PERCEPTION

SRI VENKATESWARA UNIVERSITY, TIRUPATI, A. P., INDIA

Perception

A Seminar conducted by the Philosophy Department of Sri Venkateswara University, 1964

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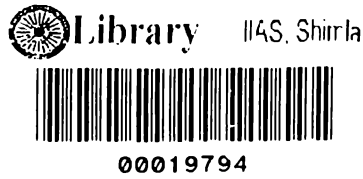

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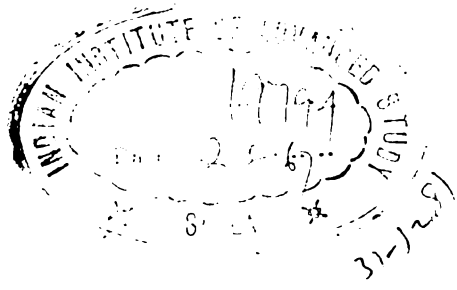

Introduction

> " The most incomprehensible thing about the world is that it is comprehensible. "
>
> ALBERT EINSTEIN

WE ARE happy to welcome you all today to participate in this seminar. We hope that all of you would find it convenient to participate on all the days and give us the advantage of hearing your valuable opinions on the subject.

Some time back when the idea of holding such a seminar on perception was raised, many friends and colleagues in the other departments expressed surprise that there could be anything common between philosophy and the pure sciences, more so in the field of perception. This is because, perhaps, many are under the impression that philosophy can have nothing to do with a scientific study of empirical things. Philosophy is a systematic, logical and empirical evaluation of human experience which would in turn lead to the postulation of a plausible theory explaining the intricacies and contradictions involved in such an experience. You will find thus philosophy is an ever-present search for a world-view in terms of human experience. Hence our interest in perception.

Usually the word perception means knowledge derived through all sensations. To the common man, this situation does not seem to provide any difficulty. We just open our eyes, and we ' see ' the object that is out there. Such a ' seeing ' gives us a knowledge of the characteristics of those objects seen—and this is a simple, effortless procedure which cannot give rise to any problems. All that we have to do is to explain as far as possible, using scientific methodology and measurements, how such knowledge arises. Such is the common opinion about perception.

But for the philosopher, there is much more involved in this than what appears at first sight. Even if we are all agreed on the facts of perceptual experience—which in itself is a very optimistic hope, it is in the interpretation of these facts in the light of the manifold of human experience that difficulties arise. That such an interpretation is necessary cannot be denied by any thinking man. Of all channels of knowledge to the human being it is the perceptual channel that is important and amongst these, it is the

sense-organ of visual perception that is most important, for it is this that immediately makes us aware of the seeming duality that is involved in experience. So we need a theory of perceptual knowledge with special reference to vision which would supply a sufficient answer to traditional and customary beliefs—and yet a theory which would be built on scientific and psychological findings. The postulation of such theories has hitherto been the function of the philosopher. But today, since the field is wide and the facts are numerous it is necessary for us to sit together to build a theory.

This brings us to another problem which is almost synonymous with the problems mentioned above and that is the problem of the relation between body and mind or shall we say, body, mind and soul? Perception seems to be a transition from one end of this triad to the other, whichever end we may start with. Awareness of the physical object by the self is linked up with the transitional changes in the electro-chemical activity of the physiological organs and the brain-cum-mind. But these in turn are somehow manipulated by the factors of motivation, learning, attention and recollection. Such a tangle has to be put in an order to present a possible theory of perception.

These, in brief, are the problems before us. Some are problems of explanation, some are of assessment and still some are problems involving an evaluational judgment of the trustworthiness of knowledge so gathered by sense experience. The experience of illusions, hallucinations, and chemically induced intensified sense-perceptions on the one hand, and the almost authentic account of extra-sensory perceptual experiences on the other hand complicate the problems to an almost maddening degree.

This then is the task set before this seminar and we in the Department of Philosophy fervently hope that we would arrive at an overall picture after due deliberations of this knotty problem of perception.

January 1964

SARASVATI CHENNAKESAVAN
General Editor

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Acknowledgments

We are grateful to the Vice-Chancellor and the Syndicate of the Sri Venkateswara University for their generous grant for the printing and publishing of the proceedings of this Seminar. Of course without the co-operation of many of the members of the staff of the various departments the seminar could not have been a success. We are particularly grateful to Prof. S. Parthasarathy, Professor of Psychology, who was not only constantly with us throughout the seminar but also very generously made available to us the recording equipment of his department. We regret very much that it has not been possible due to various reasons, to include in the publication the paper on the physicist's views about perception. However, we are very grateful to Sri Sreerama Murthy, Reader in the Department of Physics, for presenting a paper for the Seminar.

We express our sincere appreciation of the help rendered by Sri P. V. Ramamurthy, Miss C. Sampurna and Miss C. Celiamma in transcribing the recorded discussions.

We record our appreciation of the prompt manner in which Asia Publishing House agreed to jointly publish these proceedings along with Sri Venkateswara University.

Sarasvati Chennakesavan
K. Pampapathi Rao

PART I

1

Biochemistry of Vision

DR. K. S. SWAMI

LET US start where the physicist leaves off, namely, the retinal image. The retinal layer consists of visual receptors, rods and cones which contain photo-sensitive pigments. The image of the object focussed on the retinal screen manifests in the form of difference in illumination, spread on the retina. If the object has uniform colour, the light emission will also be uniform and the image falling on the retina will have equal illumination, affecting all the exposed receptors uniformly. The discrimination of different intensities by the retina is dependent on the extent of the photo-chemical reaction involved within the layer.

Today let us consider the nature of the photo-chemical reactions prevailing in the visual pigments, which result in visual excitation.

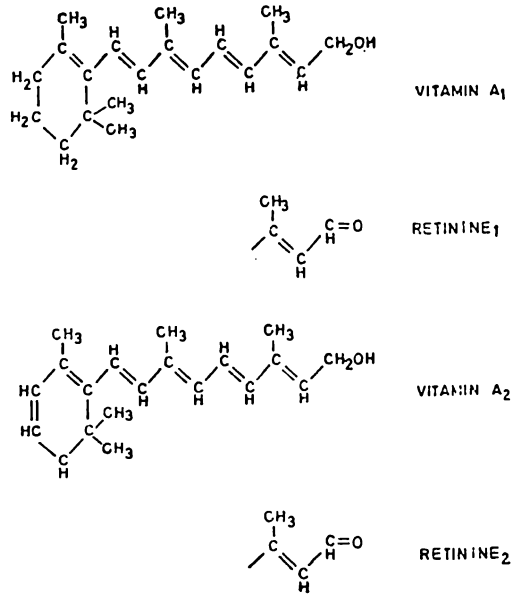


Fig. 1

These photo-chemical reactions gulf the incidence of light and visual excitation. Retina contains rods and cones which contain the photo-sensitive pigments. Rods are concerned with dim light while cones are concerned with bright light and colour vision. Both these structures contain retinine which is vitamin A aldehyde in combination with a specific protein opsin.

Two types of vitamin A namely A_1 and A_2 are found to exist among the visual pigments in its oxidized form. Vitamin A_2 differs from A_1 in possessing an extra beta ionone ring. These two types of vitamins, form retinine 1 and 2. With two types of opsin molecules, namely cone and rod opsin, four major types of visual pigments of vertebrate vision are formed.

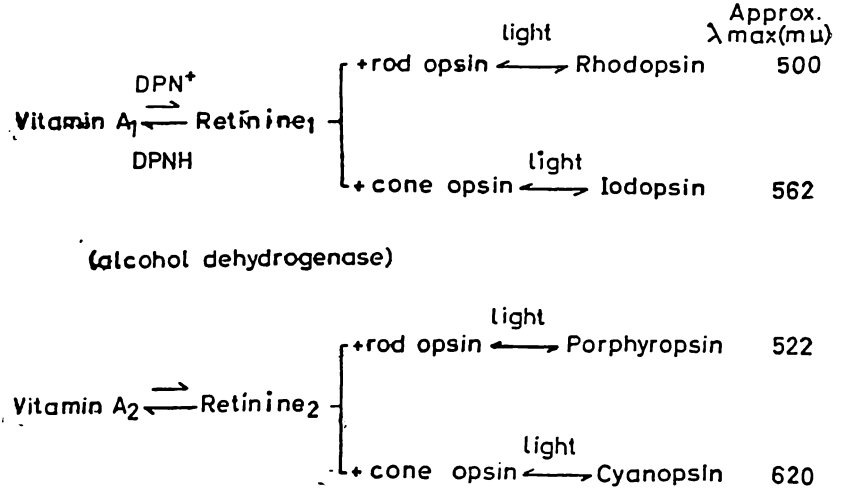


Fig. 2

The alcohol group of vitamin A_1 is oxidized to $retinine_1$, by alcohol dehydrogenase and NAD (DPN) giving a red pigment rhodopsin on combination with opsin of rods and violet pigment iodopsin with opsin of cone. Similarly vitamin A_2, on oxidation, forms $retinine_2$ which in its turn forms a purple coloured porphyropsin with rod opsin, and a blue pigment cyanopsin with cone opsin.

Among invertebrates, number of other types of pigments were detected varying only in the opsin molecule.

In general the pigments are bleached to colourless form in the presence of light, called light adaptation. In dark, colour reappears

and the process is called dark adoption. The dark adopted retina contains rhodopsin, which splits into retinine and opsin in the presence of light. The other pigments undergo similar changes in light adoptation.

These pigments can be isolated by mashing the tissues and hardening the rods with alum and extracting the fat with petroleum ether. The residue is treated with 2 per cent digitonin in water. The extractions are carried in deep red light, where rhodopsin is found insensitive.

On exposure to light rhodopsin yields an orange coloured transient product called lumirhodopsin. This step is the only photo-chemical reaction in visual excitation, while the chain of reactions beyond this step are ordinary thermal type. Lumi-rhodopsin is stable at temperatures below —50°C. If warmed to about —20°C it forms another intermediate, an orange-red pigment called metarhodopsin which is stable up to temperatures below —15°C. If this substance is warmed further in the presence of water, it is hydrolyzed to retinine and opsin. The retinine is reduced to vitamin A by the action of alcohol dehydrogenase and NADH.

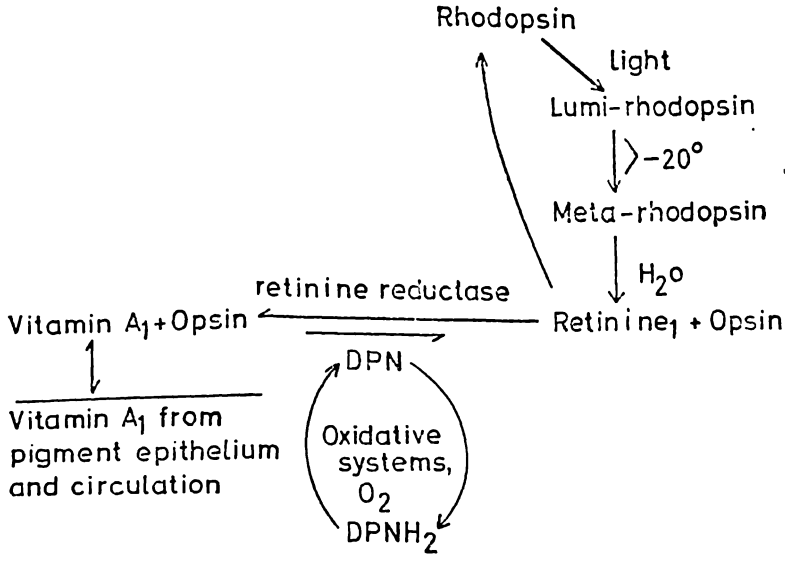


Fig. 3

Regeneration of rhodopsin involves two features, the oxidation of vitamin A to retinine and the combination of retinine with opsin.

In the interconversion between vitamin A and retinine, the rate of reduction of retinine will be greater than the oxidation of vitamin A. However, in the presence of an aldehyde trapping agent such as opsin, oxidation is accelerated.

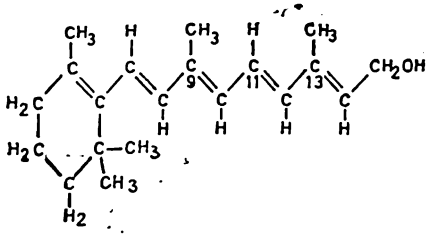
The combination of retinine with opsin is an exergonic reaction and hence it is spontaneous. By removing the retinine, it drives the endergonic oxidation of vitamin A. Soon after the conversion of opsin into rhodopsin, the reaction ceases. Vitamin A migrates from the pigment epithelium into rods and cones. The reoxidation of NADH to NAD requires respiratory enzymes of the retina and oxygen from blood, promoting the action of dehydrogenase towards the synthesis of retinine. The steps involved in bleaching of the pigments are similar to the synthesis.

Vitamin A is formed as an end product of bleaching and the vitamin going into the synthesis of retinine is not one and the same; one is a trans and the other a cis form. During the synthesis of rhodopsin vitamin A goes in cis form and comes out in trans form after bleaching. Hence isomerization of the retinine part of the molecule occurs during bleaching.

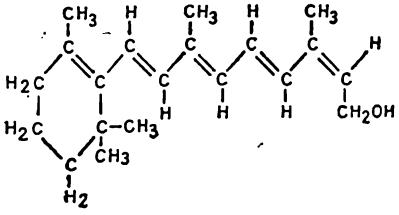
The trans form of vitamin A is a straight chain molecule while the cis form is bent. Pauling suggested that cis form can occur at 9 and 13th carbon atom which contain methyl group, without encountering internal steric hindrances. Cis isomer at 11 carbon atom will have to face steric hindrance as the hydrogen atom on carbon 10 would overlap with methyl group on carbon 13.

Hence the unhindered isomers are all trans, 9-cis, 13-cis and 9, 13 dicis. However, sterically hindered 11-cis isomer of retinine$_1$ or retinine$_2$, named as neo-b, is generally found in the retina.

