweetness for half an hour or so. Very recently, a gene called T1r2 has been identified in mice, which are selectively switched on in taste bud receptor cells. It turns out that strains of mice that lack sweet taste (they don't prefer sweet food to non-sweet) have a mutation of this gene. There is a very similar gene in human beings.

Researchers have recorded with tiny electrodes from individual nerve fibres innervating the taste buds, in anaesthetized animals. One might have expected that each fibre would respond, with a burst of impulses, when a solution of just one of the primary taste substances was dripped on to the appropriate taste bud or buds. Such selectivity of response is, in fact, very rare. Most nerve fibres respond to two or more of the basic taste stimuli, the magnitude of the response varying from one taste substance to another. In other words, the activity of such a fibre does not provide unambiguous information to the brain about the nature of the stimulus. At some point the brain must perform a comparison between the activities in several different nerve fibres in order to decide what the taste actually is.

The signals from the taste buds are relayed, via a chain of nerve cells and fibres, at various cell stations in the brainstem and thalamus, up to the cerebral cortex.

Some experiments in monkeys suggest that nerve cells at higher levels in the taste pathway respond more selectively, with a larger proportion of them essentially responding to only one basic taste. At the first relay in the brainstem almost no neurons respond to one taste, yet in the taste area of the cortex, about 75% of neurons respond to a single taste. The ‘common chemical sense’ is the sensation caused by the stimulation of free nerve endings by potentially harmful chemicals. The evidence suggests that the free nerve endings are ‘polymodal’ nociceptors (receptive nerve endings that respond to mechanical, thermal and noxious stimulation). Amongst the chemicals that are known to stimulate these receptors, besides noxious, damaging chemicals, are alcohol, menthol, peppermint and capsaicin (chili pepper).

Summary

In this lecture, we have discussed the tongue, and noted that taste papillae can be seen on the tongue as little red dots, or raised bumps, particularly at the front of the tongue. We noted the mechanism involved in taste and the functioning of Gustatory receptors. We also examined the five basic tastes: salt, sour, sweet, bitter and umami and the various taste areas of the brain contributing to behaviour in different ways. The hypothalamus apparently releases taste to hunger and satiety. The final destination of a taste stimulus is the taste area in the parietal lobe of the cerebral cortex where taste is perceived.

Post – Test

1. Highlight the function of the papillae in gustatory mechanism.
2. How do the receptor cells on the tongue help in dictating taste?

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LECTURE FIFTEEN

Inputs into the Body or Body Inputs

Introduction

If we look at the human body from an engineering point of view, we notice that it has many types of inputs and outputs. The traditional five senses process stimuli from outside the body, or exogenous signals. However, because the body is a very complex structure, there are also endogenous or internal signals that can be perceived by the senses. Many of these stimuli cannot be detected immediately, but only after they have had an effect on the body. Sometimes, the effect of these stimuli is on the brain, and if this causes decreased mental function it may prevent us from becoming aware that we are affected.

Objectives

At the end of this lecture, you should be able to:

1. highlight the body inputs and explain each of them;
2. demonstrate full understanding of exogenous and endogenous inputs; and
3. differentiate between verbal and non-verbal inputs.

Pre-Test

1. Define body input?
2. What do you understand by verbal and non-verbal input?
3. Briefly explain the body inputs you know.

CONTENT

Breathing

The very act of breathing brings air into our lungs and whatever else is in the air. Our nose hairs filter out insects and some dust, but gases like carbon monoxide, vapours, smoke, pollens, bacteria, viruses, and small dust particles are carried into the lungs. The body has many self-cleansing mechanisms to keep the lungs clean, but constant exposure to air pollutants eventually takes their toll on the lungs or other organs of the body. The tar and chemicals carried in the smoke of cigarettes has been linked to many types of respiratory disorders and nicotine has an addictive effect on the brain. Carbon monoxide produced by gasoline motors or charcoal fires in enclosed places interferes with the oxygen-carrying function of the blood and is responsible for many deaths each year. Paint solvents and gasoline fumes can damage the liver. Gases like nitrous oxide and vapours like ether affect the nervous system and are used as anaesthetics.

Eating and drinking

We have to eat and drink to sustain our life, but what we ingest can carry not only nutrients, but also substances that can adversely affect our health and mental processes. There are regions in the United States where there is a great prevalence of kidney stones that are associated with the hardness of the water. The "goiter belt" is another region where the soil has a deficiency of iodine that would result in thyroid gland problems were it not for iodized salt. Grain tainted with ergot fungus, which has an LSD component, has been theorized to have caused hallucinations responsible for the witch hunts in Salem, Massachusetts.

