THE PROCESS CURRICULUM

Perceptual Competence

Vision: General Introduction

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INTRODUCTION

Of all the areas of perception, vison has received the most study--perhaps because of its overwhelming importance for man and because of the interesting and fascinating problems involved. Vision is in many ways the most distinct and powerful type of perception available to man. Literally hundreds of volumes have been written on vision ranging from studies in philosophy to cross-cultural studies in anthropology and sociological studies of social influences on perception. There is also a large number of theories of perception and approaches to studying it within each discipline and cutting across the many disciplines.

It is obviously impossible in a brief paper to give a complete overview of the current literature on vision. Yet it is very important for teachers to have some understanding of the nature of the human visual system as well as an awareness of some of the reasons our visual system has evolved to operate in the particular way it does. This background can give a depth of understanding and a framework within which the diverse facts and findings of perceptual research can be intergrated and comprehended. It will also enable a teacher to arrange perceptual learning experiences with knowledge of the sensitivities of the human eye, what kinds of visual information it is equipped to process, and how the processes of visual perception develop.

This paper is divided into two parts. The purpose of Part I is to give some background for the understanding of visual perception in terms of the evolution and physiology of human vision and to describe the development of competence in visual perception.

Part II briefly discusses the five basic processes of the ANISA process curriculum which are essential to competence in visual perception. The educational significance of these processes and the implications for planning and conducting visual learning experiences are also discussed.

As teachers continue to increase their understanding of the functions and purposes of vision and the development of the human visual system with its sensitivities andlimitations, they will be better equipped to diagnose the perceptual needs of their pupils. This knowledge will lead to teaching that is diagnostic and prescriptive.

PART I: THE NATURE AND IMPORTANCE OF VISUAL PERCEPTION

DEFINITION

Visual perception is the detection and utilization of information about the environment that is carried in light waves reflected from the environment. Competence in the area of visual perception is the ability to differentiate critical features of the environment that are transmitted through light, to integrate these features into a singular and unified pattern and to generalize these patterns to other visual experiences.

DESCRIPTION

The Significance of Visual Perception

In recent years developmental psychologists have begun to alter their view of human development significantly. Instead of focusing solely on the nature of the human genetic endowment or on the determining characteristics of the environment, the significant issue now seems to be the interaction between the organism and the environment within which it develops. For this reason, we have identified interaction with the environment as the means by which the actualization of potential is sustained. Since potential is actualized only through this interaction with the environment, any function of the body that is important to interaction will be important to the development of a human being.

The word "perceive" comes from the root words that literally mean "to receive through", in this case, to receive information through some type of perceptual system. Perception is thus defined as the means by which the organism can be aware of and sensitive to patterns, features and changes within its environment. Every living organism has some means of identifying features of its environment that are critical to its survival and growth. But the particular nature of the perceptual system will depend on the types of environmental information that an organism needs in order to insure its survival. Since interaction is dependent upon an ability to perceive the environment, the actualization of potential will also depend on some type of perceptual ability.

As the level of biological organization has evolved to become increasingly complex phylogenetically, the interactive needs of the organism often become more complex as well and the perceptual systems become increasingly localized and developed into sense organs. For example, the basic geotropic response of plants to the pull of gravity is not localized in any one organ or group of cells. However, the evolutionarily more advanced animals have highly organized and complicated vestibular systems which enable them to distinguish clearly their position in relation to gravity and to move in ways that will not disrupt this relationship. Since perceptual systems are essential to an organism's interaction with the environment, we have classified perceptual competence as a basic category of psychological potentiality and have organized the perceptual curriculum around the main ways through which human beings can receive information about the environment. This information is gathered through light (vision), and sound (hearing), through the feeling of gravity (vestibular senses), the body (kinesthetic perception), through the pressures of objects which are external to the body (touch or haptic perception), and throught chemical reactions that result in tasting and smelling.

Visual perception is detection and utilization of information about the environment that is carried in light waves reflected from the environment. Competence in the area of visual perception is the ability to differentiate critical featrures of the environment that are transmitted through light, to integrate these features into a singular and unified whole pattern and to generalize these patterns to other visual experiences. Such generalization leads to knowledge of patterns, objects and features within the environment such as a parent's face, a rattle, the edge of the crib or the shape of the feeding bottle.

The Relation of the Environment to the Evolution of Visual Systems

To understand the processes that make up the complex act of seeing in a human being, it is useful to have a general idea of how sight systems evolved in relation to a specialized environment and the different ways different organisms are able to utilize light energy. Human sensitivity to the visible spectrum of light is a particular instance of a general ability of organisms to detect and utilize for their own purposes the energy carried in electromagnetic radiation. In all cases the energy is used through the means of a photochemical reaction in a sensory receptor that is initiated by the electromagnetic radiation. In plants, the response to light is very basic and consists of photosynthesis and generally some phototropism, the mechanism which re-orients a plant's leaves into positions that enable them to receive the maximum amount of light.

But the response of plants and many simple animals is only to the presence or absence of light energy, it is not perception in the sense of detecting some invariant property of the environment. It is only with the development of the ability to detect areas of contrast in the pattern of light falling on the organism that any kind of visual perception can be said to exist.

These invariant contrasts in the pattern of light stimulation can give basically three kinds of information about the environment. They can enable the organism to detect the layout of the environment and to detect the locomotion of the organism. It will also be able to detect gross differences in light stimulation, intermediate differences, or both of these plus small and subtle differences, depending on the organism's needs.

The needs, previous experiences, and intentions of the organism determine the kinds of environmental information that are necessaary for interaction with that environment. The range of the electromagnetic spectrum that is visible and the types of information utilized will therefore vary according to the needs and purposes of the organism. For human beings, electromagnetic waves approximately 400 to 750 nanometers[3] long, a very small percentage of the total range of electromagnetic radiation, constitute the visible spectrum (see Fig. 1). It has been shown, however, that bees are sensitive to a wavelength band that encompasses the near ultraviolet (300-400 nanometers). For example, many flowers that are yellow to humans are in fact "bee-purple" due to the amounts of ultraviolet light reflected. Also, many flowers that have no pattern for the human eye display to insects characteristic patterns of ultraviolet reflection known as "nectar guides" (Rockstein, 1974).

It has also been strikingly demonstrated by Von Frisch (1967) that bees can utilize the polarization patterns of the sun's rays to guide navigation to and from the hive. This polarization is completely invisible to man.

Environmental Information and the Patterning of Light

The question of what a human being actually "sees" has long plagued psychologists and philosophers. Are the objects of our vision "real" or do they exist only in our heads? And if they are real, then how do they get inside our heads? As we begin to understand the nature of light and the nature of perception more clearly, it appears that the answer is a little of both. There is an environment that has certain physical characteristics of which humans can become aware. What we see are light waves approximately 400 to 750 nanometers long that have been reflected in varying degrees from environmental objects. As these patterns of reflection are differentiated one from another and integrated into visual patterns, they are eventually seen to corespond with the features of actual things in an external surrounding.

Several things are involved in the environmental structuring of light patterns perceived by the eye. The first requirement is some type of light source, such as the sun or stars, fire, lightning, or from man-created sources. Light radiates in every direction and if a person is standing in the direct pathway of a ray of light with his eyes directed toward the light source, then his retina will directly receive light energy and he will "see" the light source. If the light is very intense, this direct receipt of light can be painful or even damaging. For example, looking straight into the sun is damaging to the eye.

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[3] A nanometer is one billionth (10^{-9}) of a meter long and is equivalent to a millimicron.

