SENSORY RECEPTORS

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MENTAL FUNCTIONS AND CODING

Incoming sensory stimuli are coded into electrical impulses of very low amperage and low voltage and are transmitted over nerve fibers. Whether or not the incoming information is attended to, ignored, or inhibited is determined by central mechanisms, and also variations in the intensity and quality of the stimulus source. There is some evidence (at least in cats) that indicates that central mechanisms can also dampen or abort the generation of electrical impulses at the sensory receptor. This was illustrated by implanting electrodes in the cochlea of a cat and noting that when the cat was visually attending to a mouse loud sounds in the environment produced little or no measurable response in the cochlear nerve fibers.

DIGITAL OR ANALOG TYPE OF CODING MECHANISMS

In many ways our sensory receptors, brain, and musculo-skeletal apparatus function much like an electronic computer with attached data processing apparatus. Our nervous system functions primarily like an analog computer with attached digital components. Analog computers can process a tremendous amount of information at one time and come up with almost immediate answers or responses. Digital computers are usually designed to process information in a serial or sequential manner, e. g. the incoming information is dealt with in several operations, usually in a progressive and sequential way.

In the coding system of our sensory receptors the coded information is sent over many nerve fibers at one time rather than the total message being sent over one fiber or wire. It appears likely that periodic scanning rhythms bring about the simultaneous collection of this coded information as the information becomes available in dendritic branches. In this way rhythmic scanning can give the illusion of a continuous flow of sensory input. This illusion would be similar to the impression we get of a continuous scene when we watch a movie. A moving picture is actually a sequential series of individual still pictures projected at a rate of sixteen or twenty-four frames per second. It appears probable that we perceive this rapid change of pictures as an even and continuous flow of movement because the rate of change of the individual pictures exceeds the rate of the scanning rhythms of the brain. It is interesting to note that the dominant rhythms of the adult brain are about 9 to 12 per second--the alpha rhythm.

EARLY CLASSIFICATION OF STIMULI--INITIAL SORTING AND SCREENING

Our sensory receptors perform an initial sorting and screening of the stimuli that come in from the physical environment. This initial screening or sorting is a type of primitive classification of the events in our environment. The same external stimulus may be perceived differently by different sensory receptors--our eyes will evaluate the light coming from the sun while our temperature receptors in our skin will make us aware of the heat. In a similar manner, the vibrations of a tuning fork or similar object may be felt as vibrations or heard as sound.

THE NATURE OF NERVE IMPULSES

It is usually thought that the character or quality of a single impulse naturally given off by a sensory receptor is independent of the type of stimulus source. In 1838 Johannes Muller postulated the principle of "specific nerve energy." This principle claims that regardless of the source of stimulus the character of the impulse transmitted by a single nerve fiber will always be the same. Some recent findings make it appear that though this is generally so it is not a universal truth.

Increasing the intensity of a stimulus source will result in a sensory receptor giving

off impulses of the same or similar character or quality (voltage or potential), but at an increased rate. Within the usual range of functioning of a sensory receptor the rate of increase of nerve fiber impulses given off by the sensory receptor is often logrhythmically proportional to the direct increase in intensity of the stimulus source. Put another way, to double the rate of nerve impulse output of a single sensory receptor cell one has to increase the intensity of the stimulus ten times.

CLASSIFICATION

How we know and comprehend our world depends on the systems of classification and categorization that we build up. At the simplest level these systems of classification are built on the different sensory qualities we perceive in our environment. Higher levels of classification are built up on the basis of relationships found by analyzing sensory intake for similarities and differences. This continual comparison of stimuli that are taken in occurs by the process of scanning input for similarities or equivalence and also scanning input for differences The development of an awareness of similarities or an awareness of equivalences leads to the process of recognition and also to the process of generalization or transferance. The development of an awareness of differences leads to discriminations and the process of differentization, e. g. being aware that something is different and so putting it in a different class or category.

Though the most elementary classification of stimuli starts at the sensory receptors, higher order classification of information is a basic mental process. Classification is basic to such mental processes or functions as: discrimination, perceptual organization, equivalence of stimuli, generalization, transfer of learning, abstraction, association, and conceptual thought. These different psychological functions all represent processes classification operative at different levels of brain function.

SENSATIONS BECOME ORGANIZED INTO PERCEPTIONS

Our sensory receptors allow us to build up images of the external world. The images we build up depend on internal factors (level of consciousness, motivation, and type of development, previous experience, and the events we focus on, etc.) and external factors (the events in our environment that we register and perceive.) Thus what incoming information we attend to and how we mold, shape, develop and organize it will depend on many factors in the life history of the species and the individual.