We cook foods to make them more digestible and to kill harmful microorganisms and parasites. However, cooking may decrease the nutritional value of the food and charring during grilling may create nitrosamines that have been associated with some cancers. Our mass markets require the preservation of food by the use of food additives. Many of these preservatives were discovered by analyzing foods, such as cheese, which don't readily spoil. Other food additives are only used to improve appearance, e.g., artificial colours. Not all additives are harmful, but some people prefer to buy "natural" or "organic" products because they do not want to eat residual pesticides used in agriculture. Some "natural" and "organic" products may be quite harmful. Opium, coca leaves, marijuana, and tobacco are all natural products with addictive or mind-altering properties. This does not mean that they may not have legitimate medical uses. Opium has been the source of morphine, which is a powerful pain killer.

Caffeine, which occurs naturally in coffee, tea, and chocolate, is a nervous system stimulant and also a diuretic. Large amounts of caffeine can cause tremors or shaking. Caffeine can be addictive for some people even in small amounts. It is not by coincidence that soft drink manufacturers use caffeine as an additive. If you drink more than one cup of coffee, tea, chocolate, or cola drink per day you may be addicted to caffeine. This can be easily verified by abstaining from caffeine-containing foods or drinks for a couple of days. Restlessness, sinus pressure, or headaches are common withdrawal symptoms.

Medicines and drugs

Medicines and drugs may be administered orally, by injection, by inhalation, etc. The purpose of medicines is to help the organism return to a healthy state. However, sometimes medicines are prescribed to maintain a "normal" state. Antibiotics fall into the first category. Once an infection has been eliminated, the medication can be stopped. Diabetes is in the second category. It is necessary to take insulin all your life in order to live normally. With the large number of drugs available, it is not surprising to find that some of them interact or interfere with each other. Some women on birth control pills have become pregnant while taking some types of antibiotics. Also, grapefruit has been found to elevate levels of some medicines to toxic levels.

"Recreational" or illegal drugs sometimes such as heroin, cocaine, and LSD are mind-altering drugs that affect the brain adversely, permanently. Certain non-prescription medicines, such as cough suppressant syrups with dextromethorphan, act on the brain and can dull thinking and creative abilities. "Ritualistic drugs", such as peyote, have hallucinogenic properties and are used in certain religious ceremonies. Alcohol is the most frequently abused mind-dulling drug. It acts as a brain intoxicant that reduces reaction times and impairs the motor functions of the body. Drugs used in psychiatry also modify the way in which the brain works. When used to treat depression or other debilitating mental conditions these drugs actually help to restore the normal functions of the brain, but generally not without side effects.

Skin absorption

The skin acts as a protective barrier for the body, but it is not impervious. Many substances pass through the skin and can affect various organs of the body. When the skin is exposed to harsh chemicals, such as chlorine bleach or detergents, there may be just a local irritation or chemical burn. Organic solvents such as gasoline, mineral spirits, and dry cleaning fluids can be absorbed through the skin and reach toxic levels in the body. The liver is the organ most frequently damaged as it tries to detoxify these substances.

Radiation/Light

Electromagnetic radiation can be good, and it can be bad for the body. It depends on the type of the radiation and the duration of the exposure. Infrared radiation, which is low-frequency radiation, is felt as heat. Sitting by a fireplace or a pot-bellied stove on a cold winter night can feel comforting without any harmful effects. Excessive doses of infrared radiation can result in burns. Normal skin produces Vitamin D when exposed to sunlight for brief periods of time. When exposed for long periods of time, the skin reddens and becomes painful to the touch. Repeated exposure to sunlight stimulates the skin to produce a protective dark pigment called melanin. Chronic exposure to sunlight eventually breaks down the cellular structure of the skin and can result in wrinkling, cancerous melanomas, or other skin disorders.

The amount of light to which the body and eyes are exposed may affect the central nervous system. Seasonal Affective Disorder (SAD) is a form of depression that includes feelings of sadness, tiredness and cravings for carbohydrates. It is believed to be related to the decreased sunlight in winter and the release of melatonin. Melatonin is usually produced by the pineal gland at night and induces sleep. Besides sunlight, the body may also be exposed to moonlight, which is sunlight reflected off the moon. The light of the moon is weak, but it enabled early humans to have some nighttime activities before the invention of fire and artificial lighting. The word "lunatic" is derived from the Latin for "moon". At one time it was believed that the influence of the moon triggered mental disorders.

