1. Details of Module and its structure

Module Detail	
Subject Name	Psychology
Course Name	Psychology 02 (Class XI, Semester - 2)
Module Name/Title	Sensation and Attention – Part 2
Module Id	kepy_20502
Pre-requisites	Knowledge about functioning of sensory organs.
Objectives	1. To understand the nature of sensory processes, 2. To explain the processes and types of attention,
Keywords	Photoreceptors, Choroid, Sclera, Retina, Scotopic, Photopic, Adaptation, Accommodation, Hue, Saturation, Afterimages-Positive and Negative, Pinna, Organ of Corti

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The role of sense organs

Our sensory processes do not depend only on the stimulus characteristics. Sense organs and the neural pathways connecting them to various brain centers, play a vital role in the process. A sense organ receives the stimulus and encodes it as an electrical impulse. For being noticed this electrical impulse must reach the higher brain centers. Any structural or functional defect or damage in the receptor organ, its neural pathway, or the concerned brain area may lead to a partial or complete loss of sensation.

Different animal species depend more on some senses than others for example dogs on smell, bats on hearing but humans depend highly on vision. Consequently, a lot of study has gone towards the study and research on vision. To understand the process of sensation and how do we experience vision and hearing particularly, we need to study the internal working of the human anatomy related to these sensations.

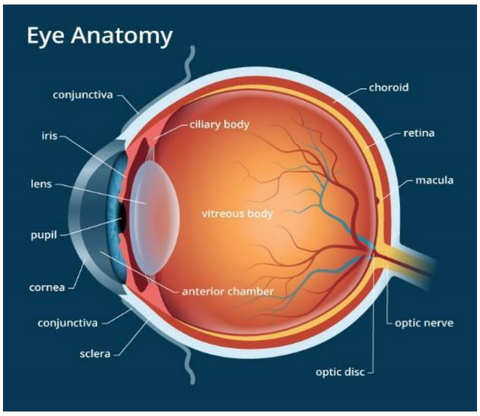
Visual Sensation

Among all sense modalities, vision is the most highly developed in human beings. Various estimates indicate that we use it in approximately 80 per cent of our transactions
with the external world. Audition and other senses also contribute significantly to information gathering from the external world. We shall discuss vision and audition in some detail.

Visual sensation starts when light enters the eyes and stimulates our visual receptors. Our eyes are sensitive to a spectrum of light, the wavelength of which ranges from 380 nm to 780 nm (nm refers to nanometer, which is one billionth of a meter). No sensation is registered beyond this range of light.

The Human Eye

A diagram of the human eye is necessary to explain its functioning. As you can see in the diagram given below, our eye is made up of three layers.



Source: https://cdna.allaboutvision.com/i/resources-2017/eye-anatomy-700x635.jpg

In the **outer layer**, there is a transparent **cornea** and a tough **sclera** that surrounds the rest of the eye. It protects the eye and maintains its shape.

The middle layer is called **choroid**, which is richly supplied with blood vessels.

The inner layer is known as **retina**. It contains the **photoreceptors (rods and cones**) and an elaborate network of interconnecting neurons.

The eye can easily be compared to a camera, both the eye and camera have a **lens**. The lens divides the eye into two unequal chambers, namely aqueous chamber and **vitreous chamber**. The **aqueous chamber** is located between the cornea and the lens. It is smaller in size and is filled with a water- like substance, called **aqueous humor**.

The vitreous chamber is located between the lens and the retina. It is filled with a jelly like protein, called **vitreous humor**. These fluids help in holding the lens at its appropriate place and in proper shape. They also allow enough flexibility for the occurrence of **accommodation** —a process through which the lens changes its shape in order to focus the objects at varying distances. This process is regulated by **ciliary muscles**, which are attached to the lens. These muscles flatten the lens to focus on the distant objects and thicken it to focus on the near objects. Like a camera, the eye also has a mechanism to control the amount of light entering it.

