Course: Psychology of Deafness & Child Development (681)
Semester: Spring, 2022

ASSIGNMENT No. 1

Q.1 Write brief notes on following:

a) Types of deafness

Hearing loss affects people of all ages and can be caused by many different factors. The three basic categories of hearing loss are sensorineural hearing loss, conductive hearing loss and mixed hearing loss. Here is what patients should know about each type.

Sensorineural Hearing Loss

This type of hearing loss occurs when the inner ear or the actual hearing nerve itself becomes damaged. This loss generally occurs when some of the hair cells within the cochlea are damaged.

Sensorineural loss is the most common type of hearing loss. It can be a result of aging, exposure to loud noise, injury, disease, certain drugs or an inherited condition. This type of hearing loss is typically not medically or surgically treatable; however, many people with this type of loss find that hearing aids can be beneficial.

Sudden Sensorineural Hearing Loss

Sudden sensorineural hearing loss may occur very suddenly or over the course of a few days. It is imperative to see an otologist (a doctor specializing in diseases of the ear) immediately. A delay in treating this condition (two or more weeks after the symptoms first begin) will decrease the chance that medications might help improve the problem.

Conductive Hearing Loss

This type of hearing loss occurs in the outer or middle ear where sound waves are not able to carry all the way through to the inner ear. Sound may be blocked by earwax or a foreign object located in the ear canal; the middle ear space may be impacted with fluid, infection or a bone abnormality; or the eardrum may have been injured.

In some people, conductive hearing loss may be reversed through medical or surgical intervention. Conductive hearing loss is most common in children who may have recurrent ear infections or who insert foreign objects into their ear canal.

Mixed Hearing Loss

Sometimes people can have a combination of both sensorineural and conductive hearing loss. They may have a sensorineural hearing loss and then develop a conductive component in addition.

Hearing testing is critical for discovering exactly what type of hearing loss you have, and will help determine the hearing care solution that is right for you. Hearing aids are available in many sizes, styles and technologies; there are also many alternatives to hearing aids.

Hearing Loss in Adults

People over age 50 may experience gradual hearing loss over the years due to age-related changes in the ear or auditory nerve. The medical term for age-related hearing loss is presbycusis. Having presbycusis may make it hard for a person to tolerate loud sounds or to hear what others are saying.

Other causes of hearing loss in adults include:

- Loud noises
- Heredity
- Head injury
- Infection
- Illness
- Certain prescription drugs
- Circulatory problems such as high blood pressure

b) Degrees of deafness

The level of your child's deafness can be described in terms of their decibel (dB) hearing level, or by the terms 'mild', 'moderate', 'severe' or 'profound'.

Based on British Society of Audiology definitions of hearing loss, this is the decibel hearing level range each of these terms refer to:

- mild (21–40 dB)
- moderate (41–70 dB)
- severe (71–95 dB)
- profound (95 dB).

Your child's audiologist will be able to give you more information about the level of your child's deafness. They will also be able to explain the sounds that your child can and can't hear.

Frequency

All sounds are made up of different frequencies, measured in Hertz (Hz). The frequency of a sound affects the pitch that it's heard at. For example, the high notes on the right-hand side of a piano keyboard are examples of high-frequency sounds. If your child has a hearing test where the results are plotted on an audiogram, you'll see low to high frequencies marked along the top.

It's possible to have the same level of deafness for all frequencies or to have different hearing levels at different frequencies. For example, your child may have more difficulty hearing higher frequency sounds.

Speech consists of vowels (a, e, i, o, u) and consonants (the remaining letters), that are made up of a range of frequencies.

Consonants communicate most of the information when a person speaks and they're also what make speech intelligible (able to be understood).

Consonants appear in the higher frequencies of an audiogram chart meaning that children need to be able to hear the full range of speech sounds at a quiet level to be able to understand speech.

Your audiologist will be able to explain your child's audiogram and give you information about the frequencies affected by your child's deafness.

c) Time of diagnosis

Hearing Screening

Hearing screening is a test to tell if people might have hearing loss. Hearing screening is easy and not painful. In fact, babies are often asleep while being screened. It takes a very short time — usually only a few minutes.