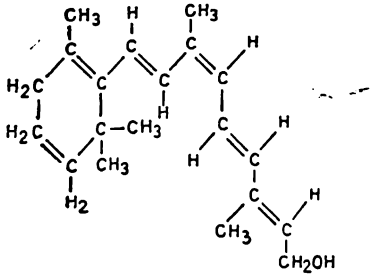
A solution of cattle opsin was kept in an absorption cell and a solution of 11-cis retinine in digitonin was added and quickly stirred. The spectrum was recorded. Neo-b retinine has maximum absorption at about 380μ and rhodopsin at 500μ. On incubation in dark the peak at 380μ decreased, while the peak at 500μ increased indicating the appearance of rhodopsin as a synthetic end-product. Then the solution was exposed to orange light and the spectrum was recorded at different periods of exposure. The process was found reversed. However, the



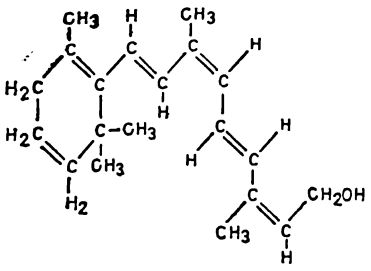
ALL TRANS. VIT, A



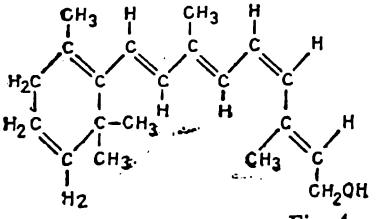
13-cis(neo-a)



9-cis(iso-a)



9,13 dicis(iso-b)



11-cis(neo-b)

Fig. 4

extinction of retinine at the end of bleaching was about 1½ times than at the beginning. This is because the trans isomer has molar extinction 1·7 times greater than the hindered 11-cis species.

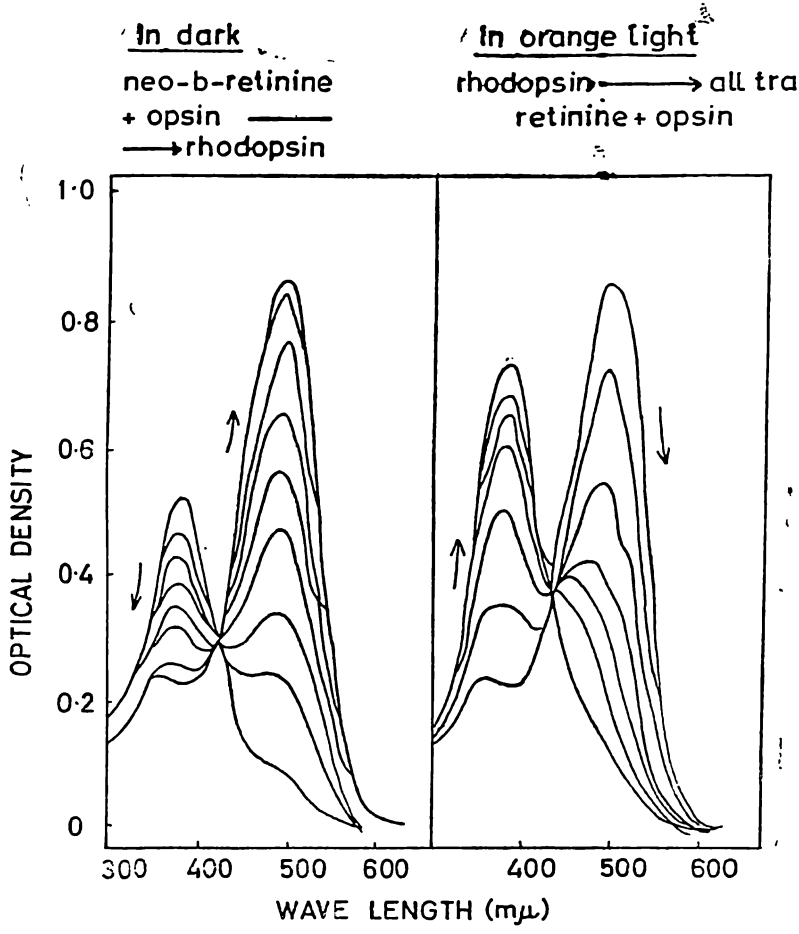


Fig. 5

Light converts all visual pigments into trans type while their resynthesis requires cis form. Hence the cis-trans isomerism is one of the basic phenomenon underlying the rhodopsin system.

Retinine contains a terminal aldehyde group which condenses with amino group of opsin in a schiff-base linkage. The geometric

configuration of the hydrocarbon portion of the molecule is important as it should fit exactly on to the opsin.

The association between 11-cis retinine and opsin can be illustrated as follows (Fig. 6).

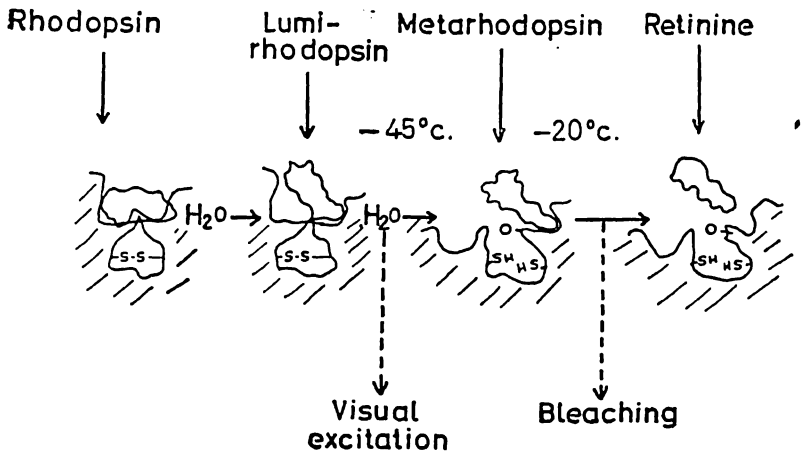


Fig. 6

Retinine is lodged tightly in a pit of dimensions suitable for bend cis-form in the opsin molecule. Underneath this pit, within the opsin molecule, there is a pocket which is tightly held together by SS bonds.

The shift of absorption maximum from 380μ to 500μ is due to the protonation of schiff-base linkage, during the synthesis of rhodopsin. A charge is introduced into the conjugated system which results in the shift towards the red. Ordinarily the protonation of schiff-base linkage shifts λ max from 380μ to 440μ. The negative charge of opsin draws the positive charge up into the conjugated system and enhances the resonance form of the chromophore.

It is very difficult to obtain natural pigments direct from the retina as they are present in extremely low concentrations as compared to the mass of protein present in the layers of the eye. It is possible to get one mg of retinine from a homogenate of one thousand retinae. Artificially, retinine can be prepared in a matter of few minutes in required quantities, by drawing vitamin A in petroleum ether through a column of dry powdered manganese

dioxide. The retinine obtained thus is relatively pure and similar to the original pigment in the activity but has shorter wavelengths than the natural ones, $\triangle\lambda$ max for rod pigments being 15μ and for cone pigments 50μ. Hence they are called isopigments.

At the time of bleaching, the pigment absorbs light quanta and isomerize 11-cis to all trans retinine, but remain in protonated schiff-base linkage to opsin, forming lumirhodopsin. The next step involves opening of the pocket in the opsin molecule, exposing SH groups (2 to 3 of them per molecule) by reduction of SS bonds and also one protein binding group, with pK about 6·6, forming metarhodopsin. The next step in bleaching is hydrolysis of schiff-base linkage, in the presence of water forming retinine and opsin.

If the scheme is right any treatment which affects the tight fitting of the retinine should bleach the visual pigments. When rhodopsin and isorhodopsin are bleached by heating and the opsin is denatured, 70 per cent of retinine emerged with 11 or 9-cis configuration and not in trans form. It is obvious that light alone can accomplish isomerization which results in ejection of retinine molecule from the opsin.

Visual excitation occurs in the initial steps in the process of bleaching i.e. during the formation of the lumi or utmost meta pigment. Hydrolysis of rhodopsin is too slow a process to account for visual excitation. Actually in squids and lobster bleaching ends only with metarhodopsin.

If rhodopsin is irradiated at about —60°C in glycerol-water mixture, the first quantum of light isomerizes 11-cis retinine to all trans form of lumirhodopsin. Absorption of further quanta at this temperature continues to isomerize, ending in a steady state mixture, 25 per cent of which is 11-cis, 25 per cent other cis isomers, and the rest trans. 11-cis retinine forms rhodopsin again. This rhodopsin is again converted into lumirhodopsin through isomerization of retinine by light. Similarly 9-cis also forms rhodopsin. All trans and 13-cis types which constitute half of the total pigment bleached, are hydrolyzed to retinine and opsin. When metarhodopsin is stabilized below —20°C and irradiated with visible light, a similar steady state is obtained. The light quantum efficiency of bleaching is only half as the first absorbed quanta which converts visual pigments to lumipigment, and the absorption of a second quanta undoes the work of the first quanta.

The carotenoids are better suited for visual perception than the other photo-sensitive pigments, as they possess straight chain

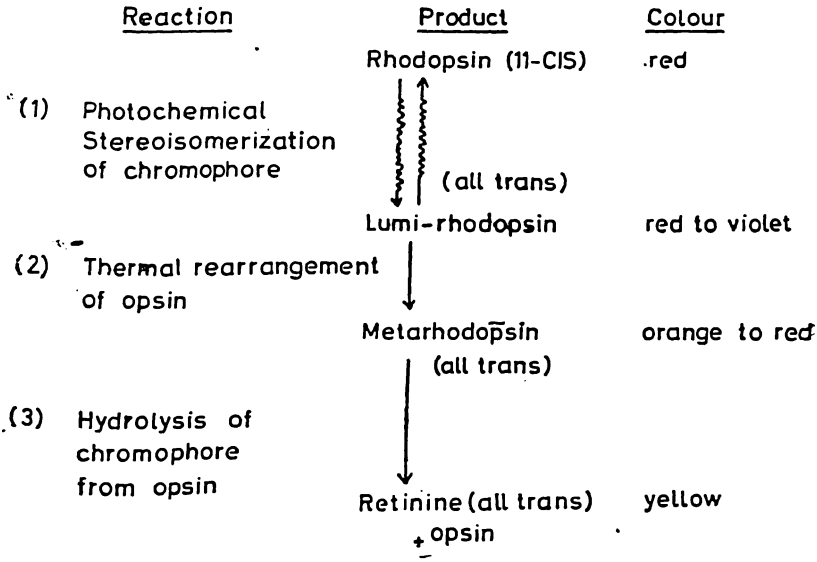


Fig. 7

conjugated systems, which can readily undergo isomerization. The other pigments on exposure to light will condense into rings, preventing isomerization.

Mollusca, arthropoda, and vertebrata are the only three phyla where the animals have well formed image resolving eyes, each one evolving in an independent line, with no genetic, anatomical or embryological connections. Strangely all of them have selected 11-cis isomer of retinine 1 and 2 in their pigments. They have selected an isomer which possesses the highest photo-sensitivity as it can be isomerized by light with highest quantum efficiency and changing from bent to linear shape on isomerization.

Right now we are faced with the problem of detection of the precise factor responsible for the initiation of the nervous stimulus or visual excitation. Some compound in the sequence of chain of reactions in bleaching process should initiate visual excitation. As it was known that initiation of the stimulus occurs in a fraction of a second, it is possible that the earliest steps in the bleaching process i.e. formation of lumi or even meta pigment, should have a role. The mechanism involved in excitation of cells in general

is not clearly established and the same thing holds good for visual excitation.

To start with, one quanta of light is capable of visual excitation when absorbed by a molecule of rhodopsin. When the illumination is intense and more than 10^2 millilamberts (field luminance), cones take up the job. In general, three possible mechanisms of visual excitation by the pigments are suggested.

One is that the impact of light into the outer segment of rods and cones can cause unimolecular hole in it, which results in local depolarization of a self-propagating type. Second one, is that the incidence of light activates zymogen, exposing the active catalytic centre. It is possible if opsin is the enzyme while the visual pigments are zymogens. However, these two mechanisms may not explain the phenomenon of quick visual excitation especially when continuous excitation occurs in the eye, as a puncture of a membrane or activation of enzymes in one hand and the return to normalcy on the other is a relatively slow process.

A third mechanism of activation is suggested by the author. It was observed that on exposure to light, the cis-form of pigment is converted into trans type resulting in the protrusion of the bent retinine part of the molecule, in the first step. Instead, the outer margin of the pit, in which retinine part is lodged, is being pushed outwardly so that the SS bonds existing between the ridges in the molecule, holding the pocket together are reduced, consequently binding some of the hydrogen ions from the free condition. Thus the inhibitory influence of hydrogen ions on the activity of potassium ions is removed, facilitating movement of potassium ions across the membrane, in response to the osmotic gradient. This process sets in depolarization accompanied by polarization, with the movement of another monovalent ion in the opposite direction, compensating for the loss of potassium. Recovery of potassium is an active process involving mitochondrial activity. The oxidative process, accompanied with mitochondria, has an added advantage, as this system can supply oxidized NAD (DPN). Hence the mechanism existing in the retina is a self-sustaining and independent unit to a considerable extent.

How is the retina capable of distinguishing between different intensities and colours?

Spectral sensitivity is dependent on the absorption spectra of the visual pigments, and the visual sensitivity (reciprocal of thres-

hold quantity needed for visual excitation) on visual pigment concentration in the rods and cones. The microelectrode measurements for rods and cones revealed that the spectral sensitivity is identical with the absorption spectra and the shift of spectral sensitivity towards the red, from dim to bright light involves the switching over from rod to cone vision. There is a parallel relation between the logarithm of visual sensitivity and photopigment concentration.

Cone adopts to light much more rapidly than the rods as the synthesis of iodopsin is quite rapid than that of rhodopsin, suggesting that the capacity of the cone is more than rod to bright and sustained vision. In general light adoptation increases the threshold for rods by 3,000 times. In rat, return to minimum threshold value in dark takes 2 hours, while in man it takes 45 minutes. During the dark adoptation sensitivity increases and in light it decreases. A relation has been established between pigment concentration and the threshold value. If 0·6 per cent of rhodopsin is bleached, the threshold value increases 3,300 times. It does not mean that further bleaching of rhodopsin will increase the threshold value further; in any case it will rise to 3,300 times only. Similarly at zero bleaching in rhodopsin threshold value is lowest.

To conclude one can say that a general picture of the mechanism of visual excitation and the associated photo-chemical changes is emerging at present. It may take some more time to establish the precise nature of the mechanism linking the stimulus inducing photo-chemical reactions and the observed response, namely visual excitation.