To facilitate this process is the **iris**. It is a disc-like coloured membrane lying between the cornea and the lens. It controls the amount of light entering the eye by regulating the dilation of the pupil. When the light is dim the pupil dilates and when the light is bright it contracts.

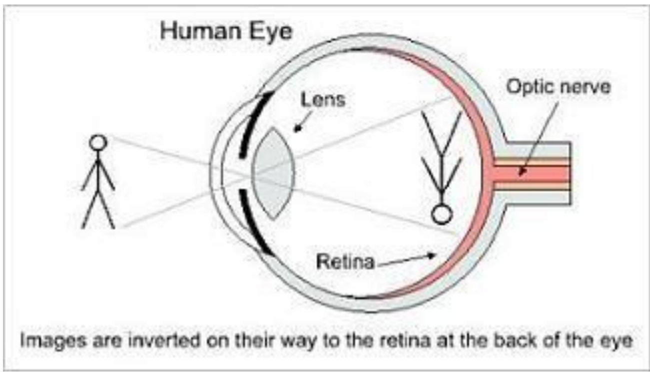
The retina makes up the inner most layer of the eye. It has five different types of photosensitive cells. Of these the rods and cones are most important. Rods are the receptors for **scotopic vision** (night vision). They operate at low intensities of light, and lead to **achromatic** (colourless) vision. Cones are the receptors for **photopic** (day light) vision. They operate at high levels of illumination, and lead to **chromatic**(colour) vision.

Each eye contains about 100 million rods and about 7 million cones. The cones are highly concentrated in the central region of the retina surrounding the **fovea**, which is a small circular region of the size of a pea. It is also known as the **yellow spot**. It is the region of maximum visual acuity. Besides photoreceptors, retina also contains a bundle of axons of a cell (called ganglion cell) that forms the **optic nerve**, which leads to the brain.

How does light travel though the eye?

Passing through conjunctiva, cornea, and pupil, the light enters the lens, which focuses it on to the retina. Retina is divided into two parts: the nasal half and the temporal half.

The inner half portion of the eye (towards the nose), taking the center of fovea as mid-point, is called the nasal half. The outer half portion of the eye (towards the temple) from the center of fovea is called the temporal half. Light from the right visual field stimulates the left half of each eye (i.e. the nasal half of the right eye and the temporal half of the left eye), and light from the left visual field stimulates the right half of each eye (i.e. the nasal half of the left eye and the temporal half of the right eye). An inverted image of the object is formed on the retina as you can see in the picture below.



Source: http://files.mda06dr.webnode.com/200000068-c6db2c7d4d/vision_retina_4.JPG

The neural impulse is transmitted to the visual cortex through the optic nerve where the image is re-inverted and processed. You can see in the given figure that the optic nerve leaves the retina from the area that has no photoreceptors. In this area visual sensitivity is completely absent. Therefore, it is called the **blind spot**.

Light Adaptation

The human eye can function at a very large range of light intensities. Sometimes we must undergo a rapid change in illumination levels. For example, when we go for an afternoon show of a movie, we find it difficult to see things in the hall on entering it. However, after spending about 15 to 20 minutes there, we can see everything. After the show when we go out into the open, we find the light outside the hall too bright to see things, or sometimes even to keep our eyes open. However, within a minute or so we feel comfortable, and can see things properly. This adjustment is faster than the one made on entering the hall. The process of getting adjusted to different intensities of light is called '**visual adaptation'**.

Light adaptation refers to the process of adjusting to bright light after exposure to dim light. This process takes nearly a minute or two. On the other hand, **dark adaptation**refers to the process of adjusting to a dimly illuminated environment after exposure to bright light. This may take half an hour or even longer depending on the previous level of exposure of the eye to light.