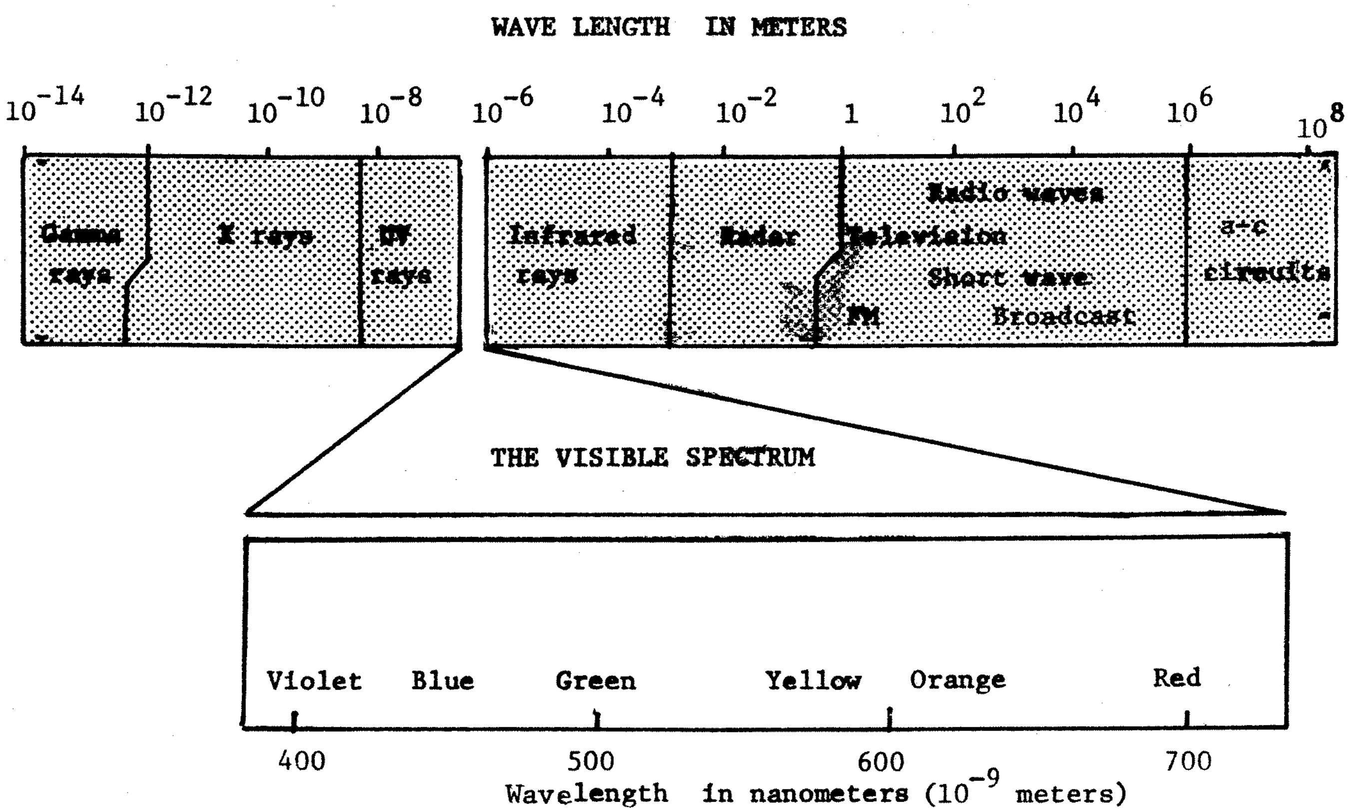


Figure 1.

The spectrum of electromagnetic radiation. The lower box shows the wavelengths in nanometers that are visible to the human eye. (After Hochberg, 1964).

Light travels in a straight line unless it encounters some object that blocks its path. This object can either absorb the light or reflect all or part of it in a different direction. If the surface of the object is highly polished as with a mirror, it will reflect the light in a single direction; if it is a rough or matte surface, it will scatter the light that is reflected. When light waves are reflected and re-reflected from the objects in an environment, the reflected rays surround a viewer in every direction. Such light is called ambient (literally meaning, "to go around") light. The light available for our vision always comes either directly from the radiating source or is reflected from the environment in ambient light. (This relationship can get quite complex as in the case of moonlight where the ambient light reflected from the landscape comes from the moon which in turn is reflecting light from the sun.)

Since objects in the environment reflect and absorb light in varying degrees, the amounts and wavelengths of reflected ambient light are not equal at all points. When a viewer is placed at a given point in the environment, some objects will reflect light directly and some will reflect light in a different direction. "White" objects will reflect much light; "black" objects will reflect less. But the complete pattern of rays of light that converge on an eye will structure a regular arrangement or array of ambient light. This array will have within it certain areas of high and low light energy that will correspond to areas of high and low (direct and indirect) reflectance in the environment. The patterns of contrasting areas of light in the visual field or the area being viewed, will provide patterns of stimulation that can be sampled by the visual system and interpreted as environmental structures. This is a simplified explanation and the full details of the process are as yet unclear. The important point to understand is that what is "seen" are patterns of contrast in the array of ambient light, light that has been reflected from some radiant source. If there were no contrasts or differences in the way light is reflected, then there could be no vision. It would be like looking at a pure white figure on an exactly matching white background with no edges to cast shadows or reflect light in a different direction.

The array of ambient light can be structured by the objects of an environment in primarily three ways. Objects can differ in the amount or wavelength of light they reflect (differential reflectance)> Or, they can differ in the direction they face so that the angle of reflection differs (differential facing). The illumination on objects can also vary because of shadows and differences in intensity (differential illuminatedness). These three types of differences are responsible for nearly all types of variations in the light that we see (see Fig. 2). A brief discussion of each type can help make clear the ways in which an environment can restructure an array of light.

<ins>Differential reflectance</ins> results primarily from differing pigmentations or colors of objects. Some objects ("black" ones) absorb a great deal of light and reflect very little. Other objects might absorb all rays of light except for one wavelength which is reflected. For example, wavelengths of 700 millimicrons are reflected and we then see that "red" wavelength as the color of the object. Differential reflectance will also result from the surface finish of an object since smooth, glossy

objects will appear shiny and matte or rough surfaces will seem dull. All these possible variations in reflectance will result in contrast in degree of reflection and will be seen as part of the pattern of the ambient array of light.

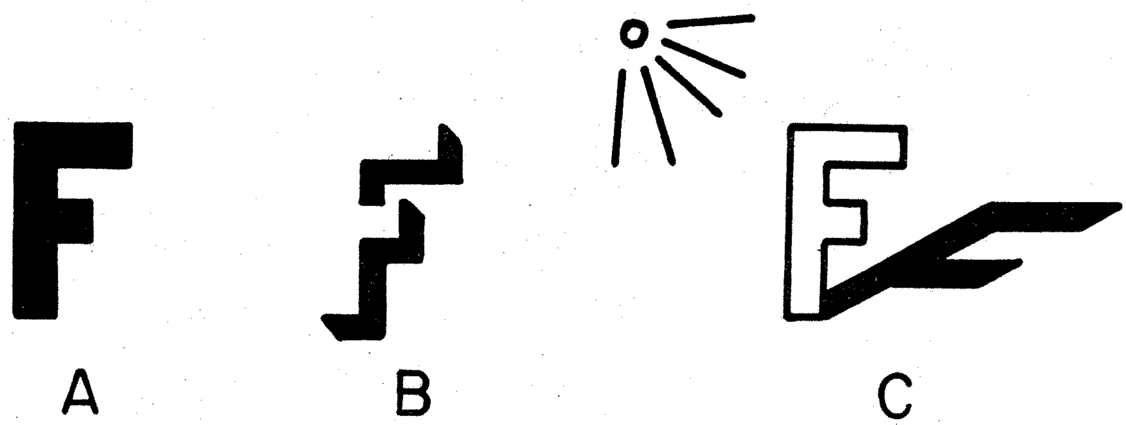


Figure 2.