The use of artificial lighting has introduced some problems that did not exist before its invention. Some people are sensitive and can get headaches from the flickering of fluorescent lights. The flickering is particularly noticeable in the peripheral vision. Flashing images from television or strobe lights can also cause harmful effects to the nervous system and can trigger seizures. A Japanese television cartoon program that used flashing pictures to simulate an explosion sent several hundred children to the hospital with various neurological symptoms.

High-energy radiation such as ultraviolet light, X-rays, or Gamma rays can destroy cells. X-rays and Gamma rays have greater penetration than ultraviolet light and are used medically for diagnostic imaging and to burn tumors. Ultraviolet lights, also called "black" lights, are used in hospitals and grocery stores to kill bacteria, but sometimes they are misused for entertainment in bars or other dark places because ultraviolet light makes some substances fluoresce.

Cosmic rays, which are high-energy particles, normally do not penetrate the earth's atmosphere. However, astronauts have reported seeing flashes of light that have been attributed to the effects of cosmic rays either on the eyes or the visual cortex of the brain.

Sounds

Our bodies respond to sounds in fairly mechanical ways. Sudden noises can cause a person to jump away from the noise, or turn the head in the direction of the noise. Soothing, rhythmic noises such as the sound of the sea, a gurgling brook, or the beating heart in a mother's breast are well known for their calming effects. Buzzing sounds close to the ears cause us to wave the hands by our ears as if to repel insects. Certain high-pitched noises such as scratching fingernails on a blackboard or the noise of a pencil on paper can "make your skin crawl", which is an erection of the hairs on the skin. Loud repeated noises can reduce the sensitivity of the ears and eventually cause hardness of hearing or even deafness. Boilermakers that used noisy riveting equipment were particularly prone to deafness as an occupational hazard. In the era of high-fidelity sound equipment with powerful amplifiers, many young people are losing their hearing by listening to music at very loud levels.

Bacteria and Viruses

Bacteria and viruses come into the body principally through the eyes, the mouth, the skin, and the nose. Some bacteria actually have a beneficial effect. The "normal flora" that are found in the mouth release substances that prevent more harmful bacteria from getting established. Other bacteria aid in digestion or produce vitamins and nutrients that the body can use. Bread, yogurt, beer, wine, vinegar, and many types of cheeses are produced by using specific types of non-harmful yeasts, bacteria, or fungi.

Disease-causing bacteria release toxins that interfere with normal body processes. Viruses, which are much smaller than bacteria, work against the body by re-directing the synthesis of normal cell components into replication of the virus. The body tries to fend off bacteria and viruses by generating chemical antibodies and by increasing body temperature. Fever creates a more hostile environment for bacteria but can result in delirium and other forms of mental changes. Some diseases like rabies or polio attack directly the nervous system.

Insect bites and stings

Insect bites and stings are unpleasant inputs to the human body. Insect stings inject toxins into the body that may elicit allergic reactions accompanied by nausea, pain, and swelling. The bite of the black widow spider is sometimes fatal. Some blood-sucking insects inject saliva at the point of the bite. Insect saliva may cause swelling and itching, but it may also carry bacteria or parasites. Bubonic plague, the so-called "black plague" of the Middle Ages, which is a bacterial disease, is transmitted by flea bites.

Parasites

Parasites come into the body through many mechanisms. Inhale the dust of a soiled bed linen, and you may get pinworms. Take a dip in a lake or river and get schistosomiasis. Get bitten by a mosquito and get malaria or sleeping sickness. Hug your mother and get follicle mites. Eat uncooked pork and get trichinosis. Eat food contaminated with fecal matter and you may get roundworms. Roundworms generally inhabit the intestine, but because of their complex life cycle, sometimes they end up in other parts of the body, including the brain.

Magnetic fields

We live immersed in the magnetic field of the earth. The human body is generally not affected and cannot detect this magnetic field. Homing pigeons, however, have been shown to use the earth's magnetic field as one means for returning home. In principle, however, the electrical activity of the nervous system could be affected by strong magnetic fields, and recent experiments suggest that magnetic fields may help to reduce certain kinds of pain.

Gravity

Our sense of equilibrium in the gravitational field of the earth is provided by the semicircular canals in the ear. These canals are lined with filaments that are stimulated by calcium carbonate crystals suspended in a fluid. The rotation of the moon around the earth every 27 1/3 days creates tidal forces that affect many living organisms, but is not known to have a significant effect on humans. Some fish are known to spawn in the beach at high tide when the moon is full. The human menstruation cycle of approximately 28 days may be a legacy of our ancestral origins in the sea.