2

Neurophysiological Basis of Perception With Special Reference to Vision

K. PAMPAPATHI RAO

IN THE following account we will mainly concern ourselves with the electrical activity that occurs in the retina and at various levels along the optic pathway from the retina to the cortex in higher vertebrates. It has already been noticed in an earlier paper that a series of biochemical changes occurs in the photopigments in the retina when light impinges on the retina. These biochemical events lead to measurable changes in the electrical activity in the nerve cells situated in the retina and nerve impulses travel along the fibres in the optic nerve to the central nervous system.

Anatomical complexity of the retina

The retina of the vertebrate eye has a very complex structure as can be seen from the great studies of Ramon Y. Cajal and Polyak. In essence it consists of a layer of receptor cells (the rods and cones) connected to a complex nervous centre. It is not always easy to distinguish the rods from the cones, but recent electron microscope studies have greatly increased our understanding of the fine structure of these two types of photo-receptor cells. In man the rods greatly outnumber the cones. There are about 125 million rods while the cones number only 4 to 7 million. The nerve fibres in the optic nerve leaving the retina are only about a million. Therefore the rods exhibit considerable convergence and are far more integrative while the cones have a lesser degree of convergence and are more discriminative.

The rods are apparently designed more to serve as collectors of light in the dark and hence they are dominant in the eyes of nocturnal animals. On the other hand in predominantly diurnal animals increasing numbers of cones are found. But most eyes are mixed in this sense. The arrangement of nerve cell layers in the retina and the connections between them are very complex.

Between the receptor cells (cones and rods) and the bipolar neurons, there are the horizontal cells. These permit interconnections between cones and cones and rods and cones. The bipolar neurons themselves are all not uniformly similar. There are midget bipolars which may connect with single cones in the fovea or with a few cones in the peripheral region of the retina. The mop bipolars which have a dendritic tuft receive connections from rods or cones. The ganglion cells are again of two types, the giant and the midget. Besides these there are the cells which apparently are without axons, the so-called amacrine cells. These are highly organized forming five to seven layers in the inner plexiform network.

The retina, therefore, and especially the inner plexiform layer, is a complex nerve centre. It is not entirely self-controlled, but receives a projection of centrifugal fibres. Even the briefest path of transmission of information in the retina involves at least two synapses: receptor-bipolar; bipolar-ganglion cell. Besides this, due to differences in the size of the ganglion cells and the conduction velocities of their fibres and due to the slow conduction across the retinal surface, the impulses from the peripheral regions of the retina are likely to be delayed as compared with those from the more central regions of the retinal surface. These properties lead to a physiological situation in the moving retina where space co-ordinates may be transformed into time co-ordinates. Even in fixation the eye always makes small oscillations.

Nature of the electroretinogram

With suitably placed electrodes one can record a polyphasic mass response across the retina, which consists of specific cornea-positive deflections at the onset and cessation of illumination. Such a record is the electroretinogram (ERG). Usually it is obtained by placing one lead on the surface of the cornea and the other lead at an "indifferent" point on the body (in mammals for example) or at the back of the eyeball in such cases where the eye may be excised (as for example in cold blooded animals).

The ERG consists of an initial small negative dip (the a-wave) followed immediately by a positive wave (the b-wave). If the illumination is sufficiently high another very slow cornea-positive deflection occurs (the c-wave) and finally at the cessation of illumination a sharp positivity (the d-wave) occurs. The different

components of the ERG may be differently developed, in terms of size and rate of rise, in different eyes and also under different experimental conditions. Studies on ERG have been extensive and attention has mainly been directed at such problems as the differences between rod and cone ERG, splitting the ERG into its component parts, relation between the ERG and the optic nerve discharge, localization of the origin of components of the ERG in specific structures in the retina and study of the ERG in man from the clinical point of view. We will not consider in any detail all these in our present review.

It is generally assumed that the ERG is an algebraic sum of a component process of opposite signs occurring in the retina. The magnitude and pattern of ERG have been related to the intensity and duration of illumination and to the state of adaptation. Considerable attempts have been made to assign the origin of the ERG to definite structures in the retina. The studies of Granit seem to exclude the ganglion cells as sources of the ERG. Whether the receptors or bipolar cells are the source of retinal component potentials may be decided through the use of non-polarizable microelectrodes. However using such techniques Brindley comes to the conclusion that only the rods and cones contribute substantially to the a-, b- and d-waves of the ERG, while Tomita concludes that the same responses are predominantly localized in the bipolar layer, with contributions from other retinal layers. However Granit is not certain whether or not bipolar cells contribute to the ERG.

Activity in the optic nerve fibres

The impulse discharge from the retina as measured in the optic nerve, has been studied in considerable detail. The majority of the fibres discharge impulses on both the onset and the cessation of light. But some fibres respond only to the onset of light while yet others are inhibited by the onset of light and instead discharge at the cessation of illumination. Therefore the on-system and the off-system form two antagonistic systems in the retina, one of which is excited by light and the other is inhibited by light. Further, as we have seen above, there is considerable anatomical convergence from the receptors, through the plexiform layers to the optic fibres. This means that each fibre has a receptive field and this has been shown to be about 1 mm in lower verte-

brates such as the eel and the frog. But because of the variations in the degree of convergence, the dimensions of the receptive field also vary from fibre to fibre. Further it has also been shown that the receptive fields vary in width with the state of adaptation of the retina.

Compared to the other receptor systems, it is only the eye that has an intricate nervous centre just behind the primary receptors. In other receptors their first neural organization is located at the level of the spinal cord. Apparently this special situation in the eye is of great significance and since this "little brain behind the rods and cones moves with the eye it can because of its place in the retina aid better in the interpretation of the ever-changing boundaries of light, darkness and colour out of which the visual world is synthesized". The eye is always moving (even if it be ever so slightly) and if experimentally the movement is stopped and the image kept stationary, the image will fade out quickly. Movement of a point across the retina "will light up a trail of on-off sparks". These factors of course, have great biological and behavioural significance.

Retinal correlates of colour vision

Most theories on colour vision have assumed the existence of different kinds of cones containing photo-chemical substances capable of absorption of light in different parts of the spectrum. While such substances have not yet been isolated, it has definitely been proved in different types of eyes that the distribution of spectral sensitivity requires a minimum of three cone substances. Likewise recent work on human ERG definitely shows that the ERG contains components of different colour sensitivity. For purposes of electro-physiological analysis one has to consider two aspects of the problem viz. the primary sensitivity distribution of individual receptors and the representation of the same in the organized message delivered through the optic nerve to the striate area in the brain, which ultimately interprets the information. The latter problem (i.e. the interpretation) is at the moment beyond the reach of electro-physiological analysis.

The best quantitative data we have are the recordings from individual optic nerve fibres of animals. Based on such extensive studies of his own and other workers, Granit has proposed the dominator-modulator concept as a basis for the explanation

of colour sensitivity. The optic nerve fibres, judging from their responses, fall into two categories: some which exhibit a relatively broad band spectral sensitivity and others which are sensitive to a relatively narrow band of the spectrum. Different narrow band modulators may have peaks at different wavelengths, such as for example in the frog at 4,700, 5,300, 5,800 and 6,000 Ångstroms. In general the modulators predominantly fall into three regions as indicated above. But it is difficult at present to state with any degree of certainty whether these modulators represent the pure absorption curves of photo-chemical substances or are merely the products of neural interaction based on a minimum of three broad band curves. However, photo-chemical analysis has so far not indicated the absence of narrow-band photo-chemical substances in living retinae.

We have mentioned earlier that the inner plexiform layer receives the endings of centrifugal fibres. The actual place of origin in the brain of these centrifugal fibres is not known. But an array of antidromic stimulation of the optic nerve results in definite effects on the ganglion cell discharge of the retina. These effects can be excitatory or inhibitory or often mixed with excitation followed by inhibition. Whether the site of stimulation is the optic nerve, in the pretectal region or the reticular substance of the brain stem, the effect on the retina is similar. When it is excitation it results in greater impulse discharge by the ganglion cells between 'on' and 'off' and therefore the 'on' and 'off' differential tends to disappear. If the effect is suppression (inhibitory) the whole effect of light is suppressed. We have to have a great deal more information to fully understand the role of this centrifugal control.

The optic pathway

The optic nerve on entering the brain forms the optic tract which contains four groups of fibres. These reach the relay nuclei of the lateral geniculate, the pretectal area and the superior colliculus. Beyond these are the radiation to the cortex and the paths to the thalamus and tectal area and finally the projection areas — the cortical, thalamic and tectal projections. However, it is not easy to so delimit the visual system, since in addition there are the association areas.

Of the four groups of fibres in the optic tract, the fastest conduct-

ing groups relay to the projection area of the cortex through layers A and A_1 of the lateral geniculate. It is likely that sensation is mediated by this direct path to the cortex via these large fast fibres. The second group, which is the next slower set, synapses in layer B of the geniculate and through it relays to the lateral nucleus of the thalamus. The third and fourth groups go to the pretectal area and the superior colliculus respectively. However, no qualitative sensory differences associated with fibre size have been found in the optic tract. Even single shocks to the optic nerve, so weak as to activate only the large-fibre group, would induce complete cortical responses. The recordable responses of structures beyond the relay nuclei, instead of being mainly spikes, differ from those of the lower levels, in that " they are extended responses involving complex pictures of chains of neurons each link active in turn ".

The cortical response is exceedingly complex even to the simplest possible peripheral input. Activity, in the afferent radiation fibres which reaches the fourth layer of the cortex spreads immediately to the other cortical layers. The pyramidal cells are activated by the short axon cells of the fourth layer. When the pyramidal cells are sufficiently intensely activated, their dendrites conduct these effects to the surface towards their terminals and this produces the sequence of slow waves so typical of the response of the visual cortex. The dendritic contribution may act like a steady current stimulus to the cell body.

Activity can be noticed in regions other than the optic cortex itself. Thus, for example, similar activity like that in the striate area, can be recorded in the lower half of the medial wall of the suprasylvian gyrus, but the amplitude of such activity is about one-eighth or less of that in the striate area. Similarly there are areas of the cortex where an overlap of optic and acoustic cortices occurs. However, there is considerable localization in the optic cortex of responses to stimulation of different areas of the retina. In other words there is point to point representation of the retina in the cortex.

The dependence of certain characteristics of vision on the presence or absence of the striate cortex has been studied using operative procedures which involve removal or destruction of the occipital cortex or other areas concerned with vision. In monkeys in which the geniculostriate systems are eliminated the eyelid

reflex to photic stimulation is permanently abolished, but the pupillary reflex is retained. Conjugate movements of the eyes are not lost, but visual placing reactions are lost. Colour vision is permanently lost. According to Klüver brightness vision is also destroyed. Klüver's studies also show that a monkey without the geniculocortical system cannot distinguish between a steady source and source flickering at as low a frequency as 4 cps. Therefore it appears that the ultimate determination of the critical flicker frequency is in the cortex. Although there is considerable patterning produced in the retina there is thus still much left for the cortex to do.

A study of responses to colour at the cortical level again illustrates clearly the important role of the cortex in the perceptual process. Any animal might possess a well-developed spectral analyzer but it may not be capable of making use of it. For example the eye of the cat apparently exhibits spectral sensitivity and the cortex also responds differentially to spectral stimulation. But the overall behavioural response of the cat shows that the animal does not utilize the cortical differentials and it has not been possible to condition the cat differentially to photic radiation. Therefore although an animal may possess an eye quite like that of man it does not follow that in these cases there is the same colour experience as in man. Of course we know nothing of subhuman experience.

While the retina is an excellent analyzer on the basis of both photo-chemical and neural mechanisms possessed by it, the central mechanism also is an analyzer in a different sense. This is apparent from the fact that colour experiences can be predictably elicited even by non-spectral stimuli in man.

The above discussion indicates that for much of what is generally called vision we have to take into account central mechanisms that are not visual in the anatomical and morphological sense. Several such areas are usually called the association areas, but really they do not merely associate limited units of activity but actually participate in the overall differentiation of activity leading to what we call perception.

A Note on some Aspects of the Psychology of Visual Perception

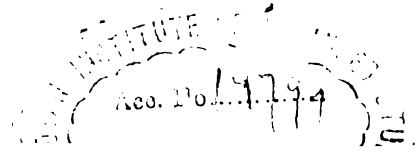
P. V. RAMAMURTI

MILLENNIA HAVE elapsed since the first living organisms appeared on this planet of ours. These organisms developed sensitivities to their environment through which they maintained contact with their surrounds and lived. As species evolved these sensitivities became highly specialized, complex sense-organs. The human organism, at the top of this evolutionary scale, has eight known sense-organs and a highly complex and organized structure, the human brain, to process and store information that is received. These sense-organs play a very important role in that it is through the information received thus the organism is able to live. The organism's knowledge of the environment is a function of its sensory equipment. The world appears to an organism the way it does chiefly due to the range of sensitivity and specificity of the sense-organ and the nature of the transducing mechanism therein involved.

The problem of perception, broadly stated, is how we come to experience and know the environment the way we do. This problem has been the subject of much thinking and research from a very long time and modern psychology has thrown much light on the understanding of perception. The information thus gained has been so vast that a study of its implications for a comprehensive understanding of perception seems to be a colossal task.

Our knowledge of perception comes from two sources. It comes from our objective observation of how it occurs in an individual as inferred from his behaviour and secondly it is got from our own subjective experiences. In any study of perceptual experience the organism is inalienably involved in that any such investigation itself involves perceptual experiences.

For purposes of convenience, we may divide the study of perceptual experience into: (*i*) the study of the nature of stimulus



variables acting on the sense-organs; (*ii*) the nature and mode of the transduction of this stimulus information by the sense-organs and onward transmission to the brain; and (*iii*) a set of dynamic internal states which determine the nature of the perceptual experience. Any understanding of a perceptual experience involves a study of all these aspects. Most of the existing theories of perception differ in the way they stress one or the other of the above-mentioned aspects. Some stress on the stimulus aspects like that of Gibson while others stress on the state of the organism receiving stimulation as is the case in Helson's Adaptation Level Theory.*

Physiological basis

An understanding of the process of perception is not possible without knowledge of its physiological basis. Light rays entering the retina are only a fraction of the amount of light reflected by the objects in the environment. This light strikes the retina after undergoing refraction at the lens. The image (more correctly a mosaic of light rays) is an inverse of the object from which it has emanated. Not all the light that is incident on the retina is absorbed by the rods and cones, the light sensitive structures. It is necessary that light quanta be absorbed by the receptor substances, the pigments, in order that they may be excited. It is likely that quite a few receptors may not be activated or some of them may be self-stimulated and this adds to the confusion of experience at liminal perceptions (13).