The photochemical basis of Light and Dark Adaptation*:* You may wonder why the light and dark adaptations take place. According to the classical view, light and dark adaptations occur due to certain photochemical processes. The rods have a photo-sensitive chemical substance, called rhodopsin or **visual purple**. By the action of light, the molecules of this chemical substance get bleached or broken down. Under such conditions the light adaptation takes place in the eyes. On the other hand, the dark adaptation is achieved by the removal of light, and thereby allowing for restorative processes to regenerate the pigment in the rods with the help of vitamin A. The regeneration of **rhodopsin** in rods is a time-consuming process. That is why dark adaptation is a slower process than light adaptation. It has been found that people who suffer from vitamin A deficiency do not achieve dark adaptation at all and find it difficult to move in the dark. This condition is generally known as **night blindness**. A parallel chemical believed to be found in cones is known as ***iodopsin*****.**

Colour Vision

Like most mammals, humans can see a range of colours; our interaction with the environment we not only experience a variety of objects, but also their colours. It may be noted that colour is a **psychological property of our sensory experience**. It is created when our brain interprets the information received from the external world. It may be remembered that light is described physically in terms of wavelength, not in terms of colour. As we have read earlier, the visible spectrum is a range of energy (380-780 nm) that our photoreceptors can detect. The energy lower or higher than the visible spectrum is harmful to the eyes. The sun light is a perfect mixture of seven colours just like a rainbow. The colours observed are violet, indigo, blue, green, yellow, orange, and red, abbreviated as ‘VIBGYOR’.

Dimension/ properties of Colour

A person with normal colour vision can distinguish more than seven million different shades of colour. Our experiences of colour can be described in terms of three basic dimensions, called **hue, saturation, and brightness**. Hue is a property of chromatic colours. In simple words, it refers to the **name of the colour**, e.g., red, blue, and green. Hue **varies with wavelength**, and each colour is identified with a specific wavelength. For example, blue has a wavelength of about 465 nm, and green of about 500 nm. Achromatic colours like black, white or grey are not characterised by hues. **Saturation** is a psychological attribute that refers to the relative **amount of hue** of a surface or object. The light of single wavelength (monochromatic) appears to be highly saturated. As we mix different wavelengths, the saturation decreases. The colour grey is completely unsaturated. **Brightness is the perceived intensity of light**. It varies across both chromatic and achromatic colours. White and black represent the top and bottom of the brightness dimension. White has the highest degree of brightness, whereas black has the lowest degree.

Colour Mixtures

There is an interesting relationship among colours. They form complementary pairs. When mixed in correct proportions the complementary colours yield an achromatic grey or white. Examples of complementary colours are red-green and yellow blue. Red, green and blue are called **primary colours of light**, because on mixing, the light of these three colours can produce almost any colour. The most common example is the television screen. It contains spots of blue, red and green colours. The combinations of these three produce different colours and shades that we see on the TV screen.

After Images

This is quite an interesting phenomenon related to visual sensations. The **effect of a visual stimulus persists for some time even after the removal of that stimulus from the visual field.** This effect is called **after image**. After images are positive and negative. **Positive after images resemble the original stimulus in terms of hue, saturation, and brightness**. They usually occur after a brief, intense stimulation of dark-adapted eyes. On the other hand, **negative after images appear in complementary colours.** These images appear when a person stares at a specific colour for at least 30 seconds, and then transfers the gaze to a neutral background (e.g., a white or grey surface). If the person looks at the blue colour, the negative after image will appear in yellow. Similarly, a red stimulus will yield a negative after image of green colour.

If you look at the image below, focus on the word afterimage written in red. Now immediately transfer the gaze to the white blank space beside it, what do you see? Have the colours changed?