Air pressure

We can sense changes in air pressure as pain or discomfort in our ears, sinuses or bones. The nerves surrounding the body cavities that contain enclosed pockets of air detect volume changes caused by external air pressure.

Endogenic inputs

Endogenic inputs come from within the body to the brain. When we start exercising, carbon dioxide builds up in the body. This buildup acts as an endogenic signal for the heart and the lungs to work harder. When the level of glucose in the blood drops, we get hungry. Hunger, thirst, pain, fatigue, kinesthesia are all inputs to the brain from the body itself.

Some physiological cycles like menstruation may trigger feelings of fatigue, irritability, and depression as the hormone levels change. Exercise has been credited with stimulating the body to generate endorphins that create a feeling of well being. Emotions such as fear release adrenaline into the bloodstream, which triggers many systemic reactions. Several studies have found that what you think can affect your health. Constant worry can create stress that lowers the body's ability to fight diseases, whereas positive thoughts and laughter can actually improve your health.

Verbal inputs

Verbal communication might have been included under sounds. However, the effect of verbal input on the mind is so different from that of the wind blowing or other noises encountered in nature that it is considered separately. Imagine that your boss calls you to his office and says something neutral like: "In two weeks we are having a meeting to discuss the progress of our new project". Your reaction may be one of anticipation or apathy. Not much is required from you except your participation. However, if the boss says something negative like: "You made several mistakes in your last report and I am very dissatisfied with your work". You may become angry or scared, your heart may start racing and you may want to justify what you did. Words have the power to make you laugh or the power to make you cry because they are not only sounds. Words have meanings that get to the root of your emotions.

Since ancient times words have had mystical power because they could represent objects, feelings, curses, etc. The word "abracadabra" was supposed to have magical powers against disease or disaster, and sometimes it was carried in an amulet. Prayers were more than just words; they provided a way of communicating with the deities.

Much can be deduced about the state of mind of a speaker from their speech. The tone of the voice can convey authority, fear, doubt, and many other different emotions.

Non-verbal sound inputs

If analyzed carefully, this category could also be grouped under other senses. However, there are some inputs that connect to the fears or desires deep within our brain and establish a special kind of non-verbal communication. The snarls of a dog, a cat rubbing against our legs, a gentle massage, or the wink of an eye are all special kinds of communication. These are more than just simple sounds or visual or tactile inputs. They are meaningful messages for the brain.

Summary

In this lecture, we have discussed numerous types of inputs of the body. We noted that the body is structured in a way to handle different types of inputs, whether gaseous, solid, and liquid, sound, and radiation, verbal, non-verbal sound and others. The different inputs were examined and distinctions were made to facilitate understanding.

Post Test

1. List five body inputs and briefly explain each of them.
2. Differentiate your understanding of body inputs with body absorption.

References

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LECTURE SIXTEEN

Outputs from the Body

Introduction

The outputs of the body include mechanical movements, radiant heat, sounds, minute electrical signals, as well as excretions and secretions that serve various biological functions. Some of these may serve as communication signals at a basic biological level, but verbal communication provides the greatest insights into the mind.

Objectives

At the end of this lecture, you should be able to:

1. list and explain five outputs from the body; and
2. illustrate how each of the body output differ from the others.

Pre-Test

1. What do you understand by body outputs?
2. Mention any three of the body outputs
3. Why are they body outputs?

CONTENT

Secretions and excretions

The skin is covered with many specialised glands that secrete sweat, sebum, megma, and earwax. In addition there are glands that produce tears, saliva and milk. Sweat serves primarily to cool the body. However, the sweat of the underarms develops a strong smell when it ferments under bacterial action. Scientists have debated whether sweaty smell is supposed to be an attractant, a repellent, an indication of vigor, or serves other functions. The widespread use of antiperspirants and air conditioning has virtually eliminated this type of stimulus from our society. However, researchers at the University of California at Berkeley conducted an experiment where women sniffed a bottle containing androstadienone, a chemical found in male sweat that smells vaguely musky. Tests showed that the blood pressure, heart rate, breathing, and levels of cortisol in the women increased within 15 minutes of sniffing the chemical and remained elevated for more than an hour. The women also reported elevated mood and sexual arousal. Sebum and megma are oily secretions that lubricate various parts of the body. They also have characteristic smells at close range to the body. The pubic area has a musky smell that may play a role in sexual stimulation.

Excretions like urine and faeces serve to carry away waste products of the body, but they also carry a lot of information about the body. From a sample of urine, it is possible to determine the function of the kidneys, the presence of venereal or parasitic diseases, and whether a woman is pregnant. Faeces can be used to identify dietary components, parasitic infections, the presence of ulcers, and many digestive functions. Menstrual fluids and semen are excretions of the body that are part of the reproductive cycle, but which can transmit disease-causing organisms from infected individuals.