Babies

- All babies should be screened for hearing loss no later than **1 month of age**. It is best if they are screened before leaving the hospital after birth.
- If a baby does not pass a hearing screening, it's very important to get a full hearing test as soon as possible, but no later than **3 months of age**.

Older Babies and Children

- If you think a child might have hearing loss, ask the doctor for a hearing test as soon as possible.
- Children who are at risk for acquired, progressive, or delayed-onset hearing loss should have at least one hearing test by 2 to 2 1/2 years of age. Hearing loss that gets worse over time is known as acquired or progressive hearing loss. Hearing loss that develops after the baby is born is called delayed-onset hearing loss. Find out if a child may be at risk for hearing loss.
- If a child does not pass a hearing screening, it's very important to get a full hearing test as soon as possible.

Full Hearing Test

All children who do not pass a hearing screening should have a full hearing test. This test is also called an audiology evaluation. An audiologist, who is an expert trained to test hearing, will do the full hearing test. In addition, the audiologist will also ask questions about birth history, ear infection and hearing loss in the family.

There are many kinds of tests an audiologist can do to find out if a person has a hearing loss, how much of a hearing loss there is, and what type it is. The hearing tests are easy and not painful.

Some of the tests the audiologist might use include:

Auditory Brainstem Response (ABR) Test or Brainstem Auditory Evoked Response (BAER) Test

Auditory Brainstem Response (ABR) or Brainstem Auditory Evoked Response (BAER) is a test that checks the brain's response to sound. Because this test does not rely on a person's response behavior, the person being tested can be sound asleep during the test.

ABR focuses only on the function of the inner ear, the acoustic (hearing) nerve, and part of the brain pathways that are associated with hearing. For this test, electrodes are placed on the person's head (similar to electrodes placed around the heart when an electrocardiogram (EKG) is done), and brain wave activity in response to sound is recorded.

Otoacoustic Emissions (OAE)

Otoacoustic Emissions (OAE) is a test that checks the inner ear response to sound. Because this test does not rely on a person's response behavior, the person being tested can be sound asleep during the test.

Behavioral Audiometry Evaluation

Behavioral Audiometry Evaluation will test how a person responds to sound overall. Behavioral Audiometry Evaluation tests the function of all parts of the ear. The person being tested must be awake and actively respond to sounds heard during the test.

Infants and toddlers are observed for changes in their behavior such as sucking a pacifier, quieting, or searching for the sound. They are rewarded for the correct response by getting to watch an animated toy (this is called visual reinforcement audiometry). Sometimes older children are given a more play-like activity (this is called conditioned play audiometry).

With the parents' permission, the audiologist will share the results with the child's primary care doctor and other experts, such as:

- An ear, nose and throat doctor, also called an otolaryngologist
- An eye doctor, also called an ophthalmologist
- A professional trained in genetics, also called a clinical geneticist or a genetics counselor

Q.2 Suggest some activities in a child's normal day that could be utilized to associate with language for learning:

a) Activities at home.

Children can benefit from playtime. Games offer a fun-filled, relaxed environment where they can practise using new words and are free to express themselves. Participating in recreational activities is an effective way to develop language and communication skills. It also helps your children to be more socially confident and may be a way to forge friendships.

Below are some examples of games and playtime activities that integrate language learning with fun:

- Word games. Expand your children's vocabulary with word games. It can be as simple as pointing out items at home or during a road trip e.g. "I am now mixing the butter into the batter" or "Tall buildings are also called skyscrapers". You might even give the definition or share background information about these words. Games like Scrabble, Pictionary or a round of Charades also encourage vocabulary development and communication skills.
- Jokes. Telling age-appropriate puns will also help foster good humour and creativity in children. This also encourages wordplay and imagination. You can read through kid-friendly joke books and take turns telling witty stories. Avoid being too critical of their gags, speech, or articulation. Instead, model proper pronunciation or grammar by repeating the statement back to them in the correct way e.g.

when your child says "I goed so fast!" instead of saying, "That's not how you say it", you can opt to say, "Yes, you went so fast!"