Figures can be made visible in several ways. The pigmentation can be altered as in (A) (differential reflectance) or the angle of the surface could be changed as suggested in (B) (differential facing). In (C) the dark figure appears because of a shadow or a difference in illumination (differential illuminatedness).

Differential facing results in light being reflected at different angles and in different directions. If an object is tilted toward the source of light it will reflect more light than if it is tilted away from the source. This will be seen in objects that have different parts facing different directions like a sphere. Whn the sphere is illuminated from one direction only, the side towards the source will reflect much light whereas the side directly opposite the source will reflect no light. A variation in facing is one source of patterns that give visual clues as to the angles and layout of surfaces in the environment.

Differential illuminatedness is a third source of ambient light structure. In the natural environment this arises in cases of shadowing when one object is between the light source and another object. Since not as much light arrives on the shadowed portion of a surface, it will appear darker even if the angle of reflection is the same as the rest of the surface. A special case of diferential illuminatedness arises when there are two sources of light that are unequal in intensity. For example, one side of a room will be seen as darker if it has only a 25 watt bulb and the other side of the room has a 100 watt bulb. Another special case of illumination differences is made in motion pictures which are really elaborately colored shadows being cast on a screen.

These three sources of pattern in the ambient light array, differential reflectance, facing, and illumination, are the basic ways in which the light energy that is available to us can be patterned by an environment. The three types of patterns, however, rarely exist in isolation so that in any natural environment we will have available at all times cues as to the reflectance, inclination, and illuminatedness of the surroundings. Obviously, there are several types of structure that could result in similar arrays, for example, a darker patch in the array could be the result of less reflectance from darker pigmentation, from being tilted away from the light or from being in shadow. Therefore, highly refined human vision can also utilize cues that result from binocular vision and movement parallax. (These are defined in the section on the physiology of human vision.) The various types of cues will be more thoroughly discussed in sections dealing with the processes of visual perception. The important point, however, is that our system of visual perception makes it possible for us to perceive the structures and objects of the environment as being the sources of contrast in the light reaching the eye.

A special kind of light structuring occurs when man artificially structures light on a two-dimensional surface through drawing, photographs, etc., in a way that corresponds to a three-dimensional environment. This is a case of man's having learned how to produce a visual array on a flat surface that contains many of the same cues that an actual environment would produce from a similar viewpoint. It is in this sense that painters can educate our vision by isolating cues that are signs for specific aspects of the environment, for example, the depth cues in perspective drawing or the relation of color intensity to distance. Reproducing visual cues through drawing can also help an individual pay attention to distinctive visual structures in his environment and can be a valuable tool in visual perception training.

A drawing may be ambiguous in some respects. This happens especially in line drawings where so much information is left out that sometimes it can be difficult to interpret exactly what is intended. Because information is left out, it is possible to put contradictory information in the picture and still have the lines connect. Many optical illusions can be understood if the nature of what has been left out is examined and, often, when more information is included, the picture is no longer ambiguous (see Fig. 3).

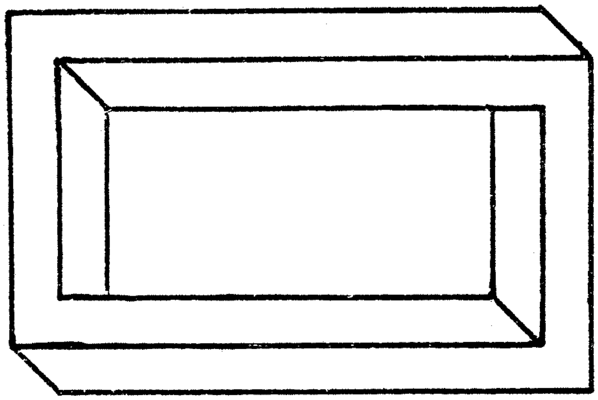


Figure 3.

This "impossible" figure can be drawn only because other depth cues (e.g., shading) have been left out. (After Hochberg, 1964.)

The main difference between a two-dimensional painting and a three-dimensional scene is that there is no viewing angle from which we can see a portion of the painting that is behind an object in that painting. For example, in three-dimensional viewing we can move our heads to one side to see if there is a light switch behind the chair. This is not possible with a drawing of a chair.

Physiology of Human Vision

The most evolutionarily primitive eye is the simple photoconcentrator or ocellus of some invertebrates. This ocellus merely registers light or dark. As more photoconcentrators become available, areas of light and dark can be compared and contrasts detected. By virtue of the most basic photoconcentrators, some marine animals can detect only the direction of light (the sky or top of the water). As eye-spots evolved, there were two evolutionary possibilities--more ocelli could receive light in many different directions or the efficiency of a single ocellus could be improved. Gibson (1966, drawing heavily on Walls, 1942) feels that these two tendencies probably resulted in the divergent evolutionary patterns of compound versus comlex eyes. In compound eyes (such as those of insects) many receptor cells are grouped together registering different directions by being oriented in different directions. In the compound eye the single receptor registers direction by means of a lens that concentrates light and focuses an inverted image on the photo-sensitive cells of a retina (see Fig. 4).

In certain lower vertebrates and in mollusks, this image falls directly on photosensitive cells. Impulses are then transmitted to cells behind the photo-receptors. This necessitates an immobile eye. However, a type of eye evolved in vertebrates that has transperant nerve cells in front of the photo-sensitive cells. These nerve cells transmit impulses to a single optic nerve that exits through a hole in the retina. The place where the optic nerve trunk exits results in a retinal "blind spot" where no photoreceptors can lie. Nevertheless, this structure allows the eye independent mobility which makes possible the scanning and focusing of images from different directions (see Fig. 5).

This latter type of eye is found in human beings. An iris regulates the amount of light passing through the cornea and then through the lens. The curvature of the lens can be adjusted by means of optic muscles so that the image, passing through the transparent layer of nerve cells, will be focused on the photosensitive cells of the retina (see Fig. 6). Stimulation of the rods and cones will be transmitted through the nerve cells into the main optic nerve. These nerve impulses finally stimulate the visual cortex in the occipital lobe of the brain. It is in the occipital lobe that pattern of light stimulation is finally interpreted.

Most phylogenetically advanced animals have two eyes which make a wider field of vision possible. In human beings (and some other primates) these eyes are arranged so that they both must converge and focus on the same point in the visual field at the same time. This limits the field of vision to be primarily in front of the viewer but it allows for fine discrimination of depth through simultaneous comparison of two different angles of view. This comparison occurs in two ways. First, the degree of convergence or the extent to which the eyes must turn toward each other indicates the distance of the object being viewed. Secondly, the two slightly different angles of view falling on each retina can be compared. When a single point in the environment is fixated, the brain can interpret the depth indicated by the disparity between the two retinal images. (see Fig. 7).