Put another way, how sensory experiences and other experiences in man are experienced depends not so much on the concrete nature of the sensory stimuli or the experience itself but on two other factors. First is how the experience is ordered or developed in a perceptual way. The second is the relationship of this ordered experience (percept of concept) to the total psychological organization that exists in the individual at that moment in time (or that may develop at a future time.)

If the newly developing percept or concept contradicts existing psychological schemes its further development may be inhibited; it may be discarded; it may be modified to fit the existing total psychological organization; a segment of the total organization may be modified or reorganized to fit the new percept or concept; or the existing system of psychological organization may be disorganized or broken down. If disorganization or breakdown of the existing system of psychological organization occurs there appears to be an inner demand or drive for a reorganization of some type. The reorganization may be at a simpler level. The reorganization may or may not include the contradictions that precipitated the disorganization.

DEVELOPMENT OF PERCEPTUAL SKILLS

Our sensory apparatus and neural mechanisms need stimulation if they are to function effect-

vely. Sensory deprivation during the developmental period when simple functions are de-loping can cause severe and sometimes permanent impairment of the function of sensory receptors and their central neural mechanisms. Total deprivation of light if initiated before birth and continued for a number of months after birth causes permanent blindness in dogs and monkeys. On the other hand, in experimental animals increased amounts of stimulation in a programmed way may result in the improved development of perceptual skills. Could it be that the observation that musicians' children have a better sense of pitch discrimination is partly due to the greater exposure and training of these children and their identification with their parents?

THE TOTAL PSYCHOLOGICAL ORGANIZATION FORMS A COMPLETE SYSTEM REGARDLESS OF THE LEVEL OF DEVELOPMENT

At any point in our development the functioning of our sensory receptors, mental apparatus and neuro-muscular apparatus forms a complete system. Different individuals are apt to have developed perceptual and cognitive systems to different levels. Different individuals are apt to have some subsystems of perception or cognition that may be comparatively atrophied or hyperatrophied when compared to the norm.

All incoming information (that is selected for attention) appears to be ordered or classified in a qualitative and quantitative way by comparison with other information already existing within the system. Individuals with only partial deficits in their sensory apparatus may not be aware of the nature of their deficits if they have never experienced better functioning. Illustrations are individuals (especially children) with color blindness, myopia, partial conduction deafness, and partial nerve deafness. Thus the qualities of sensation we perceive are ordered or classified in our mental apparatus in a subjective way depending on the range of function of our sensory receptors and the levels of development of our mental apparatus. Piaget has shown that children feel they comprehend their world regardless of their age. However, childrens' comprehension of their world ranges from very simple to sophisticated.

OUR SENSORY RECEPTORS DO NOT RECORD INFORMATION WITH SCIENTIFIC ACCURACY

How we perceive a sensation is influenced by a number of factors. How sensory stimuli are perceived depends in part on both the qualitative and quantatative aspects of sensory stimuli. In visual perception we usually correlate the wave length of a color with hue; saturation with homogeneity and intensity with brightness. Yet a change in only one aspect of color--e.g. wave length (or intensity) also causes apparent changes in saturation and brightness as well as a change in hue. In a like manner in music: frequency corresponds to pitch and intensity to loudness; but perception of pitch not only depends on the frequency but also on the intensity of the sound waves. Pure or "unique" red does not correspond to a single wave length, but can be produced by various mixtures of a number of different wave lengths.

LEVELS OF CLASSIFICATION AND PRIORITY

How a sensory impulse is classified is only partly determined by the nature of the physical event that acts as the stimulus source. We easily recognize a tune played in different keys or tones and by different instruments. Here we classify sounds according to the rhythm, tempo, and the relationships of the frequencies rather than by the pure quality of the discrete single sounds. It is probable that the single sounds were first classified according to tone in an automatic way, but that then a higher level of classification was given priority. After they are once established, basic perceptual skills tend to operate automatically. Conscious awareness and attention are then directed to higher orders or levels of classification of incoming stimuli. Thus at a primitive level we recognize the pure tone. We then place the pure tone in a time sequence to give it more meaning in

its relationship to other tones that occur before and after. We then focus not so much on the pure tone as on the relationships of the tones to form auditory gestalts. We analyze these auditory gestalts on the basis of memory. These gestalts may then take on more abstract or symbolic meaning for us on the basis of previous experience or new learning.

Thus as information is developed from sensory receptor input to percept to abstract concept we can see information being processed or developed a step at a time. Many of the steps become automatic in time and function at an extremely rapid rate.