- Riddles. Riddles are fun ways to use words and paint pictures of scenes or situations. Read or say riddles aloud to each other and explain to your children the different definitions of a single word e.g. school as in a place of learning or school as in a group of fish to help them understand the riddle better.
- Rhymes. The repetitive chanting, reading, writing, or hearing of rhymes promotes good listening skills and memory retention, aside from developing speech. You can also narrate what you do at home with rhyming words or let your children tell you about their favourite toys using rhyming words.
- Homonyms. Promote listening and comprehension skills by playing with words that sound the same but have different meanings. Allow your children to think of words that sound alike and let them try to define each one. This is also a good gauge of how much your children's vocabulary has expanded and if their understanding of the words is correct.

b) Activities outside home.

- Storytelling. While storybooks provide ample entertainment, sharing stories – whether real or make-believe – can provide a good bonding time with your children while helping develop their communication skills. Exchange stories about daily events. Broaden their imagination with fantastical stories and let their creativity grow as you make up stories about anything and everything around them.
- Songs. Aside from harnessing their musical abilities, songs also help children learn new words. Lyrics have a sense of rhyme and rhythm so it will be easy and entertaining for them to sing along. In addition, simply putting a tune to an activity can be a fun game that you can play with your children.
- Tongue twisters. Tongue twisters are an excellent and fun way to teach children correct pronunciation and enunciation of words. It is a fun way to train their tongue to pronounce words. Start with simple ones and work your way up.

Words can be a lot of fun if we know how to maximise their use. Together, they can be made up into stories, songs, and a whole lot of other things that will help your children be more eloquent. Continue to encourage your children to speak well by constructing a healthy and fun learning environment where they can unleash their creativity and broaden their linguistic skills. Guide them on how to express their thoughts, feelings and actions better through the use of words as this will prepare them to face the world with confidence as they grow.

Q.3 What is the extent of perception and cognition, and its link with language to develop the concepts of maturation and intelligence in hearing impaired individuals?

The terms "cognitive processes" and "language" are entirely associated with the neocortex functions by the majority of researchers, since it is known that evolutionarily it is the cerebral cortex that distinguishes man from other animals. The familiar "horizontal" model of the brain implies analysis of the involvement of the right and left hemispheres in the development of these and other cognitive abilities and the exchange of information between the hemispheres (Friederici, 2012; Hagoort & Indefrey, 2014). But it does not take into account the contribution of the subcortical structures: the brain stem, the hippocampus, the cerebellum, the basal ganglia, etc. During recent decades, a considerable number of studies have been published that indicate that the subcortical structures take part not only in the movement and conduction of sensory information, but also in cognitive processes such as memory, thinking, and speech (Felix, Gourévich, & Portfors, 2018; Koziol & Budding, 2009; Kraus, 2001).

It is obvious that many speech abilities in a small child are quite well developed, despite the immaturity of the cerebral cortex (Werker & Hensch, 2015), since the neocortex reaches full functional maturity much later than the development of speech and many cognitive functions in normatively developing children. One may assume that structures of a lower order may be involved in a child's cognitive and linguistic development, structures related to the transmission of auditory information and orientation of the body in space. The role of the vestibular system in cognitive development is being actively discussed at the present time (Rine & Wiener-Vacher, 2013; Wiener-Vacher, Hamilton, & Wiener, 2013). This is connected with the fact that the brain, as it constructs a picture of the surrounding space, fixes it relative to the position of the head; that is why the vestibular system is active in almost all cognitive processes (Bigelow & Agrawal, 2015). The role of auditory information is associated with the sensorimotor integration that underlies both the production and understanding of speech (Basu & Weber-Fox, 2009; Bishop, Hardiman, & Barry, 2009; Leite, 2014). There are few works that have used auditory brain stem responses (ABRs) to register the deceleration of the auditory signal conduction on the level of the brain stem in children with developmental disabilities (Hornickel, 2011; Leite, Wertzner, & Matas, 2010) It is known that based on latency, three groups of acoustic evoked potentials are distinguished: short-latent, mid-latent, and long-latent. ABRs are short-latent potentials, fixed within a duration of 10 ms from the moment of acoustic signal production. This method is used in pediatric neurology for assessment of the integrity and functional maturity of the brain stem structures that participate in conducting auditory information. The absence of ABR components (peaks) or their gross deviation from the norm indicates brain stem dysfunction in the child (Abadi, Khanbabaee, & Sheibani, 2016; Choudhury & Benasich, 2011).