It should be noted that the binocular vision is not the only way human beings can obtain depth information from different angles of view. When the head moves from one position to another, objects that are nearer to the viewer seem to move faster and portions of the environment that were previously hidden can now be seen (see Fig. 8). This is referred to as motion parallax and it has been shown to be just as important as binocular vision in human depth perception. Motion parallax explains why the moon always seems to "follow us" at night. We are able to pass by objects in

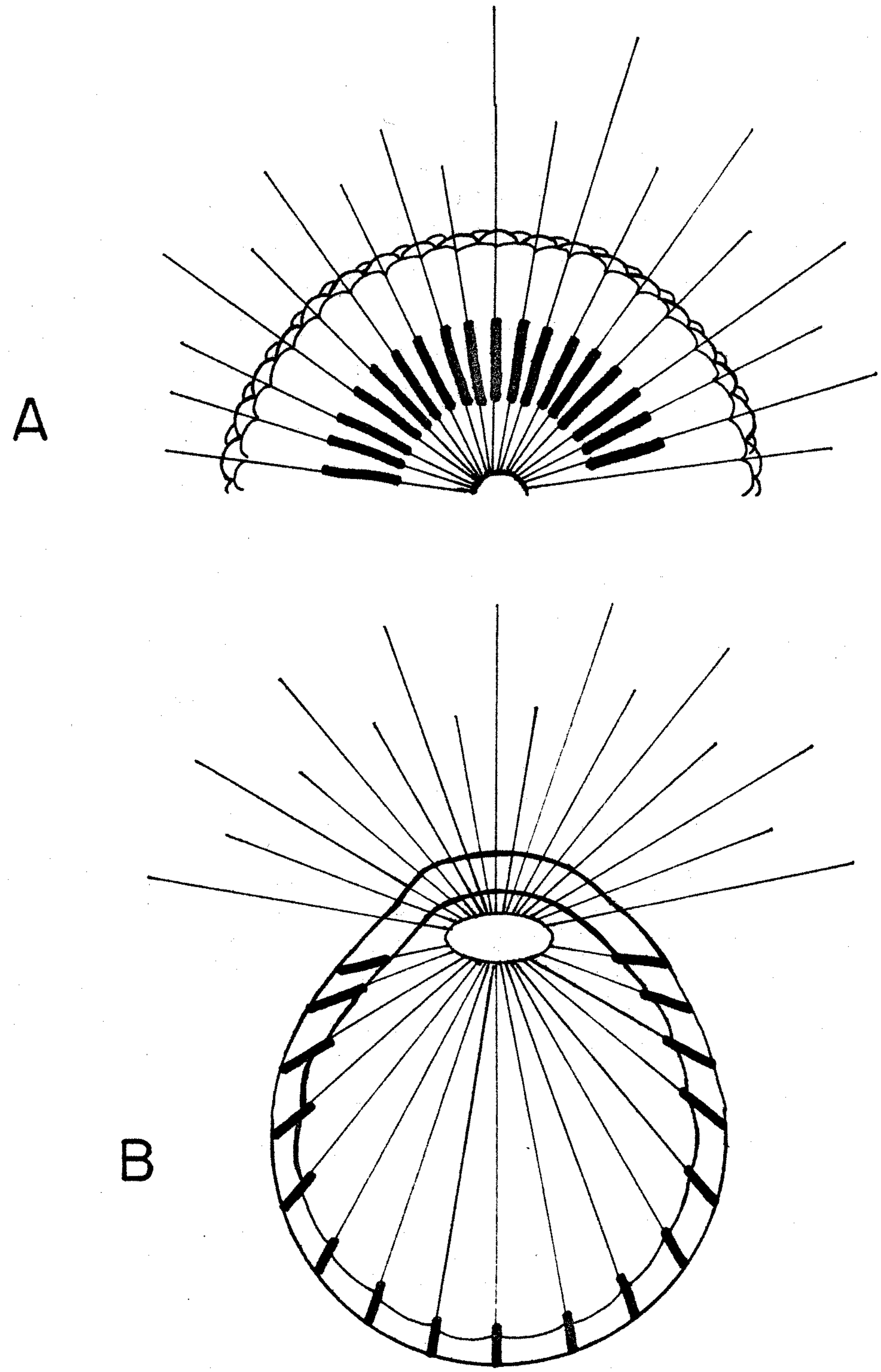


Figure 4.

Acceptance of light by (A) compound and (B) complex eyes. In (A) the convex arrangement allows a light ray to fall directly on a recptor. In the concave arrangement of (B) the receptors register different directions by means of an inverted image by the lens. (After Gibson, 1966.)

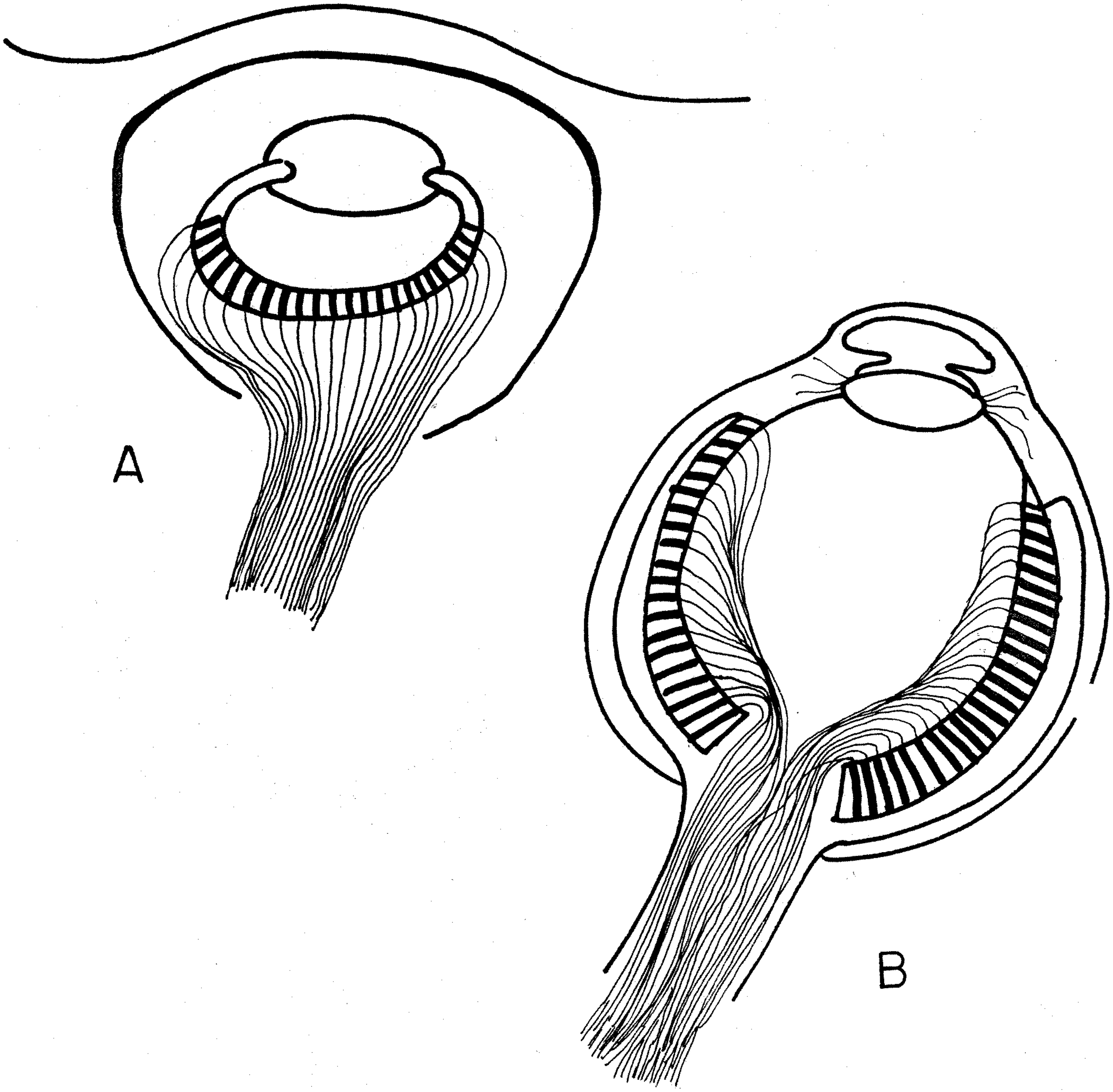


Figure 5.