Nerve impulses generated at the retina are conducted to the brain via the geniculate body with off-shoots to the reticular formation. Unless impulses from the ascending reticular formation are diffusely discharged into the cortex the image is not sustained and appears disturbed. This alerting seems to be connected with the full awareness that results in our perceptual experience. Further molestation of certain parts of the brain stem produces loss of consciousness. It is also known that the impulses that pass down the descending reticular formation can restrain these impulses coming inwards (10, 12).

Much research has been going on in the study of physiological mechanisms involved in colour perception. Colour as we know

* Gibson: 'Perception as a Function of Stimulation', in Sigmund Koch (ed.) *Psychology: A Study of Science*, McGraw-Hill, 1959. Helson, H.: 'Adaptation Level Theory', ibid.

is the nomenclature given to certain experiences of light of differing wavelengths. There are a number of theories of colour vision and one of the more recent ones postulates the existence of three kinds of cones with their maximum sensitivities centering in the blue, green and red ranges of the spectrum (2). There are a number of other phenomenon associated with colour vision which I don't propose to deal with here.

Some phenomena of visual perception

Perception is not a passive process. It is an active process. It is exploratory and not merely receptive. The brain, it looks as though, determines the selectivity of stimulation. One can see this sort of activity when individuals are stricken with strong needs or severe anxious states, or other similar motivating conditions. The goal of perception seems to be to achieve clarity of the percept. The organism adjusts in order to get maximum meaning out of stimulation. When ambiguous stimuli are presented they are meaningfully interpreted under certain conditions (17). There is a strong tendency to resolve ambiguity into a meaningful percept. This tendency seems to be determined by the organism's past experience, present motivational condition and set.

Stimulation exhibits certain constancies. If stimuli did not possess certain invariant properties concepts could not be easily formed and our reaction to the environment would not be as orderly as it is and would become chaotic. The organism looks for relatively permanent features of environment to which it reacts. No doubt stimulus patterns vary from occasion to occasion. But these do possess certain invariant properties which sustain this variation. This has led to the study of the invariant properties that constitute stimulation.

We perceive, as we all know, by reduced cues. A broken outline of a human face is enough stimulus for us to perceive and understand it as a human face. As our experience with objects in the environment increases our cues become sharper and our reaction to these epitomes is as good as our reaction to the full-fledged stimulus. Now, what aspects of the stimulus complex become the cues for perception of that complex is an individual matter determined by the experiencing organism. Stimuli that have the same residual cues are often confused one for another.

I would like to digress a little here to say that a few of the Ames demonstrations like that of the rotating trapezoidal window, the chair illusion are so perceived due to certain similarities of cues that we use in perception of the stimuli created by these demonstrations and that of normal stimuli. So it is in the case of bisymmetrical figures, the cues for oscillation and rotation are one and the same wherein a rotating figure may appear to oscillate and vice versa.

Individuals differ in their reliance on the cues they use. It is also likely that different members may use different cues for the same stimuli. Thus since the cues vary from person to person and as each person's perceptual experiences vary each lives in his own phenomenal world. But to say that this would cause gross disagreement among individuals with regard to what they perceive would be a point stretched too far. The deviations are minor and generally we ignore them for the substrata is usually common. These deviations in cues become large when stimuli are human or social objects. These objects present different cues at different times. A soft, indulgent husband at one time may appear angry at another time and may appear totally indifferent on a third occasion. Hence our perceptions of these depend on chance and our percepts accordingly vary.

Stimuli may take on new and improved meanings as we accost them again and again. With every subsequent stimulation there is a feedback which may modify the percept or change the cue for that stimulus. This brings us on to a very important aspect of perceptual research, that of perceptual learning. Our perceptual meanings are mostly learnt. We learn the significance of stimuli. The new-born organism with certain specific needs may not have 'meaningful' perception of all stimuli. It is only gradually that stimuli take on meaning. The organism relates every new stimulus to some thing of its past experience or some of its outstanding needs and understands the implication of these stimuli. The richer its experience the complex the stimulus meaning. Unfortunately little is known of the nature of the experience of stimuli in the new-born infant. Now, if we mean by perception meaningful awareness of stimulation then can we call the infant's experience of stimulation as perception? The infant's first stimulus registrations do not of course contain the connotation that we as adults experience. Perhaps quite a few of the stimuli that the infant

may receive may not have any meaning at all. But a few others become meaningful as they possess a need reduction or tension reduction function for the organism. Other meanings are slowly built through learning.

To hold the extreme nativist or the extreme empiricist standpoint in the explanation of perception seems to be untenable. The Gestalt psychologists and their followers hold that many of the organizations of perceptions like pattern or form perception, are native to the individual. They have enunciated a number of principles governing this native organization of perceptions relating these mostly to cortical dynamics. It is interesting to note at this juncture certain experiments. Gibson and Walk have reported that the maturation of kittens in light is a sufficient condition for avoiding the deep side of a visual cliff. Similar behaviour is reported for children who have not had any experience or training to learn to avoid the visual cliff (5). These findings are not above criticism however. In the apparatus used by them the break in the chequered surface at the point of the cliff in the set-up used by Gibson might have created a strange and unfamiliar experience for the child or the animal and this might have inhibited the child from walking over the visual cliff. What at best the child or the animal might have noticed is a certain break in the continuity of the surface and not that the break involves a fall in the surface which when walked over may cause hurt and this is to be avoided. Thus it seems to me to be a doubtful evidence for nativity of perception of depth in the child. When I say this I do not mean that the necessary information is not present in the stimulation the child gets but that the child has to learn to make use of the stimulation property to understand that there is a cliff, which of course can come only through experience.

The perceptual system is a very adaptive one. The organism shows extraordinary ability to reorder its perceptual mechanism to suit a changed environment. We all know Stratton's classical experiment wearing glasses which inverts the image of the object even before it undergoes refraction at the optical lens. This makes the normally inverted image on the retina become upright. The result is that the subject sees everything upside down. But as days go by the subject who wears the glasses continuously is found to adjust well to the 'inverted world'. He sees things once again upright. Kohler had repeated this experiment with

similar results. The wearing of certain glasses create a difference of size in the two retinal images. Here again the subject has been found to adjust to the changed retinal stimulation. The question that confronts us in such findings is that how this adjustment is achieved and also how the usually inverted retinal image of the world is perceived upright. Kohler has tried to explain this in terms of conditioning but how exactly such conditioning takes place is not known (15). It is, however, plausible that we relate the upness or downness of an object to our body position and cues resulting from such positions. It should be, of course, interesting to study how one would react to an inverted world when tactual, kinaesthetic and all other cues are completely cut out leaving him only with the information available through the inverting lenses. In this connection it is important to note that 'upness' or 'downness' is a relative terminology given by us to a certain part of the living environment as we see it in the usual inverted way from birth. This does not as some would believe lead us to the error of considering the real down portion of the environment as up and vice versa. On the other hand we have nominated the head side or the sky side (whose image falls on the bottom portion of the retina) as 'up' and the floor side as the down side. In addition, in the adult individual the position of any object is judged in relation to other objects in its surrounds. Thus no intervening process is needed to set the 'inversion' upright.

Learning plays a role also in the phenomena of perceptual constancies. An object that is close by is judged as equal in size with that of an equal-sized object at a distance though the retinal images involved in the two cases are not of the same size. We do not base our judgment on retinal size alone. It could be experimentally demonstrated that when a near object is compared with that of a distant object of the same size with its adjacent frame-work cut out (by a reduction tunnel), the near object appears larger than the distant object.

Similarly depth perception is made possible because of the utilization of various well-known cues, monocular and binocular. One of the cues of importance for this is the one reported by Gibson, that of density gradient. It states that as we glance from the near to the far over a field or landscape the density of objects becomes more and more as distance increases (3). Thus

though the retinal size of an object nearby is larger than that of a distant object yet their relative sizes to other objects at that distance is the same.

Motivation, personality factors and perception

This is a very vast field and is the subject matter of a great deal of continuing research. Its importance cannot be over-stressed for much of what has come to be our personality is the outcome of knowledge gained through perception. This personality and internal states of the organism in turn determine our perception. A few of them we shall discuss. Ambiguous stimuli are interpreted dependent upon the dominant motive or set of the person. The more ambiguous the stimuli the more are the possibilities of personality and motivational dynamics entering into its interpretation. If the stimulus is clearly defined it has an impelling force on the individual to perceive it with the least amount of distortion.

Subjects deprived of food for long hours when asked to interpret vague shapes reported seeing food objects. Values also have been reported to determine the nature of perception. Poor people have been reported to over-estimate the size of coins. Though these experiments have since been repeated and some doubt has been cast on the claim of these earlier experiments it has to be conceded that values and interests do determine to some extent the nature of perception of these ambiguous stimuli! Similar are the studies that have come to indicate that certain words and figures that are threatening or offensive to the individual are perceived delayedly than are normal words — a phenomenon called perceptual defence. The term perceptual vigilance has been given to the phenomenon wherein certain words have been perceived more quickly than 'normal' words. Some later studies of these phenomenon had brought in factors such as familiarity, obscenity and certain personality aspects in explanation of the delay or the quickness of these perceptions (17). A few investigators have postulated certain subceptive factors involving a feed back mechanism that prevents the person from 'perceiving' and reporting what they see (7). To admit anything of a subceptive mechanism like this is difficult unless its regular presence is proved rather than inferred like this. On the other hand factors like attentiveness, set, seem to be easier and simpler concepts in the explanations of such phenomena.

The stimulus in perception

One of the basic problems which the perceptionist confronts is the definition of the stimulus in perception. What is the nature of the stimulus? Are stimuli just rays of light or are they patterns and arrays of light? Are stimuli only those that come from the external environment? Can we also include the so-called 'intervening variables' in a perceptual experience under stimuli? Are stimuli phenomenal? These are but some of the problems that one comes across. Gibson's conception, for instance, is that stimulus does not consist of mere rays of light but is to be understood in terms of surfaces, edges, shapes etc. For him the optical array of light impingent on the retina contains all the information necessary of the environment from which it has emanated. Single rays of light do not constitute stimuli. Instead, the flow of energy, the array at a mosaic of receptors is informative of objects. Stimulation is to be conceived in terms of higher order variables, patterns, surfaces, edges etc. Perception, he defines, is a function of stimulation and that this stimulation contains all the necessary information to determine perception (4).

The question now is whether this concept of stimulus is adequate in the explanation of a perceptual experience. How shall we deal with the so-called 'intervening variables' in perception of objects in general and in social perception in particular. It is of course possible that intervening variables or organic states may determine the selection of stimuli. But the organism's conditions and its past experience do determine the meaning of stimuli. The state of the organism, its past experience available for use at the time of stimulation and not the stimulus alone is adequate in the explanation of a complete perceptual experience. Helson's concept of adaptation level is a step in this direction. Nevertheless Gibson and his followers have opened new vistas in the understanding of new stimulus dimensions and thrown more light into our knowledge of a what constitutes a stimulus. But if we want and are looking for a complete stimulus-response causal link then we have to take into account the so-called organismic variables. Our difficulty, then, is primarily one of the delineation and quantification of these variables so as to give meaning to the equation $P=f(S, O)$ where P stands for the perceptual experience and S stands for the stimulus variables and O refers to the so-called 'organismic conditions'. It is this S and O that combine to

contribute to the phenomenality of the stimulus. Objects in the environment, as they are, do not become the 'effective stimuli' to the individual (by effective stimulus is meant the stimulus complex as taken by the subject). The pattern and content of 'effective stimuli' vary from individual to individual and to that extent it appears as though it is the individual who chooses his stimuli. It is this aspect that brings on difficulties in the delineation and quantification of the 'effective stimulus'. So long as we quantify stimuli along physical continua and in physical measures, I am afraid, we may not get a clear cause-effect relationship in explaining perception. The stimuli for perception are not purely physical. They are to be reckoned from the perceiver's psychological point of view. Stimuli are phenomenal and it is this that brings on difficulties of quantification of stimuli.** Stimuli are to be measured accordingly.

I would like to add to this brief and by no means complete account of perception certain well known studies in psychopharmacology. We all know the drug effect of LSD-25. It produces hallucinations of various sorts. The subjects report experience of various stimuli which we know do not objectively exist. Unfortunately we do not know how this drug acts in producing this experience (9). Apart from this we have certain reports made by Dr. Wilder Penfield and his associates that stimulation of certain areas of the cortex produces hallucinatory experiences. Certain other areas when stimulated bring back to his mind certain events that took place a number of years back. In these cases it should be noted that the subject 'really' experienced these 'stimuli'. They were real for the experiencing individual. Only *we* know as observers that there are no such things in the subject's environment.

The interest for the perceptionist in these above-mentioned studies is whether he should call these hallucinations also as perception. If we so admit, then, what are the stimuli? What is the nature of any psycho-physical relationship therein involved? As we know, there are no objectifiable stimuli involved in such experiences. Thus one way to escape the uncomfortable position is to define stimulus as a thing that is not only experienceable

** One wonders whether the equation $P=f(S, O)$ is satisfactory. So long as the knowledge of the stimulus comes from how it is perceived, as discussed above, it looks as though we may have to reverse the equation to read viz. $S=f(P)$

but also objectively verifiable and in turn define perception as the experience of a stimulus which is objectively verifiable. Thus whether perception has occurred or not cannot be determined purely from the report of the subject alone. An objective verification of the stimulus is to be made. What actually happens in the hallucinating subject perhaps is that artificial cortical stimulations (by drug or by electrical stimulation) set off certain electrical activity which is similar to that resulting from actual stimulation or that they stimulate certain traces of memory whatever be the nature of that trace. This perhaps creates an analogous situation to actual and normal stimulation. However, by this elucidation one does not escape from the need to either define perception in terms of an objectively verifiable stimulus or change his definition of stimulation to one that would make the brain activity as the stimulus for perception. In one case it is the real external stimulus which results in neural activity, while in the other the neural activity in question is directly produced by the drug effect or electrical stimulation.