The study of ABRs also makes it possible to keep track of the recovery of sensory functions. An increase in the number of registered peaks and the reduction of latent periods indicate restoration of function (Efimov, Efimova, & Rozhkov, 2015). ABRs are detected even in the prenatal period, in the fetus aged 32-38 weeks. Their parameters allow us to evaluate the neurophysiological maturity of infants. The principal development of ABRs occurs by the age of 12 months, due to the myelination of nerve fibers (Choudhury & Benasich, 2011).

Myogenic potentials evoked by clicks are a clinical test of the sacculo-cervical reflex. When the ear is stimulated by a loud click, a stapes movement occurs, and the sacculus receptors of the otolith apparatus are activated. The afferentation passes along the lower vestibular nerve through the vestibulospinal tract and activates the motoneurons of the nucleus of the accessory nerve, which causes contraction of the sternocleidomastoideus muscle. In response to the click, registration of the contraction of the sternocleidomastodeus muscle allows evaluation of the functioning of the sacculus, lower vestibular nerve, and vestibular tract (Cal & Bahmad, 2009; Murofushi, 2014; Zhou, 2014).

These methods are used to assess the functioning of the otolith apparatus, which allows the organism to sense gravitation, gauge its head position in space, and react to changes in that position. Impairment of the otolith function in adults may lead to full spatial disorientation. In children, most often, vestibular system dysfunction entails deceleration of motor and cognitive development, because the formation of body scheme projections in the cortex and the development of representations about space are performed on the basis of distorted perceptual signals (Rosegren & Kingma, 2013; Rosengren, Welgampola, & Colebatch, 2010; Young, 2015).

J. Ayres, the author of sensory integration theory, believed that full-fledged vestibular afferentation, which is an organizing factor for all sensory information, is remarkably important for the cognitive and motor development of the child (Ayres, 1972). Wiener-Vacher et al. (2013) provided evidence of the importance of the vestibular system for the development of cognitive functions in children related to orientation in space. They hypothesized that the loss of vestibular function before the critical stages of development would lead to specific cognitive deficits. Experiments on animals proved that the absence of vestibular stimulation before the critical periods of hippocampus development leads to its atrophy. Wiener-Vacher et al. considered the ages of two, seven, and 11 years to be critical periods for hippocampus development.

Since the otolith organs react not only to vestibular information but also to low-frequency sounds, they are involved in the recognition of the intonation and rhythm of an utterance, which is crucially important for full communication, including language. It has been shown that the sacculus is necessary for speech perception amid background noise. It is also known that during lessons with a speech therapist, vestibular stimulation facilitates speech understanding by the child and enhances his or her speech activity (Ayres, 1972). That is why there is a need for further study of the interrelations between the auditory and vestibular systems (closely connected both anatomically and evolutionarily) and the influence of those interrelations upon a person's cognitive and language development.

One may suppose that part of a child's speech problems may be due, not to processes taking place in an underdeveloped cortex, but to a pathology on the level of the subcortical structures, caused by some peculiarities of the child's development at the earliest stages of ontogenesis, first of all during the prenatal period (Kraus, 2001).

We found a statistically significant relationship between the increase of the duration of peak interval III-V ABR and the severity of language disorders. This is consistent with the view that in the absence of speech in a child, the inability to transport stimuli from the surrounding world because of a deficiency in the conducting pathways was relevant, but organic lesions of the brain's cortical linguistic areas (Vizel', 2015) were not. As a result of these impairments, the cortex did not receive the necessary stimulation and could not develop fully. The pathogeny of such dysfunctions has not been studied enough, but it is obvious that if they exist, the child's development occurs on the basis of distorted perceptual information (Bishop, Hardiman, & Barry, 2012; Kraus, 2001; Skoe, Krizman, Spitzer, & Kraus, 2013; Stefanics, 2011). Thus, disturbance of conduction and primary processing of information in the brain stem could be the reason for derivative cortical dysfunctions.

In a number of studies, the following concept of the bond of the ABR components to the auditory system has been proposed: I – the auditory nerve; II – the cochlear nucleus; III – the core of the superior olive; IV – the lateral loop; V – the lower tubercle; VI – the medial geniculate body of the thalamus (Efimov et al., 2014; Leite, 2014). Thus, the deceleration of the auditory signal conduction in the region from the olivary complex to the lower tubercle on the right turned out to be the most significant in our study.