(A) A schematic drawing of the chambered eye of a mollusk. The lens forms an image on receptor units which are connected to nerve fibers lying immediately behind them. (B) The vertebrate eye, however, has transparent nerve fibers that lie in front of the retina and connect to emerge through a hole in the retina. (After Gibson, 1966).

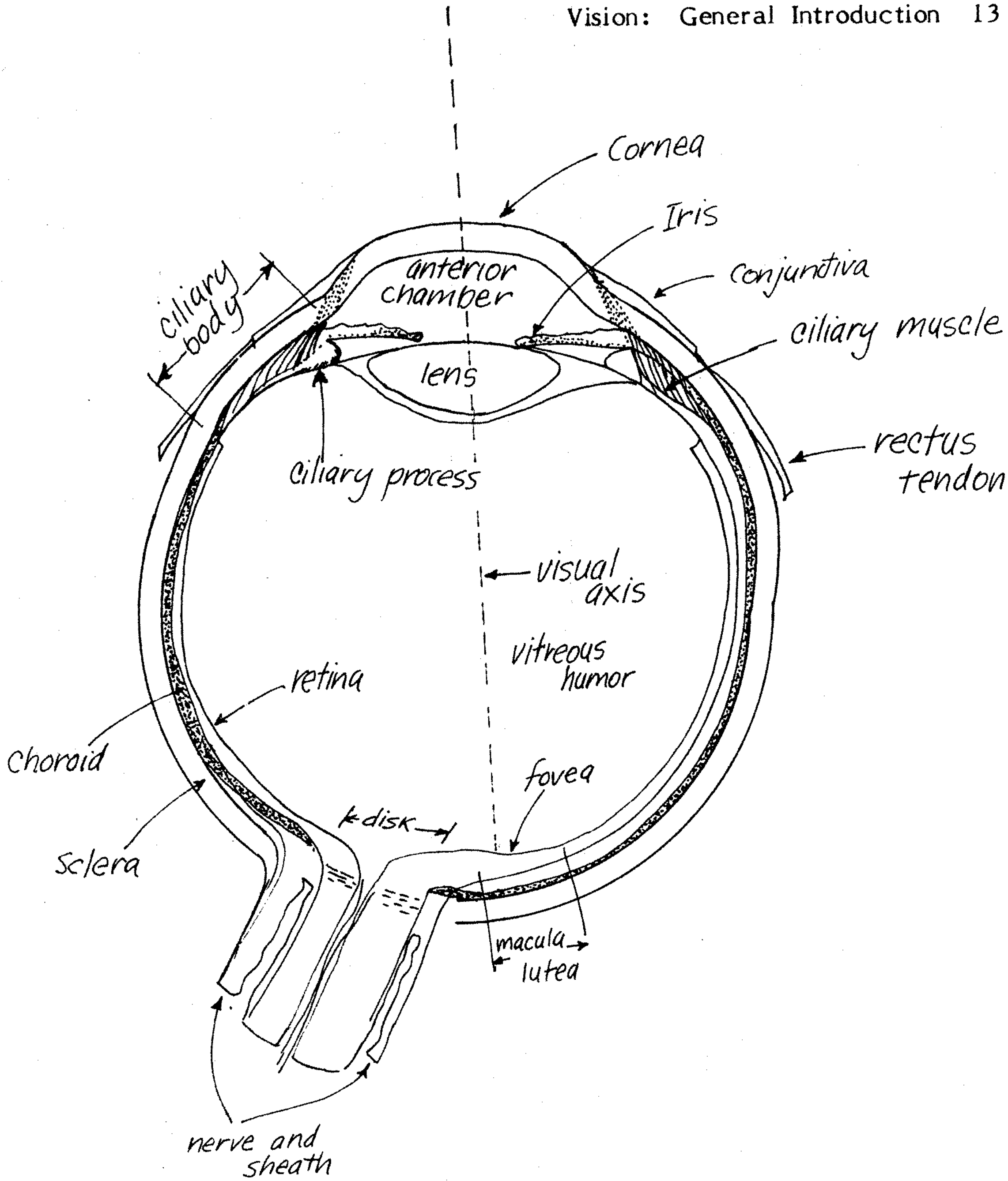
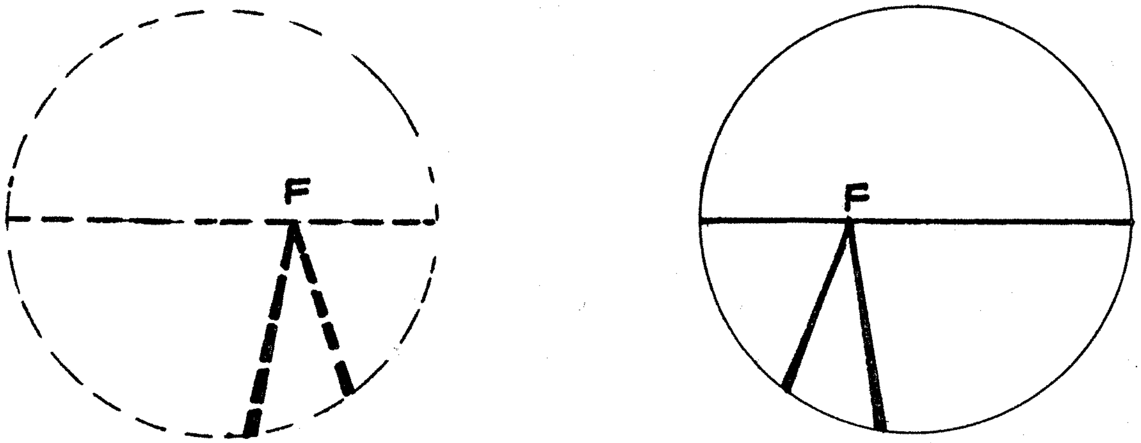


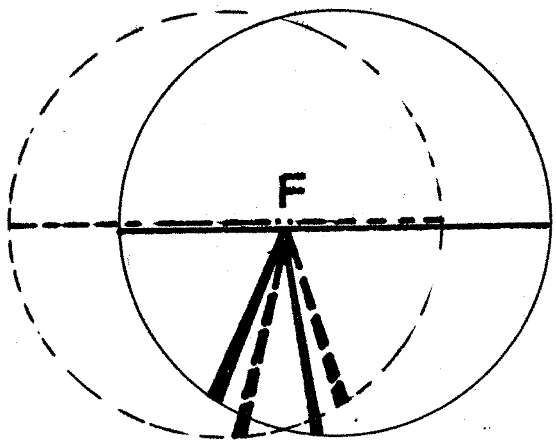
Figure 6.

The human eye—sketch of a horizontal section of the right eye. (After Gibson, 1966.)