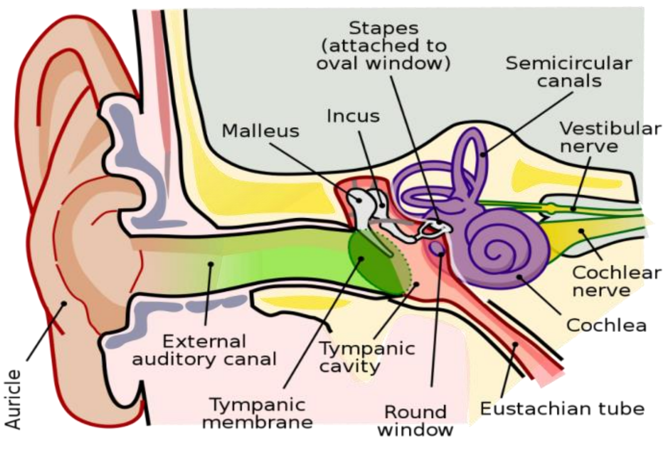
Source:
https://upload.wikimedia.org/wikipedia/commons/thumb/f/f7/Afterimagenpov.svg/1200px-Afterimagenpov.svg.png

Auditory Sensation Hearing

Sounds and noise are psychological experiences created by the brain when there is a stimulus. Audition or hearing is also an important sense modality that carries great value for us. It provides us with reliable spatial information. Besides orienting us to certain objects or individuals, it plays a vital role in spoken communication also. Auditory sensation begins when sound enters our ear and stimulates the chief organs of hearing.

The Human Ear

Ear is the primary receptor of auditory stimuli. While its well-known function is hearing, it also helps us in maintaining our body balance. The structure of an ear is divided into three segments, called the external ear, the middle ear, and the inner ear (Fig.below).



Source:
https://upload.wikimedia.org/wikipedia/commons/thumb/d/d2/Anatomy_of_the_Human_Ear.svg/1200px-Anatomy_of_the_Human_Ear.svg.png

External Ear: It contains two main structures, namely *pinna* and *auditory meatus*. Pinna is a cartilaginous funnel-shaped structure that collects sound waves from the surroundings. Auditory meatus is a canal protected by hair and wax that carries sound waves from pinna to the *tympanum* or *ear drum*.

Middle Ear: The middle ear starts with ***tympanum***, a thin membrane highly sensitive to sound vibrations. This is followed by the *tympanic cavity*. It is connected to the pharynx with the help of Eustachian tube, which maintains the air pressure in tympanic cavity. From the cavity the vibrations pass to three ossicles known as *malleus* (hammer), *incus* (anvil), and *stapes* (stirrup). They increase the intensity of sound vibrations about 10 times and send them to the inner ear.

Inner Ear: The inner ear has a complicated structure known as *membranous labyrinth*, which is encapsulated in a bony shell called *bony labyrinth*. A lymph-like fluid is found in the space between bony labyrinth and membranous labyrinth. This is called *perilymph*.

The bony labyrinth has three semi- circular canals at right angle to each other, a cavity, called vestibule, and a coiled structure, called cochlea. The semi-circular canals have fine hair cells, which are highly sensitive to postural changes as well as changes in the body orientation. Inside the bony cochlea, there is a membranous cochlea, which is also known as scala media. It is filled with endolymph, and has a spirally coiled membrane, called basilar membrane. It has got fine hair cells arranged in a series to form the organ of corti. This is the main organ for hearing.

Working of the Ear

Pinna collects the sound vibrations and serves them to the tympanum through the auditory meatus. From the tympanic cavity the vibrations are transferred to the three ossicles, which increase their strength and transmit them to the inner ear. In the inner ear the cochlea receives the sound waves. Through vibrations the endolymph is set in motion, which also vibrates the organ of corti. Finally, the impulses are sent to the auditory nerve, which emerges at the base of cochlea and reaches the auditory cortex where the impulse is interpreted.