The stand taken by the representative theorists is that they consider the neural activity, being a representation of the objectively found stimulus, as the cause of perception, this activity being at the near end of the causal chain connecting stimulation with perception. The question then would be whether there is a cause-effect relationship between cerebral activity and perceptual experience, involving a temporal relationship of sequence. R. J. Hirst has strongly argued against such stands and states that perceptual experience and cerebral activity are simultaneous events but yet they are not one and the same (8). This would lead us to ask whether awareness is different from cerebral activity or whether cerebral activity itself is awareness. This would take us into a new world of body-mind relationships where perhaps more speculation than facts exists.

There is a term used by some perceptionists, the term 'sense-datum'. I understand by this that those who use it may refer by it the penultimate stage of the stimulation-experience causal chain, the stage just before complete perception has occurred. This term appears to be an abstraction, and purely hypothetical, — a construct necessitated by the rationale that the mind identifies something that reaches it and gives it meaning. If we take this as identical with the 'pure percept' then I am afraid that it

can never be experienced and much less isolated and studied. It seems to be an unnecessary concept that has clouded much of our understanding of perception. As mentioned already, it is dubitable whether any such thing as a 'raw experience' exists. Even if it exists it is incommunicable. The moment we are aware of it and 'identify' it, a considerable amount of past experience and learning have entered.

It becomes difficult to draw the parameters of perceptual experience. For when a stimulus is experienced the identification and recognition of the stimulus involves or starts a series of associations which colour and modify the meaning of the stimulating object based perhaps on the neuro-physiological traces in the brain activated by the stimulus. Now, when does perception start and when does it end? Neurologically speaking could it perhaps be that perception starts when the stimulus starts activating the connected neural patterns and ends when such activity ends?

It is however necessary to have a more clear idea of the stimulus. The question being whether we should subsume under the head stimulus certain organismic factors usually indicated by the term 'O variables'. There is a dire need to re-examine the conception of the term stimulus. We should no more cling to the physical definition of the word stimulus. This cannot explain the why of perceptual experience. It is the phenomenal stimulus i.e. stimulus as seen by the subject, that is the real stimulus for his perception. This fact has already been mentioned. The task of psychology shall be in the delineation and the quantification of this stimulus. It is only under this condition that perception can be treated as a function of stimulation. We can then see a more meaningful cause-effect relationship between stimulus and response (by response I mean the report of perceptual experience). Then we can account better for how the same objective stimulus brings forth different meanings for different individuals. Strictly speaking they are not the same stimuli. They are different stimuli for these different individuals. If this is accepted and measurement of stimuli reckons with this fact things will become more clear. Stimuli are individual to an extent and are thus phenomenal in a sense. The organismic factors are to be suitably subsumed under the head stimulus. There can be only one cause and one effect in the ultimate sense. Unless these other factors

of stimulation determining perception are understood and quantified the causal chain of stimulation-perception will have many missing links. This is especially so in social perception or ego-involved perception.

Stimulation-perception is a continuous process. A very sharp line distinguishing them is difficult to draw. Such sub-divisions are artificially created and are arbitrary and matters of convenience. Further when we are perceiving a single stimulus we are also receiving stimulations from other objects in the same modality as well as through other modalities. Some of them are inhibited while others are accentuated. They carry in their wake a host of associations setting into activity a multitude of neural traces. Consciousness may be that activity itself for there are possibilities that every experience perceptual or otherwise has a neural concomitant. To hypothesize in this connection the existence of a knowing entity is beyond science. To say that such a thing does not exist is audacious. But science cannot be sterile. It tries to account for an orderly description and explanation of phenomena of experience. Its parameters are limits of experience (thought included) aided and unaided.

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4

Illusion and Perception

G. S. HERBERT

MAN, ENDOWED with the instinct of curiosity and placed in an environment with which he is in constant interaction and on which he so much depends for his existence and sustenance, is in constant quest of knowledge about it. Sensory perception is one of the important gateways of knowledge, and visual perception is said to be a more important means of acquiring knowledge than other sensory perceptions. In the course of acquiring knowledge, it is common experience that man sometimes gets false knowledge in addition to true knowledge. Illusion is a category of false knowledge.

In spite of being false knowledge, illusion is not without value for the following reasons: (*i*) One way of knowing what is right is by knowing what is not right or what is wrong. As a matter of fact there cannot be true knowledge apart from false knowledge, and the study of one naturally reveals the other. (*ii*) A proper understanding of illusion helps us to guard ourselves against such illusory knowledge. For example, the distant hill appearing as being smooth is an illusion. Such an illusion is due to the distance between the perceiver and the hill and the limitations of the human eye. When once we know it, thereafter, whenever we judge a distant object, we know in what respects we have to be careful so as not to be deluded. (*iii*) Illusion is a stimulus which keeps the individual in constant quest of right knowledge. For instance, when we know that we are mistaken in perceiving a rope as snake, and sometimes we do so perceive,we are constrained to know why a rope and a snake really look alike. Thus an illusory experience goads us to know what true knowledge is. Illusion, in a sense, is a window through which we can perceive what is not illusion or veridical knowledge.

Let us see what an illusion is. Illusion is " the experience and the result of misconstruing or misinterpreting some real sense

stimulus or stimuli".[1] In an illusion, physical objects appear to possess properties they do not have, or appear not to possess properties they do have. In other words, in an illusion, the way a thing appears is not in fact the way it really is.

Some of the noted examples of illusion are, 'rope-snake illusion', 'mirage', 'Muller-Lyer' illusions.

Very often hallucinations are also classified as illusions, which classification seems to be wrong and hence a passing reference might be made to them at this stage. Hallucinations are sensory perceptions in the absence of corresponding sensory stimuli. They are creations of one's own mind. For instance, in a visual hallucination a person sees things which are not present before him. Hallucinations differ from illusions in a very fundamental way. Illusions indicate inaccurate perception of the given object, whereas in hallucination, the external object is non-existent.

We may now consider the various explanations of illusion. These explanations may be classified as follows: (*i*) Physical, (*ii*) Psychological, and (*iii*) Logical or Philosophical.

(*i*) Physical explanations

Some illusions are explained as due to the result of the operation of physical laws. Such illusions are, 'mirror images', 'mirages', 'the bent stick in the water' etc. The laws involved in these illusions are laws of reflection or refraction of light rays when they pass through mediums of different densities.

Illusions due to defective or diseased sense-organs, in a sense, are of the same type. In such cases, physico-chemico-physiological factors are in operation. For example, a colour-blind person mistakes one colour for another due to the retinal conditions of his eyes. A person suffering from jaundice sees everything yellow due to the chemical condition of his body.

(*ii*) Psychological explanations

Psychologically illusions are attributed to (*a*) Habit and Familiarity. These factors come into operation when two objects have similar characteristics. Proof reader's illusion where a person mistakes one word for another is an example of this type. (*b*) Set and Expectancy. A 'situation set' is present when a person is expecting something. For example, when a person is

[1] *Encyclopaedia Britannica*, 11th edition.

searching for a missing thing, similar objects appear to be like the missing thing. 'Size-weight illusions' are of this variety. (*c*) Un-analysed Total Impressions. The famous Muller-Lyer illusions come under this head. In these cases, the total impressions of the figures or lines are taken as wholes instead of the (analyzed) details which we are to judge.

(*iii*) Logical or philosophical explanations

The philosophical explanations attribute illusions to a subjective factor primarily, but there are divergent opinions with regard to the role of the subject or self. The fundamental difference is between the Idealists and the Realists.

Idealists in general are of the opinion that illusion is the result of mistaking the mental as the material; of course it should be noted that they do not deny the existence of the thing independent of the mind. What they maintain is that taking an idea or some thing which is present as only in the mind to be the object existing outside the mind. For example, in the 'rope-snake illusion', 'seeing the snake in the rope' is purely a fictitious act of the mind but without realizing that it is so, when one thinks that there is actually a snake which moves and bites in front of him, he is said to be suffering from illusion.

The Realists on the other hand take into account the objective environmental conditions also in addition to the subjective factor. They admit the subjective element to the extent the defective sense-organs and other psychological factors listed above have a role in an illusory experience, and in addition they take into consideration the environmental conditions like the lack of proper light to explain an illusion.

In Indian philosophy, the Naiyayikas and the Mimamsakas (Realists) make a detailed analysis of the subjective element in an illusory experience. Let us illustrate their points of view with reference to the 'rope-snake' illusion. To begin with, the sense-organ comes into contact with a rope. Then, according to the Naiyayikas, the self thinks of a snake because of the similarities with reference to form between the rope and the snake. Actually the snake is not present in front of the individual, but somewhere else, say, in a jungle, and the snake in the jungle is perceived as being present in front of the individual. It is important for them that nothing which is not existent in the world can be

perceived. So, according to them, if a snake is not existent, it cannot be perceived even in an illusion. Hence they maintain that the 'snake' in the rope-snake illusion should be existent somewhere or other and they attribute perceiving it which is somewhere else as being in front of the individual by supra-normal contact. By supra-normal contact, the Naiyayikas mean other possible contacts except the immediate perceptual contact. For example, memory, inference and intuition are supra-normal contacts. They admit the role of memory in the supra-normal contact, but do not admit memory cognition. They speak of memory contact only which contributes to an experience of the 'rope-snake illusion'.

The Mimamsakas, on the other hand, hold that there is sense-cognition due to sense contact and memory cognition due to memory. They attribute error as being due to confusion that exists in the knower between sense-cognition and memory cognition.

In western logic illusion is explained in a similar way to that of Mimamsakas. Instead of memory cognition, they hold that the inference or interpretation is mistakenly taken to be the observed fact. In the rope-snake illusion, we interpret a rope to be a snake and instead of saying that there is a rope which looks like a snake, we say that there is a snake, and hence the illusion.

Having narrated the various explanations of illusion, it might be pointed out by way of general observation that every explanation has its own merits. There is no explanation which can claim to explain all types of illusion and there is no explanation which is entirely right or wrong or useless. As Lean says: "There is no single concise rule of thumb which enables us to decide in all cases as to whether our judgments are veridical or not. Rather, each case, or at least each type of case, must be decided in terms of its own peculiar circumstances".[2] So, it seems to be correct to hold that a given case of illusion can be explained only by taking into consideration all the factors involved in that case. For instance, there is no use of going to philosophical explanation to explain a mirage, which illusory experience is sufficiently explained by the operation of physical laws, whereas a rope-snake

[2] Lean: *Sense Perception and Matter*, p. 132.

illusion can never be satisfactorily explained by physical laws alone and we have to take recourse to psychological factors and philosophical explanations.

However, it does not mean that there are no physical factors involved in the case of the 'rope-snake' illusion. Improper light may sometimes contribute to a 'rope-snake illusion'. But it is not always so, and there are other factors like a set, prejudices etc. which contribute to such an illusion. In other words, 'mirage' is an 'universal' illusion, whereas 'rope-snake illusion' is not so. It is universal as the operation of physical laws are the same for all men.

What is important for us in this paper is to see the light which illusion throws on perception. An experience of illusion is an experience of perception. So an analysis of a situation in which illusion occurs and the study of it should naturally help us to understand a perceptual situation and perception.

Every act of illusory perception involves: (*a*) the subject or the self, (*b*) the object, and (*c*) the process of perceiving the object by the subject.

First let us consider the nature of the subject. The psychological and philosophical explanations of illusion show that the self is active but not passive in the process of acquiring knowledge. The mind does not seem to receive the impressions as a *tabula rasa*, but interprets and builds knowledge. An illusory perception involves inference. The subject goes beyond what is given in the sense data to perceive the object as it appears to be. This inferential process definitely shows that the subject is active in perception.

Further illusion essentially belongs to the subject. It is the subject who suffers from illusion the object being what it is. Whatever might be the factors involved in an illusory experience and whatever might be the explanation of such an experience, it seems to be beyond doubt that illusion belongs to the subject. If so, perception too belongs to the subject and there seems to be no gainsaying the fact that the subject has an active role to play in the process of perception. This active role consists in constructing knowledge from the data it gets from various sources. (This point is further clarified in the consideration of the other two factors in a perceptual situation.)

Let us pass on to consider the nature of the 'object' as revealed

by a study of illusion. At the outset, we should make a distinction between the 'illusory object' and the 'object' which is the subject of illusion. In the rope-snake illusion, 'snake' is the illusory object and 'rope' is the object of illusion.

First we shall think of the illusory object. The subjective idealists, classify the 'real' objects and the illusory objects in the same category. According to them all objects are creations of the mind and do not have an existence of their own.

All the rest of the thinkers admit that the illusory object exists out in space, and the 'illusory object' of course is a real object from another point of view. Several Indian thinkers especially say so. The Mimamsakas and the Vedantins hold that the illusory object exists then and there and the Naiyayikas maintain that it exists, though not then and there, somewhere else.

However, the modern realists in the west give the illusory object a status of its own. Following their principle, "Everything that is, is and is as it is",[3] the illusory object is not considered as a subjective fiction, nor is it given the same status as the veridical object. They say that it subsists. It does not exist as the real object in space and time but subsists in a realm of its own. This subsistence is not conferred on it by the mind.

By postulating a world of subsistence, the modern realists want to indicate that "— the unreal and the illusory are as objective and independent of experience as real objects of the world".[4] Perhaps the world of subsistence might be granted, but it cannot be denied that the illusory objects are dependent on the subject. The neo-realist is quite right in pointing out that the illusory object does not exist in space and time, but they do not seem to be correct to hold that they are independent of the mind. In cases where the illusions are not due to physical laws in operation, the illusory object definitely depends upon the subject.

Further, finding a place in the world of subsistence for the illusory object seems to be mistaken and even unnecessary. The illusory object by being made to be subsistent goes beyond space and time and gets the status of an eternal which status appears to be quite unwarranted. As a matter of fact, the illusory object

[3] Chatterjee: *Problems of Philosophy*, p. 80.
[4] ibid.

disappears the moment veridical knowledge is obtained. Moreover, the status of the 'illusory object' differs from that of the veridical object and it has no real existence as the latter. It does not exist anywhere in space. But, in a way, it can be said that it has a temporal existence in so far as it is taken to exist till it is sublated. Perhaps the question of its existence is meaningless. However we might say that the 'illusory object' has no epistemological status i.e. the status of knowledge. In Indian Philosophy a distinction is made between the self (knower) and the mind, the instrument of knowing which helps in acquiring knowledge. And a further distinction is very clearly drawn in the stand taken by the Naiyayikas when they maintain that the knower is never in the wrong. The rightness or wrongness belongs to knowledge but not to the knower. This seems to be a very correct position and we might say that the 'illusory object' belongs to the domain of knowledge.