Gaseous outputs

Exhaling, sneezing, coughing, burping, and intestinal gases are all outputs of the body that give information about the body. A sigh is a form of exhaling that may indicate weariness or relief. Sneezing and coughing are used to dislodge obstructions in the respiratory passages or as a reaction to irritants. The air expelled during coughing and sneezing may carry bacteria and viruses in droplets of mucus and saliva. Burping and intestinal gases are products of fermentation and digestion that may have offensive smells. The smell of the breath may indicate diet, food residues, the presence of caries, and smoking habits. The smell of a woman's breath changes during menstruation.

Many diseases can be identified by the odors emanating from the body. In the days when house calls were common, doctors were advised to blow their nose to increase their olfactory sensitivity before going into the room with the sick patient. Bacterial colonies of Pseudomonas have a grape-like smell, whereas colonies of Proteus have a burned horn smell.

Heat

The body generally maintains a temperature of 37° Celsius (98.6° Fahrenheit). The testicles require lower temperatures for sperm production. Fever is a pathological condition where an abnormally high body temperature is sustained. Temperatures higher than 42.5° C (108° F) kill human cells.

Electrical activity

The electrical signals in the brain are in the order of 100 microvolts, which is about fifteen thousand times smaller than an ordinary flashlight battery. These signals have wave frequencies of between 1 and about 20 Hertz (or cycles per second). The electrical signals in the heart are around 1 millivolt, ten times stronger than those of the brain, but still very small and impossible to detect outside the human body except through great amplification. By contrast, electric eels have special nerve endings that enable them to generate from 200 to 600 volts, enough to electrocute a person. The neurons of the human brain have been estimated to generate about 25 watts of power.

Body language

The position of the body can indicate aggression, fear, or a whole spectrum of human attitudes. Crossed arms tend to indicate a reserved attitude or closed-mindedness; a slouch indicates disdain or carelessness; sweaty palms indicate nervousness; a weak handshake means lack of confidence, and a pale face or trembling is synonymous with fear. Facial expressions are produced by movements of the eyes, eyebrows, nose and mouth. Narrow eyes mean anger, and widened eyes indicate surprise. A frown denotes concern, and pupils expand when something is of interest. A mouth with down-turned corners is sad; one with up-turned corners is a happy smile. Happiness, sadness, fear, anger, surprise, and disgust are facial emotions that are widely recognised around the world regardless of culture. These facial expressions are made with five facial muscles.

The attire and hair styles that we wear also send messages which can be part of body language. Purple-dyed hair and body piercing indicate non-conformity; pin-striped suits form just the opposite. Expensive jewelry, cosmetics, and perfume send a message of affluence. Beards, wigs, clothing, and cosmetics are all used to decorate our bodies to send conscious or subconscious messages to on-lookers.

Sounds

Coughing, sneezing, breathing, and heartbeats are sounds output by the body. There are also mechanical noises such as clapping and whistling, but by far, the most important sounds are produced through singing and verbal communication.

Verbal outputs

As was mentioned in the previous chapter, verbal communication is more than just sounds. Words convey mental images to our listeners. What we say or what we imply changes the listener. The way in which we say something also carries a message. The use of a rich vocabulary may imply wisdom or snobbishness, forcefulness indicates conviction, and hesitation represents insecurity.

Songs and rhymes are special forms of ritualised communication. Before writing was invented, oral history was the only way to pass information from one generation to the next. Poems and songs were particularly effective at passing information, because they could be learned at an early age, even though they might not be understood until much later.

Memes

Memes are ideas or behaviours that can be passed from one person to another by learning or imitation. A culture may be defined as a collection of memes, which enable individuals to function within the society. Examples of memes include beliefs, gestures, practices, fashions, habits, songs, and dances. Successful memes propagate themselves and are adopted by the members of a society because they provide a benefit or enable survival. Simple traditions like washing the hands before eating, or the Oriental custom of taking off the shoes before going inside a house promote cleanliness and reduce the rate of infections. People who do not follow these practices will get sick more often or perhaps die from poor sanitation. Thus, the cleanliness meme provides tangible benefits.

Summary

In this lecture, we have examined the outputs of the body. We noted the major outputs of the body and the physiology of what made each different from the other.

Post Test

1. Write short notes on five or more outputs of the body.
2. Briefly discuss the differences between the body inputs and outputs.

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