Sound as a Stimulus

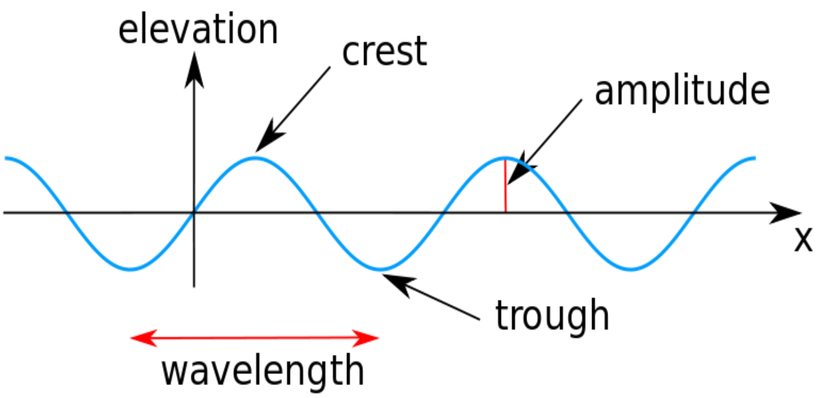
Sound as you know is the stimulus for ears. It results from pressure variations in the external environment. Any physical movement that disturbs the surrounding medium (i.e. air) and pushes the air molecules back and forth. This results in changes in pressure that spread outward in the form of sound waves, travelling at a rate of about 1,100 ft/sec. These changes travel in waves much like the ripples set up by a stone thrown into a pond. When these sound waves strike our ears, they initiate a set of mechanical pressure changes that ultimately trigger the auditory receptors.

The simplest kind of sound wave is one that causes successive pressure changes over time in the form of a single repeating sine wave.

A **sine wave** is a curve with the shape given below. It has a pattern that repeats.

The length of this repeating piece of the **sine wave** is called the wavelength.

The wavelength can be found by measuring the length or distance between one peak of a **sine wave** and the next peak.



Source: https://upload.wikimedia.org/wikipedia/commons/thumb/8/84/Sine_wave_amplitude.svg/800px-Sine_wave_amplitude.svg.png

Sound waves vary in amplitude as well as in wavelength. Amplitude is a general measure of stimulus magnitude. It is the amount of change in pressure, i.e. the extent of displacement of the molecules from the position of rest. In Fig above the amplitude of sound wave is represented as the distance ofthe crest or trough from its mean position. Wavelength is the distance between the two crests. Sound waves are basically formed due to alternate compression and decompression (rarefaction) of air molecules. A complete change in pressure from compression to rarefaction and again to compression makes a cycle of the wave. Sound waves are described in terms of their frequency, which is measured in terms of cycles per second. Its unit is called Hertz (Hz). Frequency and wavelength have an inverse relationship. When the wavelength increases, the frequency decreases, and when the wavelength decreases, the frequency increases. Amplitude and frequency both are physical dimensions. Besides these, there are three psychological dimensions of sound, namely loudness, pitch and timbre.

Loudness of the sound is determined by its amplitude. Sound waves with large amplitude are perceived as loud; those with small amplitude are perceived as soft. Loudness is measured in decibels (db). As one grows older, one loses the ability to listen to low intensity sounds. That is why the elderly may ask you to speak louder.

Pitch refers to highness or lowness of a sound. The seven notes used in Indian classical music represent a gradual increase in their pitch. Frequency determines the pitch of a sound wave. The higher the frequency, the higher will be the pitch. The range of hearing is generally 20 Hz-20,000 Hz. **Timbre** refers to the nature or quality of a sound. For example, the sound of a car engine. It is the quality of texture of sound caused by overtones.

To summarize, we can understand now how the sound waves travel through the ear.

1. The first stage of hearing involves a series of vibrations. Sound waves enter the outer ear and travel to the eardrum making it vibrate.
2. The vibrating eardrum causes the bones of the middle ear – hammer, anvil and stirrup hit each other and amplifying them
3. The vibrations are then carried to the oval window and then to the fluid in the coiled cochlea of inner ear.
4. The moving fluid then sets the basilar membrane inside the cochlea, moving.
5. The organ of corti on top of the basilar membrane moves too. Within the organ of corti thousands of receptor cells have a bundle of hair like fibres.
6. As the basilar membrane vibrates, the fibers bend and stimulate the receptor cells to send a signal to the nerve endings which make up the auditory nerve to the brain.
7. There then the impulses are interpreted as sounds.