Passing on to the status of the 'object' which is the subject of illusion, an analysis of illusion reveals that there are no unique, individual particulars. For, if one thing is entirely different from another, one can never be mistaken for another and there would be no illusion at all. But illusion is a fact of experience. So, we find that the particulars cannot be classified into water-tight compartments.

Particular objects seem to be bundles of universals. The universals cut across the particulars as the genus cuts across the species. The universal characteristics pervade all things in gradations. Individual differences are due to the differences in the degree of the possession of the universals. There can be infinite degrees of such differences in the possession of universals which gives rise to an infinite number of particulars. That is why in perception we suffer from illusion and mistake one thing for another, and it is true also that in an illusion, one 'stumbles into subtle truth'. Ultimately all things come under the universal of 'existence' or 'subsistence' and finally under 'being'. Such is the world of objects in brief as revealed by a study of illusion.

Coming to the process of perception, it is obvious that it is an active process. Perceptual knowledge, as already said, is a product of the constructive activity of the perceiver. In the process of perception the subject receives the sensory stimuli, and goes

beyond the stimuli to perceive the object. Stimulus is the 'sign' and we perceive the 'meaning' of it. It is evident from the fact of illusion that the object is not directly perceived. If it were so, all knowledge should be veridical, which unfortunately is not the case. For an illusion to occur, the stimuli may be defective or the subject may be 'defective' or both. All this clearly reveals the following points which may be briefly stated as follows:

(*a*) The process of acquiring knowledge is not direct but indirect i.e. the object is not directly known;

(*b*) The object is not a fiction of the mind but, in a sense, a construct of the mind. Knowledge of the object is a complex consisting of the sensory stimuli and the self.

Finally, 'illusion' takes us to the problem of the test of true knowledge. It is a fact that there is illusory knowledge as distinguished from veridical knowledge. If it were not so, both of them would lose their meanings. But how do we distinguish illusory knowledge from true knowledge.

It is said that knowledge which is sublated or given up later is illusory and that which is not sublated is true knowledge. But there again the question would be on what grounds do we give up some knowledge as illusory.

There is the correspondence test according to which, if the idea or knowledge corresponds to the object, it is true, otherwise false. In the case of the rope-snake illusion, the 'snake' in my mind does not correspond to the object in front of me and so it is given up. But here again the question arises, how do we know that it does not correspond. Obviously it is by further observation, going near it and if possible contacting it with a stick and so on. In doing all this, we seem to be trying to see whether the object before us behaves like a snake or not. If that is so, it would be a pragmatic test but not correspondence.

Then there is the coherence test which requires that the idea should cohere or fit into the system of knowledge. Here again the same question arises, how do we know that it coheres or not. It seems to be possible to do so by a pragmatic test only.

Then, what is this pragmatic test? According to the pragmatic test, workability or practical success is the test of truth. For example, if the object behaves like a snake, and if it produces all the effects in the environment as a snake, it is a snake, otherwise

not. But the pragmatic test suffers from several defects. If it is accepted, knowledge becomes solipsistic, for, what works for one may not work for another.

Further, truth does not depend upon workability; but workability depends upon truth. The object before us works as a snake, for it is a snake. Hence workability or pragmatic test does not seem to give us the truth.

Moreover pragmatic test does not tell us anything about the nature of the object. It only gives us its use.

Right knowledge is not efficacious knowledge as the pragmatists think. As a matter of fact, sometimes a piece of knowledge might be efficacious but false. It is so when a person actually flees from a rope thinking under an illusion that it is a snake.

Therefore it appears that there is no reliable test by which alone we can differentiate true from illusory knowledge. What is ultimately true knowledge is a transcendental problem. But from an empirical point of view, perhaps it is right to hold that what is given to normal man under ordinary circumstances is true knowledge. If at all a test is required, it might be said that the uncontradicted knowledge is true knowledge. Thus all knowledge unless otherwise sublated has the claim to be true.

We may sum up as follows: Illusion is a fact. There are various types of illusions and various explanations of them. No one explanation seems to be adequate to account for all the types of illusions. A study of illusion reveals that the subject is active in the process of perception, which process is indirect and complex, and that the status of the illusory object is indeterminable and that a particular thing is a bundle of universals. There is no one test of truth to distinguish between illusory and veridical knowledge. Truth of knowledge lies in not being contradicted.

5

A Philosophical Appraisal of the Theories of Perception

SARASVATI CHENNAKESAVAN

TODAY, IN order to construct a comprehensive theory of perception, it is necessary to have at least a good working knowledge of the following subjects, epistemology and the philosophy of sense perception, neurology, neuroanatomy and neurophysiology, psychiatry, and psychopathology with particular reference to the effects produced by the hallucinogenic drugs, anthropology, physics and experimental psychology. Since no man can be in the know of all this, at least a few of this are absolutely essential for an evaluation of perceptual knowledge and these are, philosophy, epistemology, neurology and physics. I confess, that I do not possess even this basic necessary knowledge. So my theories may be partial, incomplete and even exasperating to some of you. So I have to request you to bear with me.

There are many ways in which man acquires knowledge. Some of them are inference, presumption, analogical thinking, verbal testimony etc. Most of such ways of acquiring knowledge are dependent on a more fundamental process which we normally call the perceptual process. Now, perceiving is to become aware of something that is other than the process of perception. That is, perception is a tool which gives us a knowledge of things which are other than itself. *Ex hypothesi*, therefore, perception is the fundamental means through which we come to know the nature of the external world. Even here two questions arise. We have to ask, whether it is possible to have a knowledge of the external world and if it is possible, how do we know it is true knowledge? Philosophy studies the processes of perception, primarily to answer these two questions and all efforts are directed to this end.

There are three facts involved in visual perception i.e. in seeing an object. The outer limit is the object; the inner limit is the self that is consciousness and the third thing is the relation between these two limits. All the three are important factors, for there

can be no perception without any one of them. I would call them the least common factors of all perceptual activities. Before going further, I would like to define my terms. *By object* I mean that which is *apparently* the source of my sensations. Such a source may be external or internal. Such a source, must in addition, give rise to a content and significance to words, used ordinarily. For example, when I use the word 'table' or 'nose', these words not only act as sources of sensations, but they also give a content and significance and meaning to language words. By *self* it is to be understood as that conscious awareness for which significances, meanings and contents exist. *A relation between these two termini* in knowledge may be a physical external relation and or a logical internal relation such as identity, inherence and organic relations. Depending on the emphasis given to these three factors, various theories have developed with regard to the whole process of perception. I am not here so much interested in the theories as such, but more in the evaluation of these three terms in the light of the physical, chemical, and neurological evidences that we have been able to gather so far.

Let us take the object first. It is the most elusive of the three factors. The object as understood by the common man as having colours, extensions and weights is not the object as the physicist sees. To the physicist the object is atomic particles and wave motions of energy. If we start with the definition of the common man, we never get anywhere, since, such objects can never get into our brains for us to know them. If we start with the object as the physicist sees it, we are constrained, somewhere or other along the route, to explain the common man's ideas of the object. We cannot dichotomously keep these two in two different pigeon holes and conceive of a theory of perception. To quote Russell: "We think that grass is green, that stones are hard and that snow is cold. But physics assures us that the greenness of the grass, the hardness of the stones and the coldness of the snow, are not the greenness, hardness and coldness that we know in our own experience, but something very different. The observer when he seems, himself, to be observing a stone, is really, if physics is to be believed, observing the effects of the stone upon himself. Thus science seems to be at war with itself. When it most means to be objective, it finds itself plunged into subjectivity against its will. Naive realism leads to physics and physics, if true, shows

that naive realism is false." Hence the question; how do I know this object? involves the prior question, how do I know that the object exists? These are interdependent questions and in answering one, we may stumble upon the answer to the other.

Let us start with the object as the physicist sees it. They tell us that the so-called solid, three-dimensional object is received by the retinae in the form light incidences. These energy incidences are in the form of quanta or energy particles. After certain chemical reactions this energy becomes transformed into neuronal energy which is not directly measurable, but only indirectly through cathode-ray graphs. This neuronal energy, after traversing various pathways, reaches the visual cortex where due to the excitation of the visual ganglia, 'perception' takes place. This 'perception', evidently is again of the nature of the object as a three-dimensional, solid, coloured, shaped object, for this is what we perceive. We, as philosophers, cannot and will not challenge the accepted experimental evidences of the physicist, bio-chemist and the neurophysiologist. But, I suppose, we have the liberty to critically examine such evidence and show any logical lacunae which may exist and also judge whether the conclusions drawn from such evidences are warranted conclusions.

The first point, therefore, which I wish to discuss here is the status of the object. The evidence of the physicist goes to show, that we know of the existence of the object, only through the excitation that results in the retina due to the incidence of the light particles. Accurate measurements and experimentations are cited in support of the externality of the object. The object as such is 'given'. But such 'givenness' is dependent on the retinal activity because the measurements cited are also retinal activities, since they are knowable only through the activity of the visual sense-organ. Hence it is a circular argument to say that one form of sense-activity namely measurements and experimentations can conclusively prove another form of sense-activity namely perception of the object as coloured, shaped and with depth.

The word 'given' may be used and understood in another sense. It may be interpreted to mean a psychologically objective compulsion and lack of subjective freedom. That is, if there is a tiger in the room, I do not choose to perceive it, but I am made to perceive it by the impact the object has on my sense-organ. Such

a compulsion is no doubt a fact, but it is not an objective compulsion alone. The subject's psychological processes and conscious understanding of the meaning of the percept have as much an important role to play as the fact of the existence of the object. Unless we can determine how much of it is subjective and how much of it is objective contribution to the combined act of perception, it becomes impossible to say what part the object plays in perception. It is because this separation is not possible in the present state of our knowledge, the problems connected with illusions and hallucinations become very important for us. Subjectively speaking, if the brain-cum-mind can misinterpret a seen object as something else, or imagine seeing things where none exist, it becomes, indeed, very difficult to judge the extent of objectivity in perception. There the question about the nature of the object becomes propelled into the question: Is the object really as we perceive it?

Thus coming back to the object, we are now in a position to say that the object as perceived is not the same as the object which we are supposed to perceive. What the cortex registers is only neuronal impulses in the form of patterns, whereas what we perceive is the object which has form, colour, beauty etc., and gives rise to logical and emotional satisfactions. But such interpretataion is not entirely free, as we do not perceive 'green, where there is 'blue', nor a circle as a square. Is there any reason for this limitation, as objective compulsion is not responsible for any such limitations? All that we can reasonably say is that it is our perceptual understanding that fills out the details and gives a form and a content to the data supplied by the physiological organs *and not vice versa*. Thus this double-edged sword of perception does involve a reference to reality as the object, but at the same time it also refers to the important factor of conscious thought which is manipulating the physical and the physiological processes right from the beginning.

This brings me to the most persistent question regarding the nature of the object in visual perception. First let me discuss the nature of the image on the retina. As we have hitherto seen throughout this seminar, there is no scientific evidence to show that the image at any time, corresponds to the actual object. I say this, because, in the first instance, we have no way of establishing such correspondence. Even if there is any, since we

cannot know the object in any other way except through the retinal stimulation, no correspondence can be truly established. But the inversion of the image is established by analogical experiments of the behaviour of the light rays and their focal points when they are passed through double convex lenses. Now the question is, what is our knowledge of the object vis-a-vis the inverted image? If at some time or other, there is no reinversion of the object, it means we are all living in a fool's paradise, viz. an inverted world. Hence to review the position of man's experience of the world of objects with reference to the retinal image becomes imperative to a philosopher. Somehow or other reinversion must be made possible, or we must accept the fact that all our knowledge bears no relation to objects as they exist.

Such reinversion can take place at two levels. First it can take place even before the light rays reach the retina and form the so-called inverted image. Secondly, such reinversion can take place sometime after the neuronal impulses leave the optic nerve. At this juncture, like the detective in crime stories, I venture to put forward a theory of reinversion, which is very much subject to correction. Firstly, we all know that it is not a single light ray that reaches the retina. It is a band of light. Such a light is in the form of energy units. These units or photons are all qualitatively alike and their movement is one of random haphazard movement. Hence in their rambling, tumbling movement successive processes of inversion and erection of the original pattern *can* take place. Thus, perhaps, by the time the light quanta reach the retina and converge to form the image, they are already in an erect position and not in an inverse position as is assumed usually. I make bold to hypothesize like this because many of the so-called facts of retinal images are purely analogical inferences as I have already pointed out. Even the theory that light travels in straight lines is only a hypothesis. So in the light of these assumptions, one more assumption to give a logical explanation to establish the veracity of human experience may be acceptable. Secondly, that the same tumbling of impulses may cause an erect pattern of the inverted image after they leave the optic area and by the time they reach the cortex, may also be a plausible explanation.

Both the scientists and the psychologists have been resisting even to consider the possibility of any such explanation of the

visual process, because the scientist says, what does it matter how the image is, provided the end product, namely the percept is accepted as the real object by all. The psychologist, goes a step further and says that man is capable of learning many things and one such learned activity is to read the inverted image as the erect image and language which is the vehicle of such learning helps him as the starting point here. In other words, language patterns, which are learned patterns, help to habituate man to see the inverted image as the erect one according to the psychologist.

I think both are very naive ways of explaining the situation. There are two fundamental objections to this. Logically speaking, learning, by its very definition is not an automatic mechanical process. It must start somewhere. One learns and makes others learn from such previous experience. Before physics put forth its analogical inferences regarding the inversion of the visual image, man did have experience. Does it mean that the pre-physics behavioural patterns are different from post-physics behavioural patterns? Otherwise, I am not able to understand what is meant by learning by experience.

Secondly, the erect position of the object with reference to the inverted image on the retina is not a learned process, for there are other physical laws such as gravity which accept a certain pattern and form and size for the object. Newtonian physics which is what we follow for all practical purposes, gives us the position of the object with reference to other laws apart from our retinal image. Then again man learns to live with illusions because they are pragmatically valid. If this is what is meant by learning, then I am prepared to accept their position.