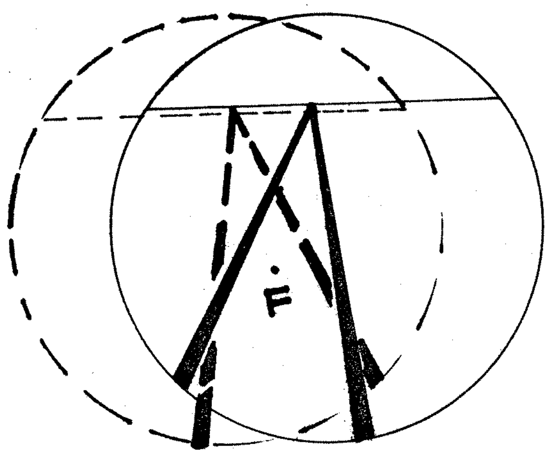


Array to the left eye

Array to the right eye



Disparity of the two arrays when fixating the horizon.



Disparity of the two arrays when fixating a near point.

Figure 7.

Retinal disparity in binocular vision. Because the two images are slightly different the combination of the two images will vary for each point in the scene that is fixated. (After Gibson, 1966).

the landscape but the moon is so far away that it is not possible for us to pass it and "leave it behind".

There are two types of pigmented photosensitive cells in the retina, the rods and the cones. The pigmentation of these cells makes them able to receive energy from light and transmit this energy into the optic nerve. Rods are sensitive only to very low levels of light (such as are found at night). They are not able to register color differences of lightness and

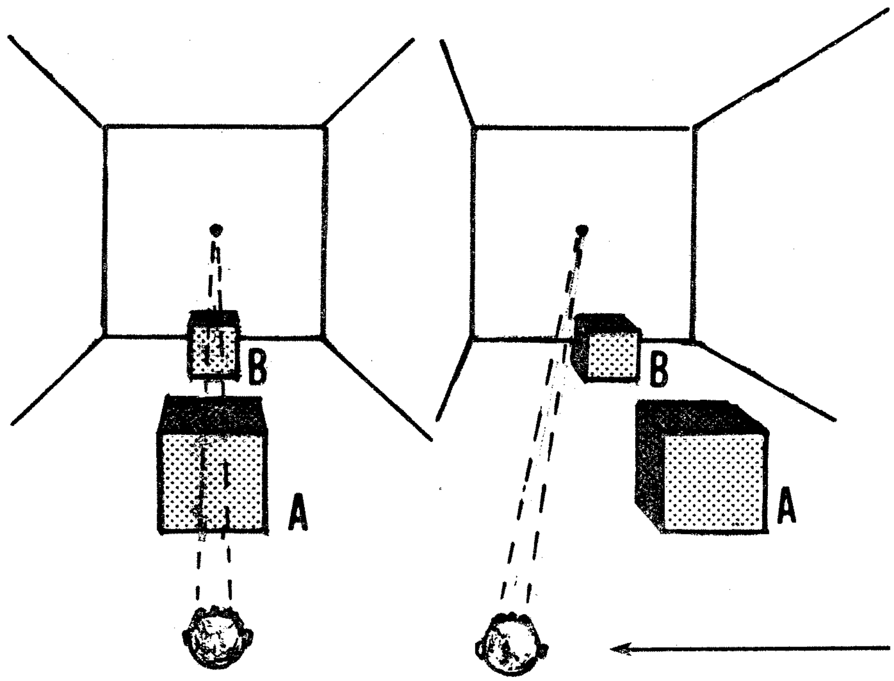


Figure 8.

Motion parallax. If the head moves to the left, the nearest objects appear to move farther and faster to the right. Portions of the environment that were at first hidden by the front box will become visible. (After Bower, 1974.)

darkness. Animals with rod-only retinas are nocturnal and must avoid blinding daylight. The cones are employed in photopic (literally lightseeing") vision that occurs in brightly lighted scenes and they respond to both brightness and wavelength differences. Animals with cone retinas are diurnal and must seek shelter at night. The human retina like many vertebrate retinas) is a dual retina containing both rods and cones on the order of 130 million total (Hubel, 1963) of which approximately 6 - 7 million are cones (Evans, 1974). This enables the human retina at night to respond to light stimulation that is estimated at one-millioneth of the intensity of bright daylight (Gibson, 1966). In fact, it has been found that a rod can be stimulated by one quantum of light, the smallest amount of light possible.

The cones in the retina are concentrated most heavily in the fovea which is the area where greatest focus of detail can occur. There are no rods in the fovea but the proportion of cones to rods decreases with distance from the fovea. Detail discrimination also decreases steadily as the proportion of cones decreases.

Under scotopic (literally, "darkness seeing") viewing conditions of low-level light, only the rods are stimulated. Since there are no rods in the fovea, it is necessary at night to look slightly to one side of an object in order to see it. Because of this and because of the type of neural connections, rods are primarily suited for detection of motion and for general orientation-the two most important needs at night.

Although the light array falls on the retina in much the same way as an image falls on the film in a camera, the pattern of stimulation sent to the brain along the optic nerve is completely unlike direct reception of a simple image. It has been demonstrated recently that there are three movements that the eye continually makes, all of which the viewer is totally unaware (Pritchard, 1961). One movement makes the image drift slowly away from the fovea. Then, a quick flick returns the image to the foveal area. Finally, there is a tremor of approximately 150 cycles per second that covers a range of about half the diameter of a cone. These movements occur continually whenever vision exists. If the image is experimentally stabilized on the retina, vision ceases within a fraction of a second. Hence the transmission of the retinal image is really <u>not</u> a static image but could be more properly conceived of as a scintillating, flickering pattern of light stimulation.

Although it is not known exactly how the brain interprets this stimulation, it is hypothesized that an object can be perceived only if the image falls on several sets of cells while it is being viewed. The brain somehow compares the stimulation of these several sets of cells and if there is some aspect of the stimulation that remains constant (e.g., a corner), then a visual pattern (in this case, a corner) will be seen. The tremor is mainly responsible for this comparison of stimulation on different sets of cells.

The fact that a human is never aware of the tremor, or of the "blind spot", can possibly be explained in terms of the perceptual need to detect information about the environment. Since no information about the light pattern or the environment is carried by the tremor, it is not important for us to be aware of it and in fact it would detract from our attempts to accurately perceive the external world. Therefore, the tremor is not perceived. The fact that the retinal image seems stable led many people in the past to conceive of vision as the direct transmission of sensations to the brain. We can now see that this is a vastly over-simplified and inaccurate portrayal of visual perception.

The final physiological mechanism to be discussed is adaptation. Through processes that are not completely understood, the iris allows only the amount of light that will insure optimal stimulation to enter the eye. Everyone has had the experience of flicking on a light in a dark room and having to wait several moments for the eye to adapt to a higher intensity. The phenomenon is also apparent in the darkening of windows as twilight when the light in the room is turned on.

The adaptation level of the eye is determined largely by the overall intensity of the surrounding illumination and it has been shown (Evans, 1974) that if a stimulus is less than 1/1000th of the overall illumination, it will be seen as black--regardless of the wavelength. It is important to realize then, that because of the adaption phenomena, factors such as brightness are all relative to the surrounding illumination. A related phenomenon is the fact that a color will change in appearance depending on what other colors are next to it.

The Dynamics of Visual Perception

Human vision is an active and dynamic process. Therefore, it is not enough to understand the nature of patterns of reflected light or the physiological mechanisms that respond to contrasts in light stimulation. The final perception is greatly influenced by the viewer's past visual experiences (his visual immanence) and by his purpose and intentions (his transcendance). Visual immanence includes the effects of culture and previous experience and will largely determine the extent to which context can give additional cues as to the meaning of a certain visual pattern.