With normal peripheral hearing, the inability of the child to effectively perceive auditory information is called Central Auditory Processing Disorder (CAPD) in the English literature. This term was adopted by the American Speech-Language-Hearing Association (ASHA) in 1996 to denote problems in one or several fields related to the brain's processing of information perceived by the ears: localization of the sound source, differentiation of sounds, recognition of the sequences of sound stimuli, and speed of processing of the auditory information. CAPD may be combined with other dysfunctions, such as language development disorders and specific learning disabilities. The latter were pronounced in children with speech disorders and autism (Moore & Hunter, 2013; Vandewalle, Boets, Ghesquière, & Zink, 2012).

Development of the language function in the child depends, first of all, on the coordinated interaction of the afferent and efferent systems, beginning from the auditory nuclei of the lower part of the brain stem and ending with the cerebral cortex (Billiet, 2014); these are regions in which the vestibular and auditory systems interact closely.

According to L.A. Orbeli (1961), the cerebral cortex has no direct connections either to the muscles or to sense organs, and it perceives and transmits signals by means of the spinal cord and the stem structures of the brain. That is why the child's cognitive activity depends not only upon the cortex, but also the whole brain. With functional deficiency of the lower regions of the brain, the CNS is overloaded with "corporeal" information, and cannot fully function and develop (de Quiros & Schrager, 1978).

Our research confirmed the correlation between the subjects' nonverbal intelligence as assessed by the Raven test and the vestibular function as assessed by the cVEMP method.

It is known that the hippocampus is involved in memory. M.-B. and E. Moser (2008) detected specific neurons in the hippocampus that were called place neurons. Perceiving information from the vestibular system, those cells determine the head position and allow orientation in space, building and memorizing unique "spatial grids". Our data showed that a psychologist has additional techniques for enhancing the intelligence and speech abilities of the preschooler. During the preschool period, the brain is quite flexible. Research on the development of the vestibular apparatus and increasing the conduction efficiency of the auditory system might considerably hasten the development of speech in children with speech disorders.

Q.4 What are the merits of intelligence testing of deaf children? How intelligence testing may indicate the areas of needs and aptitude?

Intelligence involves the ability to think, solve problems, analyze situations, and understand social values, customs, and norms. Intelligence testing is the estimation of a student's current intellectual functioning. It requires them to perform various tasks designed to assess different types of reasoning.

Standardized testing with norm-referenced tests indicates a child's IQ. While IQ tests have long been used, educators continue to debate their usefulness and current relevance.

Types of Intelligence Testing

Most intelligence assessments look at two different areas.

- Verbal intelligence is the ability to comprehend and solve language-based problems.
- Non-verbal intelligence is the ability to understand and solve sequential and spatial problems.

Purpose of Intelligence Testing

Intelligence testing can help educators assess a student's needs and understand how the student can be expected to perform academically. In the past, intelligence testing was used to confirm or rule out the presence of learning disabilities and to establish IQ for the purposes of diagnosing an intellectual disability.[3]

Depending on the type of intelligence test administered, it may provide important information on how students approach problem-solving. Properly interpreted, intelligence testing may help educators develop appropriate specially designed instruction and educational strategies that can help kids learn. These are often spelled out in an individual educational plan (IEP).

Understanding Standardized Test Scores

Benefits of Intelligence Testing

Sometimes when a child is not succeeding in school, it is the result of a learning disability. When left unidentified or unaddressed, learning disabilities can make a child appear less capable of learning than they actually are.

As many as 8% to 10% of kids under the age of 18 have a learning disability.[5] These include dyscalculia, dysgraphia, dyslexia, and other specific learning disabilities, all of which can affect achievement at school.

Intelligence testing can rule out a low IQ as a reason for poor performance in school. Intelligence testing also can help clear up any misjudgments made by educators who might not realize that a child's classroom performance doesn't indicate their true abilities.

Overall, IQ tests for children can be a controversial subject. But it is generally accepted that intelligence testing can be useful to identify gifted children and children with developmental delays.