This takes me to an important assumption with regard to the existence of the object. It is agreed by scientists that what we call as 'the object' is only the neuronal impulses, with a pattern. We never have a representation of the object, but always something which is not the object. Shall I say then, that we never have proper perception, but always a misconception? What is not solid and three-dimensional morphologically, is really perceived as a solid and three-dimensional object. Again what are not colours and shapes are perceived as colours and shapes. Why is this so? Why is there this misconception? One explanation given by scientists and psychologists is based on the empirical causal theory of sense-data. Sense-data cannot occur by themselves. They

have to have an external source other than the human body. But unfortunately this sense-datum theory assumes much. It maintains that although sensations cannot be caused by anything internal, still the externality of the source cannot be guaranteed. The neurophysiologists are better. They say, as far as our ground is concerned, the source for the sensations must lie outside the neuronal impulses since there is nothing within them to explain sensations. Such externality is said to become possible by what is known as 'projection technique'. It is admitted that there is no experimental evidence for this. Let me elaborate this point. The word sense-datum is now so frequently used that its meaning is taken for granted. However, for our purposes, I would like to define it as those things that are immediately known in perceptions such as colours, sounds, smells etc. Or it may also be defined as C.D. Broad does "as the objective constituents of the perceptual situations" (*Scientific Thought*, London, 1923, p. 243). The physiological theory of the projection of sensations, maintains that although the rousing of the sensations occurs in the cortex, they are not exactly known to belong to the cortex. The patterns that are formed in the visual cortex may be said to have only *two* functionally important states; that of discharge and that of rest. In other words, it has to be emphasized that the brain can only do basically one thing and that is to form extremely complex and ever-changing spatio-temporal patterns of neuronal impulses between fluctuating potentials. These are not therefore sensations. Hence neurologists and psychologists project these sensations outside the body and say that sound comes from the bell and light from the lamp etc.

There are many objections to this theory of projection. The most important ones are: (1) There is no evidence from physics for this. That is, the projection itself cannot be a physical process. It is also shown that neither nerve cells nor fibres, neuronal impulses, radiation, nor any chemical, electrical or physical activity of any kind is projected from the cerebral cortex into the external world.

To get out of this difficulty it is maintained that such a projection is a psychological concept of learning. This implies, and I am subject to correction, that in the child the senses are actually in the brain, but at sometime during the course of maturation these senses leave the brain and get projected into external space. The basic fact of such a projection would then have to be that

the first and last members of a causal chain must be identical events. "Whoever accepts the causal theory of perception is compelled to conclude that percepts are in our heads, for they come at the end of a causal chain of physical events leading, spatially, from the object to the brain of the percipient. We cannot suppose that, at the end of this process, the last effect suddenly jumps from the starting point like a stretched rope when it snaps" (Russel: *Analysis of Matter*, p. 320). Since we cannot imagine any such jumping of the effect to the cause, this theory of the projection of sensations is not acceptable. Perhaps all that we can mean by such projection is the fact that the physical and the physiological factors owe much to the brain-mind for their being interpreted as 'object'.

Thus we find that from every point of view, be it the physical, the physiological or the psychological, the status of the object and its relation to the knowing self is not satisfactorily explained. Some of the logical lacunae that I have raised so far become resolved if we look at the processes of perception from the point of view of Indian Philosophy.

I have already mentioned that the brain-mind has to play a dual role if we are to explain properly the processes of perception. It not only has to account for the physiological processes, but also has to explain the factors of selection, attention and interpretation. It is for this purpose that the Indian philosopher introduces the concept of the self as conscious awareness. According to most Western thinkers, whether they be psychologists or scientists, mind and self are identical. Most of the difficulties of understanding the status of these concepts arise because of such identifications or because they try to make them mutually disjunctive. If we accept the classical Indian philosophical definition of self as simple conscious awareness and mind as material, vitalized by such consciousness, I think we can understand the processes of perception better. Without the self making the mind-brain combination conscious, all conscious activities of the human species do not find a probable and satisfactory explanation.

While the Indian philosophers so divide the self which is awareness and consciousness, from the mind-brain which is material and activated by such consciousness, they do accept that it is not possible, empirically, to prove the existence of such a self apart from its activities as the percipient self. We can only know introspec-

tively that such a consciousness is present in every pore of our body. It is not a mere idea, for it is a pre-requisite for the knowledge of all other ideas. There is nothing mystical, mysterious or magical about the existence of this self as it is experienced introspectively by every one of us. Now such a conscious self cannot directly contact the external world. As far as the body and the internal states of perception are concerned, no further mediation is necessary, for the identification of the body and the self is felt from within and is examplified by statements like " I do not understand this paper ". But for external objects, a medium is necessary before the consciousness can contact the object. Such a medium is the sense-organ at one level and the mind-brain at another level. The culminating point which is the identification of the neuronal patterns with the percepts is the point where consciousness identifies itself with the physiological impulses and neuronal patterns. But the identification is not a complete, total, point to point identification. This is not possible for we make statements like " I know I see the table ". As far as the latter portion of the sentence " I see the table " is there, there is an identification between the perceptual processes and the conscious self. The other aspect is the proposition *I know* which is the overall witness self. Thus the conscious self is both the witness self as well as the acting self exemplified by the activities of the sense-organs and the brain.

Such a theory may appear at the outset to be very arbitrary, far fetched and unreal. I shall only cite two important factors of visual perception which give a plausibility to this theory. First of all, let us take the continuity of perceptual experience. None of us can deny that our perceptual experience, specially of the visual perception, is one continuous experience, connecting the object and the knowing, conscious self. But the actual evidence from physics and neurology does not give room for holding any such continuity to be true. To explain, if light energy is made up of discreet quanta, then there cannot be any continuity between the quanta. If neuronal energy is also of discreet units, then there seems to be a flow of discreet particles from the beginning to the end. There is inter-particle space, however microscopic it might be, which all the same breaks the felt continuity. Physically such breaking might be condoned taking into consideration its microscopic measurements. But logically it is still a break and

hence. it is in contradiction to the felt experience of continuity. Such a logical contradiction poses a most fundamental problem for a philosophical understanding of perception. This contradiction can be resolved, only if we accept the principle of consciousness, spatially pervading the whole process in the order of mind-brain, sense-organ and the object.

Consciousness denotes the essential experiencing being who is aware of the sense and imagery fields presented. To a certain extent, this also explains the facts of attention and selection. Sometimes we see and hear without being conscious of them. This means that although the physiological processes are present there is no contact between the witness self and these processes via the mind-brain. Hence, there is no ' perception '.

Thus, I have to conclude, logically speaking, the existence of a conscious self as the witness self and as the activating self is a *sine qua non* of all perceptual experience, and more so, with regard to visual perception.

6

Extra-Sensory Perception: A Review

P. NAGARAJA RAO

PERCEPTION IS one of the basic and immediate instruments of knowledge for man. It is knowledge derived through senses and acted on by the cortex, illumined by the consciousness principle. It does not depend on previous knowledge, as other instruments of knowledge such as inference and verbal testimony do. If we knew not the invariable concomitant relation between smoke and fire, we would not be able to infer fire. If we did not know the meanings of words, we would not understand the speeches and writings of anyone. In the case of perception, we have just to open our eyes and we see the object and have the experience. Perceptual experience (despite illusions and hallucinations) carries for many of us the air of certain knowledge, immediately felt, which dispels doubts. Hence, the primacy of perception among the instruments of knowledge.

Normal perceptual knowledge is confined to sense range. It is confined to the here and now. We cannot perceive what is in the past and is removed from us in time or space. This is the limitation of perception.

Seventy-five years ago in the last century men came across certain phenomena in their study of human personality. It is called the *psi* phenomena. Men became aware of something outside, without the use of sensory channels. Awareness of the thought and the mental states of others is *telepathy*. Awareness of an objective event, removed from space and at a distance of time is *clairvoyance*. Awareness of the events in the future is *pre-cognition*. All the three phenomena are known as *psi* phenomena. This is broadly described as extra-sensory perception. It is knowledge derived without the use of the sense-organs directly by the mind. Individuals produce an effect upon some objects in their environment without the use of the motor system. It is the direct action of mind on matter. ESP in short is the direct interpretation

of the subject and object without the mediation of the sensory-motor system of the individual.

We have a few examples here. " Mrs. A. woke up one morning during the war — the morning of November 18th — sobbing, 'Jack is dead'. Jack was her son, a soldier. Her husband, unable to calm her, called the family physician who gave her a sedative to send her to sleep. On the morning of November 23rd, Mrs. A. again woke up crying. Her husband unable to calm her went to get a psychiatrist. That very day they received a letter from Jack, saying he was well. Still Mrs. A, insisted that the boy was dead. That evening a telegram was delivered reporting Jack's death on 17th November in Hawaii. Mrs. A. said 'I knew it all the time but you would'nt believe it' ".[1]

An English lady, Mrs. Atlay, the wife of a bishop, dreams one night that after reading the family morning prayers, she went into the dining room and saw an enormous pig between the table and the side board. The dream amused her and she told it before prayers, to her children and the governess. After prayer, she opened the dining door and there was a pig where she had dreamt it was. It had escaped at the time of the prayer from the sty.[2] Instances of ESP are to be found from beginnings of time in all our cultures and religions. For a very long time, men sought to explain the ESP instances as the result of supernatural gifts given to some men by Gods and angels. The agnostics explained the phenomena in terms of 'coincidence' and as 'freaks of nature'. Coincidence is too simple an explanation to account for them. The scientists were not, till recently, prepared to accord a scientific status to such knowledge. Thanks to the experiments conducted by the British Psychical Research and American Institute for Psychical Research, ESP is slowly gaining recognition.

Psychology for the most part followed the mechanistic model of scientific patterns of thought after the more successful sciences of the physical universe and attempted to explain human personality in terms of the dynamics of the nervous system. Whatever occurrences in human behaviour which challenged physical explanations were strictly kept out of sight.

[1] Huxley, Aldous: 'A case for ESP, PK and psi', *Life*, Nov. 1958, pp. 39–65.

[2] ibid.

The men who were imbued with the scientific temper of mind, alert, patient to doubt, fond of observation, slow to assert and ready to reconsider, took to the examination of the ESP experiments under the guidance of Mcdougall in 1930. The investigation of the ESP phenomena was extensively carried out in the para-psychology laboratory attached to the Duke University in U.S.A. In 1934 a monograph on extra-sensory perceptions was published. In 1937, they started a journal of para-psychology. In 1930, Prof. Rhine and his associates designed several experiments to search for ESP powers in men. The tests were devised with playing cards. The experiments were conducted with rigour and circumspection. Rhine's work in the 'thirties developed controlled experimental conditions and subjected all the results to statistical appraisals. The evidence was too solid to be explained away. The experimental conditions were stringent.[3]

The experiments conducted in Duke University early in the century sought to find those who have ESP capacities and show that it is really extra-sensory. The Western psychologist does not admit that all of us have ESP powers. According to him only a few individuals have it to a lesser or greater degree and it is spontaneous and unconscious. As such they say that it is not the result of conscious logical reasoning. It is an immediate awareness. It is a potential normal faculty men possess. This faculty is both a form of knowledge and a form of action. Although Western thinkers regard ESP as a gift of a special kind possessed by some individuals only, according to Indian thought all possess it potentially, but the need to awaken it is necessary. Bergson the great French philosopher was of the opinion that our civilization by its complex mechanism is repressing these (ESP) powers in men. He held the view that "mind in itself is aware of every thing without regard to time and space". The sense-organs limit our venue and scope of knowledge.

The ESP is indirectly related to health. Experiments show close correlation between scoring success and health. Rhine notes that disease hinders ESP.[4]

[3] K. Ramakrishna Rao's: 'The Psychological Picture of PSI Research', *Journal of Philosophy and Social Sciences*, Vol. I, Part I.

[4] *The New Outline of Modern Knowledge* (Ed. A. P. Jones) article by J. B. Rhine on Para-Psychology, pp. 193–210.

The phenomena of ESP is a challenge to the prevailing scientific concept of the nature of man and his powers. The mechanistic picture is too narrow and inadequate. It commits the fallacy of 'over simplification' (in the phrase of A. N. Whitehead). Para-psychology is revolutionary in its significance. The nature of the problem and the experimental verifications have disclosed that in human life there are operations that transcend the boundaries of what is called the physical. The distinction between the two persists. Sir Charles Sherrington writes in his *Man on his Nature*, "The search in that energy scheme for a scale of equivalence between energy and mental experience arrives at more ... The two, for all I can do, remain refractorily apart. They seem to be disparate, not mutually convertible, untranslatable the one into the other."

The professor in his Reed lectures at Cambridge observes: "Strictly we have to regard the relation of mind to brain as still not merely unsolved but still devoid of a basis for its very beginning". His final words in his broadcast symposium "On the Physical Basis of Mind" are highly instructive. "Aristotle, two thousand years ago, was asking how is mind attached to the body. We are asking that question still."

Students of the Yoga system record that at a particular stage in the practice of Yoga, the trainee acquires some strange supernatural powers (*siddhis*) of hearing, touch, sight, taste and smell. Some of these powers are described in the commentaries on the Yoga *sutras* e.g. the *yogi* can know directly the past, present and future, produce supernatural sights, sounds and smells, and see subtle entities like angels. They can see through closed doors, pass through stone walls, disappear from sight at their sweet will. But all these powers are not to be indulged in, for they are described as obstacles to spiritual life.

The age old problem of the relation between mind and brain is not fully described. The ESP discloses that the human beings can have knowledge — without the use of the sense-organs. But he cannot do that without the use of the brain. It is difficult to disregard the brain and describe it as a non-sense organ. Some of the activities of the brains are being explained in terms of brain-behaviour patterns by psychologists and neurologists. The brain is being progressively identified with the mind. At any rate, there is no doubting the factor that there is close and intimate

relation between them, though the nature of such relation is not completely disclosed.

The upholders of the concept of consciousness i.e. the self, accept its existence over and above mind and body. These two are instruments of the self. The self is not the mind. The term mind is used by Western thinkers in two distinct senses i.e. (1) awareness and (2) brain activity. The two cannot be reduced to one pattern. The mind-body problem makes some sense, if we accept the self as distinct from them. It is not body, mind or senses, but it is that which makes them act. That mind and body are controllable by the self is disclosed by yogic exercises.[5]

[5] See Dr. Sarasvati Chennakesavan's article 'Mind as an aspect of the Brain," *Research Journal of Philosophy and Social Sciences*, Vo. I: No.1 (2), pp. 130–34.