This dynamic character of perception is discussed by many perceptual theorists. James Gibson (1966), for example, points out that a human being actively seeks and selectively extracts information from the environment. Uric Neisser (1967), a noted cognitive psychologist, refers to perception as a process of "analysis by synthesis" and compares the process to the operations of a paleontologist who reconstructs a dinosaur from bits of bones carefully extracted from a mound of rubble. In the same way, we perceive the world by extracting critical features from a welter of available visual data and integrating these features into a perception which becomes a focus of conscious experience. The dinosaur and the visual patterns are already there but we can understand it. An example of the effect of experience on this process is given by Neisser (1967) who points out that a literate person will have no trouble picking out the letter "p" in this sentence and telling how it differs from a "b" or a "q". This same perceptual task, however, can be difficult if not impossible for a non-literate person.

As an individual continually differentiates, integrates and generalizes visual patterns, he is building up his visual immanence. This is similar to the type of perceptual preparation that William James (1890) refered to as the pre-perceptual image. This pre-perceptual image represents the basic stock of integrations that have already been made and thus determines in part which new integrations can be made. A good example of the effects of the pre-perceptual image is to compare a child's description of a car to the description of a car designer. Because the child has had relatively little experience with cars, he is apt to leave out many details that would be obvious and crucial to the car designer. The information was potentially available to the child in the light array but his visual immanence did not include a sufficiently complicated pre-perceptual structure which would have enabled him to utilize the more sophisticated bits of information.

An individual's culture will also affect his viause immanence laregely by determining which type of experiences will be open to an individual. An obvious example is language. A person brought up in a Chinese speaking family will be much more likely to recognize the Chinese graphic symbol for father than an individual from an English speaking family who has never seen Chinese. But culture has other, more fundamental, effects. For example, there is some experimental evidence which indicates that individuals in cultures that do not use two-dimensional representations are not immediately able to recognize depth cues indicated in line drawings (see Gibson, E., 1969). Culture and previous experience will also affect the extent to which context can provide additional clues for perception. For example, an English speaking person will be able to interpret the word hip-op-tamus even though certain letters are missing. (For another example of the effect of context, see Fig. 9).

A person's intentions and goals, as well as his future aspirations, will also affect what is perceived. A common experience is to not notice something because the person wasn't looking for it. For example, if an aspiring lawyer picks up the newspaper to read about today's happenings, he is likely to be able to tell you about the main legal battles of the day. But if that same person is picking up the newspaper for the purpose of wrapping the garbage, even the headlines might go unnoticed.

Another important aspect of the perceptual process has to do with intersensory integration. Even though vision is discussed here as a separate proces, it rarely operates in isolation from all other perceptual modes. The brain simultaneously processes all incoming sensory information to interpret the overall meaning of a visual experience. For example, we never really mistake a movie for reality because we can feel that we are sitting down. This integration of sense modalities is very important to children in verifying a child's impressions. By seeing an object, touching it, and by hearing the sound when it hits the floor, a complete image of the nature of that object will be formed.

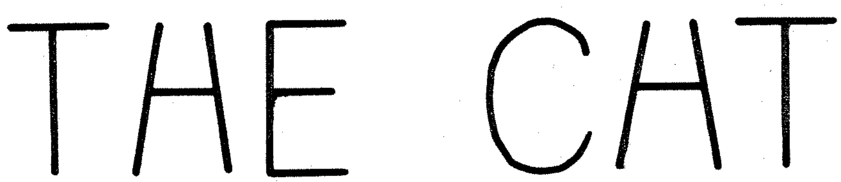


Figure 9.

The influence of context is illustrated in these two words. In both cases the center letter could be ambiguous but knowing the word enables us to interpret it. (After Neisser, 1967.)

In summary, the process of visual perception occurs only through the dynamic interaction of many things. It begins with the background, expectations, and the emotional state of the percipient. Then, depending on his present purpose, the viewer will differentiate certain features of the environment. Depending on which features have been attended to and distinguished, a pattern will be integrated. If certain aspects of this integration are familiar, it will be recognized or, in other words, familiar patterns will be generalized. These processes of differentiation, integration and generalization on the basis of previous perceptual learning will continue throughout life to be the major factors of perceptual learning. This is true for such diverse perceptual acts as learning in reading, making minute observations of color changes in a scientific experiment, and making highly sophisticated observations of the subtleties of light and dark while painting a person's portrait.

THEORETICAL JUSTIFICATION: ANISA

<u>The Relation of Visual Perception to Learning Competence</u>

In order to assess the importance of any process in terms of the ANISA theory it is necessary to determine the extent to which that process is involved in learning competence. Since perception is crucial to interaction with the environment, the ability to be a competent learner is partially dependant upon perceptual competence, and, vision is one of man's most powerful perceptual systems.

Although it is possible to exist without vision (as people like Helen Keller eloquently attest), lack of vision makes certain kinds of interactions much more complex and other types of interactions become impossible. For example, observation in science or in painting and graphic arts is largely a visual process and any real experience of color is completely dependant upon vision. Braille does make reading possible without vision but the range of writing sizes and styles available to a seeing person is infinitely greater. Vision also plays a crucial role in motor activities by directing and guiding orientation and movement. Just imagine a game of soccer or baseball wihtout vision!

But for most people, it is not a question of no vision at all; it is a question of the subtle refinement of the visual processes. A higher degree of perceptual competence means that an individual will have a greater degree of control over the type and quality of the visual information he is able to use. Consider medical diagnoses. A doctor with years of experience may be able to examine an X-Ray and detect the very beginning of disease that would go unnoticed by a less experienced person. Also, the range and subtlety of aesthetic enjoyment will depend directly on the qualities of visual experience an individual has had. If a person is used to looking for subtleties of line and shading, of color, texture, and proportion, then that person will be much more likely to respond to subtleties in the visual elements of theater, dance, film, graphic, arts, sculpture, etc. An aesthetic perception is built upon years of experience with the visual qualities of objects.

Relation of Visual Perception to Other Categories of Potentiality

Since visual perception is crucial to learning competence, it is involved in the actualization of all categories of potential. It is impossible in a short paper to detail relations to all the categories since whole volumes have been written on single perceptual relationships, for example, the role of attention in perception. The attempt here will be to mention some of the most significant interrelations that a teacher should be aware of. It is important to note that in reality all categories of potentiality are being actualized at the same time so that in a sense every division is artificial. However, it is sometimes helpful in terms of diagnosis and prescription to be aware of the various close relationships. This makes it easier to determine the source of difficulties in a learning problem and to assess its possible efect on the release of other potentialties.

Perhaps the greatest number of writings concern the relation of perception to psychomotor activities. In fact, there is an entire field of perceptual-motor study dedicated to investigating these links. As mentioned, vision is crucial to all manipulation that depends on the body making contact with a distant object like a baseball. It has been shown that this body-eye connection is probably present at birth (Kessen, 1970) since infants only a few days old are able to reorient their heads towards the position of a visual stimulus. As visual-motor coordination develops, it becomes an integral facet of steady locomotion, of manipulation and fine-motor control that is involved in copying or drawing.