They can also be used to highlight areas a child excels in and point out areas where they might require extra support. For instance, a child with learning disabilities might score high in math but low in reading. Or, they might have high oral language skills but struggle with writing.[8] These insights can help educators determine the interventions a child needs.

Common Intelligence Tests

IQ tests are one well-known form of normed testing. They compare "normal" skill levels to those of individual students of the same age. Intelligence tests (also called instruments) are published in several forms.

Group Intelligence Tests

Group intelligence tests usually consist of a paper test booklet and scanned scoring sheets. Group achievement tests, which assess academic areas, sometimes include a cognitive measure.

In general, group tests are not recommended for the purpose of identifying a child with a disability. In some cases, however, they can be helpful as a screening measure to consider whether further testing is needed and can provide good background information on a child's academic history.

Individual Intelligence Tests

Individual intelligence tests may include several types of tasks, some of them timed. They may involve easel test books for pointing responses, puzzle and game-like tasks, and question and answer sessions.

The Wechsler Intelligence Scale for Children (WISC) and the Stanford Binet-Intelligence Scale, formerly known as the Binet-Simon Test, are examples of individualized intelligence tests. The WISC test includes language-, symbol-, and performance-based questions, while the Stanford-Binet test helps to diagnose students with cognitive disabilities.

Computerized Tests

Computerized tests are becoming more widely available. They may include tasks similar to those on an analog individualized test, presented in a digital format. As with all tests, examiners must consider the needs of the child before choosing this format.

Nonverbal Intelligence Tests

Nonverbal intelligence tests, such as the Comprehensive Test of Nonverbal Intelligence (CTONI) and Universal Nonverbal Intelligence Test, Second Edition (UNIT2), are used to assess students who have language processing problems or limited English proficiency.

In these tests, tasks are designed to remove verbal intelligence from the assessment of a child's reasoning abilities. Instead, these tests isolate and assess a student's spatial reasoning, analogical thinking, and problem-solving skills.

Q.5 Write a detailed note on the brain, sensory perception and memory.

Senses provide information about the body and its environment. Humans have five special senses: olfaction (smell), gustation (taste), equilibrium (balance and body position), vision, and hearing. Additionally, we possess general senses, also called somatosensation, which respond to stimuli like temperature, pain, pressure, and vibration. **Vestibular sensation**, which is an organism's sense of spatial orientation and balance, **proprioception** (position of bones, joints, and muscles), and the sense of limb position that is used to track **kinesthesia** (limb movement) are part of somatosensation. Although the sensory systems associated with these senses are very different, all share a common function: to convert a stimulus (such as light, or sound, or the position of the body) into an electrical signal in the nervous system. This process is called **sensory transduction**.

There are two broad types of cellular systems that perform sensory transduction. In one, a neuron works with a **sensory receptor**, a cell, or cell process that is specialized to engage with and detect a specific stimulus. Stimulation of the sensory receptor activates the associated afferent neuron, which carries information about the stimulus to the central nervous system. In the second type of sensory transduction, a sensory nerve ending responds to a stimulus in the internal or external environment: this neuron constitutes the sensory receptor. Free nerve endings can be stimulated by several different stimuli, thus showing little receptor specificity. For example, pain receptors in your gums and teeth may be stimulated by temperature changes, chemical stimulation, or pressure.

The first step in sensation is **reception**

, which is the activation of sensory receptors by stimuli such as mechanical stimuli (being bent or squished, for example), chemicals, or temperature. The receptor can then respond to the stimuli. The region in space in which a given sensory receptor can respond to a stimulus, be it far away or in contact with the body, is that receptor's **receptive** field. Think for a moment about the differences in receptive fields for the different senses. For the sense of touch, a stimulus must come into contact with body. For the sense of hearing, a stimulus can be a moderate distance away (some baleen whale sounds can propagate for many kilometers). For vision, a stimulus can be very far away; for example, the visual system perceives light from stars at enormous distances.

Transduction

The most fundamental function of a sensory system is the translation of a sensory signal to an electrical signal in the nervous system. This takes place at the sensory receptor, and the change in electrical potential that is produced is called the **receptor potential**. How is sensory input, such as pressure on the skin, changed to a receptor potential? In this example, a type of receptor called a **mechanoreceptor** (as shown in

Figure 17.2) possesses specialized membranes that respond to pressure. Disturbance of these dendrites by compressing them or bending them opens gated ion channels in the plasma membrane of the sensory neuron, changing its electrical potential. Recall that in the nervous system, a positive change of a neuron's electrical potential (also called the membrane potential), depolarizes the neuron. Receptor potentials are graded potentials: the magnitude of these graded (receptor) potentials varies with the strength of the stimulus. If the magnitude of depolarization is sufficient (that is, if membrane potential reaches a threshold), the neuron will fire an action potential. In most cases, the correct stimulus impinging on a sensory receptor will drive membrane potential in a positive direction, although for some receptors, such as those in the visual system, this is not always the case.

Sensory receptors for different senses are very different from each other, and they are specialized according to the type of stimulus they sense: they have receptor specificity. For example, touch receptors, light receptors, and sound receptors are each activated by different stimuli. Touch receptors are not sensitive to light or sound; they are sensitive only to touch or pressure. However, stimuli may be combined at higher levels in the brain, as happens with olfaction, contributing to our sense of taste.

Encoding and Transmission of Sensory Information

Four aspects of sensory information are encoded by sensory systems: the type of stimulus, the location of the stimulus in the receptive field, the duration of the stimulus, and the relative intensity of the stimulus. Thus, action potentials transmitted over a sensory receptor's afferent axons encode one type of stimulus, and this segregation of the senses is preserved in other sensory circuits. For example, auditory receptors transmit signals over their own dedicated system, and electrical activity in the axons of the auditory receptors will be interpreted by the brain as an auditory stimulus—a sound.

The intensity of a stimulus is often encoded in the rate of action potentials produced by the sensory receptor. Thus, an intense stimulus will produce a more rapid train of action potentials, and reducing the stimulus will likewise slow the rate of production of action potentials. A second way in which intensity is encoded is by the number of receptors activated. An intense stimulus might initiate action potentials in a large number of adjacent receptors, while a less intense stimulus might stimulate fewer receptors. Integration of sensory information begins as soon as the information is received in the CNS, and the brain will further process incoming signals.

Perception

Perception is an individual's interpretation of a sensation. Although perception relies on the activation of sensory receptors, perception happens not at the level of the sensory receptor, but at higher levels in the nervous system, in the brain. The brain distinguishes sensory stimuli through a sensory pathway: action potentials from sensory receptors travel along neurons that are dedicated to a particular stimulus. These neurons are dedicated to that particular stimulus and synapse with particular neurons in the brain or spinal cord.

All sensory signals, except those from the olfactory system, are transmitted though the central nervous system and are routed to the thalamus and to the appropriate region of the cortex. Recall that the thalamus is a structure in the forebrain that serves as a clearinghouse and relay station for sensory (as well as motor) signals. When the sensory signal exits the thalamus, it is conducted to the specific area of the cortex (Figure 17.3) dedicated to processing that particular sense.

How are neural signals interpreted? Interpretation of sensory signals between individuals of the same species is largely similar, owing to the inherited similarity of their nervous systems; however, there are some individual differences. A good example of this is individual tolerances to a painful stimulus, such as dental pain, which certainly differ.

A sensory activation occurs when a physical or chemical stimulus is processed into a neural signal (sensory transduction) by a sensory receptor. Perception is an individual interpretation of a sensation and is a brain function. Humans have special senses: olfaction, gustation, equilibrium, and hearing, plus the general senses of somatosensation.

Sensory receptors are either specialized cells associated with sensory neurons or the specialized ends of sensory neurons that are a part of the peripheral nervous system, and they are used to receive information about the environment (internal or external). Each sensory receptor is modified for the type of stimulus it detects. For example, neither gustatory receptors nor auditory receptors are sensitive to light. Each sensory receptor is responsive to stimuli within a specific region in space, which is known as that receptor's receptive field. The most fundamental function of a sensory system is the translation of a sensory signal to an electrical signal in the nervous system.

All sensory signals, except those from the olfactory system, enter the central nervous system and are routed to the thalamus. When the sensory signal exits the thalamus, it is conducted to the specific area of the cortex dedicated to processing that particular sense.