Another category of potentiality that has been particularly investigated in relation to visual perception is volitional and especially attention. Attention is an integral part of every act of seeing (and of all learning). It is involved in the initial differentiation and eventual integration of the features of an object. For example, when seeing a semi-circular line of dots, attention must be paid to the whole figure for the "c" pattern to emerge. Otherwise it will be seen just as a random collection of dots. The nature of the pre-perceptual image will directly affect which patterns will be attended to and selective attention, in turn, will structure future perceptual expectations. This powerful influence of attention becomes clear in a discussion of the process of figure-ground perception since only one figure can be attended to at a time. Therefore, choices must be made and volition becomes an inevitable part of every perceptual act.

Perception is also very closely related to cognition and many theorists make no distinction between their theories of cognition and perception. Piaget, for example, asserts that becoming aware of the fact that a ball has not ceased to exist just because it has rolled behind a cushion is as much cognitive learning as it is perceptual. Perceptual acts will always be intimately involved with cognitive process. For example, classification of shapes and colors first depends on an ability to see the shapes and colors. Cognitive processes will also play a crucial role in perceptual organization and memory. Taking classification again as an example, if objects in a visual field have been classified it will be much easier to recall which objects were there.

Percetual organization and recall will also influence and be greatly influenced by language and symbolic meaning. For example, many experiments have shown that a word that has meaning (like "helicopter") will be much easier to recall than a random group of letters (such as "hretlpcole" or "rethlpocie"). In fact, one must look closely at "rethlpcole" to see exactly what order the letters are in, whereas the order in "helicopter" is perceived at a glance. Language also can play a very important role in perceptual learning by helping a person know what the most significant features of a pattern are. By directing attention verbally to angles and curves or significant bulges, the distinguishing features can be differentiated much more quickly.

The role of language and symbol formation in perception is also apparent in more fundamental perceptual acts. An excellent example is cited by Ernst Cassirer (1953) who describes a man who has sustained severe brain damage to the language area on only one side of the brain. When this man held an object in his left hand, he could describe all its properties--hard, smooth, circular but flattened with a bump on one end--but he could not name it. When the object was placed in the other hand, he could immediately say, "Oh, that's a watch." Obviously, the perception of watch-ness was more than the sum of all the sensations--language played a mediating role. This identifying role of language is often referred to as acquired distinctiveness. The distinctions that are acquired by attaching names to objects is one important way in which perceptual generalization is facilitated.

Visual perception is also related to processes in the affective domain. A person's behavior in any environment is always related to his perception of what is in that environment. If the consequences of his actions support his perceptions, then he gains confidence and suffers less anxiety. The state of arousal will also affect perceptual ability. If a person is very anxious or upset, it is very possible that crucial visual patterns will go completely unnoticed. How many car accidents have resulted when people were upset about something and just "weren't seeing anything."

DEVELOPMENTAL CONSIDERATIONS

Visual Capabilities at Birth and the Effects of Early Experience

In order to understand the development of visual perception it is important to be aware of the visual capabilities of the human infant. It is also important to know whether or not the experiences of a young child will have any effect on the development of his visual abilities.

The anatomical evidence available thus far indicates that the visual structures in a neonate are completely present although certain neural connections are immature. Both photopic and scotopic vision are present and the neural pathways are functioning although the pattern of functioning is different from the adult pattern. During the first few days of life the eyes are usually found to be slightly divergent but within a few days the eyes will converge on a single focal point. Control of eye movement improves very rapidly during the first few months although even then visual scanning will be primarily in the horizontal plane. (See Kessen, 1970, for a summary and bibliography on vision in human infants.)

A great deal of research has also been devoted to the types of cues to which infants are sensitive. It has been clearly demonstrated that infants notice objects and in fact prefer moderately complex visual patterns to simple or unpatterned fields (Fantz, 1961; 1963). T. G. R. Bower (1966a; 1966b; 1974) has performed numerous experiments indicating that infants are able to distinguish shape and size, depth of an object and distance from the viewer. In fact, his experiments indicate that the actual shape of an object is a powerful invariant feature for an infant and that the infant is not able to notice changes of distance or slant—both of which change the shape of the image falling on the retina. It is obvious, then, that an infant already has available some powerful perceptual tools.

Some interesting research has also been done concerning the effects of experience on visual development. The ANISA theory of development has identified interaction with the environment as a primary means through which potential is actualized. This proposition has been experimentally confirmed by numerous studies of environmental enrichment and environmental deprivation.

In a number of experiments performed by Walk and Gibson, animals were rasied in the dark for a number of days to see if this would affect their perceptual development. Kittens that were raised in the dark until they were 26 days old were found to be functionally blind when tested for depth discrimination (Walk and Gibson, 1961). In contrast, light-reared kittens of the same age showed good depth discrimination and accurate paw placement. For rats, however, it was necessary to prolong the dark-rearing period to 140 days before any effects of deprivation were found (Walk, Trychin, & Karmel, 1965). Evidently, the visual development of a kitten is more easily affected by the quality of environmental interaction than that of a rat.

However, it has been demonstrated that even for a rat, the type of early experience will affect later perceptual learning. In an experiment performed by Gibson and Walk (1956), it was found that rats raised in cages with triangles and circles on the sides were better at learning to discriminate these figures than were rats raised in cages with plain walls. Other experiments with rats indicated that exposing rats to the sides of a triangle without the angles, greatly facilitated later discrimination of a complete triangle from a circle (Fogus, 1958). Evidently this experiment capitalized on the later introduction of a novel aspect of the visual pattern, that is, angles.

Numerous enrichment studies have also been performed with human infants. In a well known series of studies by Burton White (1968), the environments of institutionalized infants were enriched in various ways, for example, by increasing the amount of handling or providing interesting visual objects. Clear perceptual effects were found such as an increase in looking behavior, and an earlier age at which hands were noticed. In another experiment by Greenberg, Uzgris & Hunt (1968), it was found that placing an attractive pattern over an infant's crib could reduce the time until the onset of the blinking response by as much as three weeks. From these and other similar studies it is clear that experience has an effect on development. Further research will be necessary, however, to tell us exactly what types of environments and interactions will affect visual development in the most significant ways.

Some Developmental Considerations

Before learning experiences can be planned for a child, it is important to know his developmental needs. It is also necessary to understand the ways in which perceptual learning and development can occur. Although developmental research is as yet incomplete, several perceptual researchers and theorists (e.g., Eleanor, Giboson, 1967 and Ulric Neisser, 1967) have identified some important general trends. One developmental trend is toward greater ability to attend to and differentiate critical features of visual patterns. This implies both a greater selectivity in attention and an increasing degree of self determination in choosing what is to be viewed. As visual processes mature, a child comes to know where to look and what to look for. For example, if his intention is to read, he will start looking for letters and begin scanning at the top left, trying to differentiate groups of letters that will form sounds and words. In observational experiences, his observations will become increasingly acute and more subtle differences will become apparent.

The second trend is primarily integrative in nature and involves a continually developing ability to detect patterns and visual structures. This means that a child will increase in his ability to see the connections between things, to integrate letters into words and words into sequences, to see patterns in the way a plant's leaves are arranged and to put objects together into a unified drawing. These increasing levels of integration arise primarily from an ability to see a higher level ordering principle or invariant in any group of objects or figures that is not randomly arranged.

A final important trend is the increasing ability to generalize previously learned patterns to new situations. This is seen whenever a child learns that "squareness" referes to relations among four edges and not to any specific set of edges. As mentioned before, language is one of the main tools to assist in perceptual generalization since it can help isolate the pattern and label it with a name. Thus, eventually, "square" is any number of objects that have a certain characteristic arrangement and not just one square of one particular size.