PART II

Discussions

Paper 1: Biochemistry

SRI S. PARTHASARATHY, *Psychology Department*

1. I learn that the rhodopsin is getting bleached by the action of light, which operates on it. Is it possible that this broken rhodopsin is reconstituted wholly in its original form by the same action of Vitamin A? Probably rhodopsin is not reconstituted directly by the action of Vitamin A.

2. Is the mechanism same in the iodopsin?

DR. K. S. SWAMI, *Zoology Department*

1. When rhodopsin is bleached, transform of Vitamin A is formed. It is isomerized to cis form and then made to form cis rhodopsin.

2. The difference between rhodopsin and iodopsin is in the opsin molecule; the rest is similar. The mechanism is identical in both.

SRI S. PARTHASARATHY, *Psychology Department*

Is the amount of rhodopsin in the rod proportional to the amount of dark vision? Has this been confirmed?

DR. K. PAMPAPATHI RAO, *Zoology Department*

What I understand from the question is whether an eye which is normally better at night vision has more rhodopsin than another type of eye. The answer is, it is so. One has to have more rhodopsin for better night vision.

DR. K. S. SWAMI, *Zoology Department*

Wild animals can see better than us in dim light because the concentration of rods is more in their eyes.

DR. G. SIVASANKAR RAO, *Physics Department*

What about explanation of the time-lag phenomenon in visual excitation?

DR. K. S. SWAMI, *Zoology Department*

This phenomenon pertains to the physiological aspects which will come in the next lecture.

SRI P. V. RAMAMURTHY, *Psychology Department*

Dr. Swamy mentioned that iodopsin breaks into opsin and retinine and that in course of time there is a formation of iodopsin again. Now (1) what is the time taken for this formation of iodopsin or is iodopsin somehow always available?

2. Secondly, iodopsin is to be found in cones. We are able to see and discriminate different colours. Are there different iodopsins sensitive to different wavelengths of colours?

3. Thirdly, we know the phenomenon of partial colour blindness. How do we account for it in the light of existing evidence?

DR. K. S. SWAMI, *Zoology Department*

1. The re-synthesis of iodopsin occurs at a quite rapid rate than rhodopsin and it can serve the purpose. This rate of back synthesis has been found to vary. Generally complete re-synthesis takes about 40 minutes. For mammals it is about a couple of hours. So the difference in re-synthesis rate of the pigments facilitates continued vision.

2. The spectral sensitivity of the pigment influences the detection of different colours since they involve different ranges of wavelengths having different energy content. So there seems to be a relation between energy content at different wavelengths and spectral sensitivity. This is a guiding feature in determining the colour.

3. The colour blindness is dependent on the nature of the pigments. The sensitivity to a particular colour varies in colour blind people when compared to the normal ones.

DR. K. PAMPAPATHI RAO, *Zoology Department*

The question is, are there different kinds of pigments which are specifically sensitive to different wavelengths of light? There is no bio-chemical evidence to show that there must be such pigments. The difficulty about having such evidence is the fact that the units, the cells, which are differently sensitive are mixed up in the retina and it is difficult to isolate them. But from the electro-physiological evidence we know there are cells which are specifically sensitive to different wavelengths of light. The present hypothesis on colour vision is as follows. It is believed that the retina is colour sensitive. Colour vision is a rare phenomenon in the animal kingdom.

Rhodopsin is a pigment whose colour sensitivity is rather broad. It is sensitive to white light. Theoretically we know that iodopsin in each of the cones is not identical. It must be separate. We can excite them only by specific kinds of lights. Therefore the different cones are sensitive to different colours. These cones can be excited only by a very narrow band of wavelength. On a single fibre we can place the electrodes and flash lights of different wavelengths. For any given fibre and depending on the position of the electrode one can get different responses which indicate its response to different colours. This means theoretically we have to accept that there are pigments for different colours.

A man who is colour-blind to green, perhaps genetically does not have the mechanism to produce green sensitiveness. Green sensitive cones are not there. Therefore he is blind to that. These are hereditary factors.

SRI VENKATRAMAIAH, *Psychology Department*

I have two questions to ask. How can negative and positive after images be explained in the light of the paper?

Secondly, when we see a fast rotating spiral and stop it immediately what is called Archimedes Spiral phenomenon occurs. You find it expanding or contracting alternately in the direction in which it was first seen. How do you explain this?

DR. K. S. SWAMI, *Zoology Department*

It is dependent on the relay system pertaining to the physiological activity and not biochemical reaction.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

Suppose there are two objects that are presented to sight and each of them release equal amount of energy. Now how much of the energy is caught by the retina, if the chemical reaction after it reaches the retina is the same? How does retina distinguish between these two objects which give the same amount of energy?

DR. K. S. SWAMI, *Zoology Department*

That is dependent on the visual excitation induced by the extent of bleaching.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

But the visual excitation is the same.

DR. K. S. SWAMI, *Zoology Department*
Still the extent of chemical reaction will be different. And the images formed on the retina would be at different places.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
Does the physical location of the object has anything to do with the consequent chemical reaction in the retina?

DR. K. S. SWAMI, *Zoology Department*
When the image falls on the retina in two different places the action is in two different places.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
Then there is a correspondence between the physical locations and retinal images.

DR. K. S. SWAMI, *Zoology Department*
Yes. The visual areas in the eye are mapped in the visual centres in the brain. Hence it is possible to visualize the spatial relationships.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
If the objects produce images and if they are spatially related to externally situated objects then these objects produce inverted images.

DR. K. S. SWAMI, *Zoology Department*
Yes.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
We have to explain how this inversion, becomes meaningful.

DR. K. S. SWAMI, *Zoology Department*
The conduction system in the nerve system is such that objects are visualized in normal posture.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
How much of the light that leaves the object is received by the retina? I asked this before.

DR. K. S. SWAMI, *Zoology Department*
It depends on the direction of the object.

DR. S. BRAHMAJI RAO, *Chemistry Department*
The energetics of photo-chemical reaction is different from the bio-chemical mechanism of vision. According to photo-chemistry for any photo-chemical reaction to take place there must be first absorption of light. Every substance has got a characteristic wavelength where it can absorb to its utmost. Rhodopsin also has got the same rate of absorption. In one of the experimental proofs, it is said that rhodop-

sin is formed by mixing opsin and retinine and putting them in the spectro-photo-meter and observing the absorption maximum. You also said the same. As soon as light falls on rhodopsin it instantaneously reacts to give rise to lumi-rhodopsin. All spectio-photo-metric designs are made to pass light through it. Is not this reaction taking place during optical density measurement? We must get at least two peaks. One corresponding to rhodopsin and the other to lumi-rhodopsin. As far as photo-chemical reaction is concerned, they are different rods and cones. For photo-chemical reaction to take place in cones it is not only the wavelength that matters but also the direction in which it falls. Unless it falls normally no reaction is possible. This is for cone vision but not for rod vision.

DR. K. S. SWAMI, *Zoology Department*

Spectro-photometric investigations are made taking into consideration the experimental conditions.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

Dr. Swami said that the change from rhodopsin to lumi-rhodopsin is almost instantaneous, that means at least there is some electric time-lag between these two. There will be some time-lag at every level of change. We do not have any inkling of this time-lag in perception. We have only continuity of perception. How to explain this? Actually the process is different from what we perceive. Do you mean to say that the brain is not equipped to record the time-lag or somehow this time-lag is overlooked by the brain or what occurs is one thing and what we perceive is another thing?

DR. K. S. SWAMI, *Zoology Department*

Whenever there is a stimulus, it has to be received by a receptor; this will involve certain amount of change in the receptor, especially chemical change. The time-lag for this is considerably small, a minute fraction of a second. In this case of rhodopsin, bleaching in light, lumi-rhodopsin is formed somewhere in the process. We do not know whether it is right in the beginning of the process or at the time of the formation of lumi-rhodopsin that excitation occurs in the process.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

I understand that part of it. But my question is still there. The time-lag is not explained by our perception of the object.

DR. V. R. KRISHNAN, *Chemistry Department*

There will be the time-lag because the mechanism involves photo-chemical reaction. We will find that. The energy picked up by the molecule has to be transformed to the proper form. Perhaps a millionth of a second time-lag is there. This does not cause any visible delay.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

We have two retinae in two eyes and behind these chemical action takes place similarly. But yet we see only one object in spite of two images being formed. How is this stereoscopic vision possible?

DR. K. S. SWAMI, *Zoology Department*

It concerns the physiological activity of nervous system which will be discussed in the latter part of the seminar.

Paper 2: Neurophysiology

MR. S. R. VENKATARAMAIAH, *Psychology Department*

During the last (Seminar) paper's discussion I raised a question about biological evidence for after images. May I request for an answer now?

DR. K. PAMPAPATHI RAO, *Zoology Department*

There is no biochemical evidence for after images under normal conditions i.e. in the normal brain. One line of thought as far as after images are concerned is based on the after potentials and secondly on the theory based on the anatomical evidence of what we call reverberating circuits in the central nervous system. Perhaps these reverberations are responsible for the after images.

MR. S. PARTHASARATHY, *Psychology Department*

With regard to selective perception Dr. Pampapathi Rao has said that the visual organ can operate sometimes and may lie in a state of rest at other times as per the likes and dislikes of the CNS. He said we psychologists call this as attention. But sometimes there is the fact that when a person is attentive and the CNS does not like to receive such stimulus we can order the visual system in a coercive way into accepting. So is the activity entirely central or peripheral?

Secondly, the threshold of the sensitivity is getting lower both from the central and peripheral. Then the peripheral may

not affect the central. There are different thresholds for these two. It is by the coincidence of these that we can think of peripheral and central working together. There is no guarantee that, physiologically speaking, both the thresholds should be the same.

Thirdly, the eye is constantly moving. Because of this the cortex is able to record the visual sensation clearly. I may be wrong in my understanding. But if it is correct, saccaidic movement is different from fixations. The former is not conducive to clear vision. But this is due to fixation. Saccaidic movement is jumpy vision.

DR. PAMPAPATHI RAO, *Zoology Department*

I did not say the CNS can completely stop the sense-organ from registering. What we know is that the CNS can alter the sensitivity of the system. So to call attention to the CNS, when sensitivity is reduced, stronger stimulus is necessary. The sensitivity of the peripheral is alterable by the CNS. Secondly, even in fixed vision there is micro-movement of the eye ball and not gross movement. Even when the focus is on the fovea, there is a slight oscillation.

MR. S. PARTHASARATHY, *Psychology Department*

You have stated that there is no colour vision in animals. How about experiments conducted on animals to establish their spectral sensitivity and the fact that they distinguish different colours behaviourally though not physiologically. Does it not show that animals are capable of colour vision behaviourally? Psychologists believe that reactions to colours from a behavioural point of view is that which shows their capacity for colour vision.

Latency factors are measurable, according to the paper, with reference to incoming sensation between the sense-organ and the cortex. What about outgoing impulses? Perhaps they are also measurable, for example, reaction to light? Has this cortex latency factor been estimated or calculated? Would not a previous experience operate with regard to brain activity? In spite of accounting for all latencies, will there not be a residual time not accounted for?

DR. K. PAMPAPATHI RAO, *Zoology Department*

Animals do not have colour vision in the same sense as man. That is why I called it spectral vision. Our sensations to

different colours are the result of the mixture of different wavelengths of light. I mean that the various hues that man experiences apart from the three primary colours are not possible for animals. We can never say whether they respond to the different hues but they can be conditioned to the basic spectra. Their perception of colour is not the same as our perception of colour. In answer to your second question: It is possible to calculate the latency for a motor response and deduce from that 'brain time'. But it is not possible to deduct this 'brain time' and still have a residue left for the simple reason there is no such residue. For example, touch. The reaction time of feeling and removing the hand can be calculated. Conduction time can be calculated from the excitation time, the time taken for this to pass through the length of the nerve fibre. We know the excitation time and of latency of the receptor and the time it takes to conduct the nerve impulse to the brain. We may also know where the motor neuron that gives the command starts. From this we can calculate the time it takes for the motor impulse to reach the nerve fibre. But we do not know how many neurons and synapses are involved between these two activities. We cannot calculate the residue because of the lack of knowledge regarding neurons and synapses in-between excitation and reaction. Such reaction time is adaptable to the rate of learning. This adaptability is present even at simpler levels. Every synapse is capable of adaptation.

MR. S. PARTHASARATHY, *Psychology Department*

Intensity of light remaining constant, the brightness that is experienced changes. How is this possible in the absence of any temporal or spatial summation of light occurring?

DR. K. NEELAKANTAM, *Chemistry Department*

This distinction between intensity and brightness is not understandable to a chemist who talks only of brightness, hue and purity.

DR. K. PAMPAPATHI RAO, *Zoology Department*

Intensity is the physical definition of the number of quanta per unit time and per unit area that is received by the retina. Brightness is a sensation. This is perception. When intensity is kept constant and there is an enhancing of brightness, it does not mean that there is any physical change anywhere. Con-

stant intensity of illumination is what is meant by intensity. Summation is of two kinds: (1) temporal, and (2) spatial. Spatial is again of two kinds — geometric and superpositional i.e. larger spaces and more illumination. Brightness enhancement that was mentioned is that where there is no change in spatial configurations of light, no change in the physical intensity. Hence there is neither temporal nor spatial summation.

This is a cortical phenomenon and not spatial summation, because if this is so then it should not diminish when they are at the peak. If it were mere synaptic facilitation then it should diminish. That is why we call it a perceptual response. Hence it is a cortical phenomenon. The enhancement is not photochemical, neuronal or synaptic. It has got to be only cortical.

DR. K. NEELAKANTAM, *Chemistry Department*

What the cortex gets ultimately may be overlapping images which enhance brightness. Perhaps this is purely electro-chemical for an overlap can produce an impression of enhancement.

DR. K. PAMPAPATHI RAO, *Zoology Department*

This is the same as flicker-fusion. Then the greater the fusion, the greater should be the brightness. But it is not so. But at a particular frequency only there is enhancement. On either side of this frequency there is no enhancement. So it cannot be the accumulation of a chemical product. It is not also psychic. It can only be that the cortex exhibits electrical response.

MR. S. PARTHASARATHY, *Psychology Department*

The experience which comes to the cortex is different from the experience at the retinal level because of the changing processes involved. The experience at these two levels is differently understood. Who is the person who so differentiates and is able to see both the experiences from a common point of view? What is the logical explanation?

DR. K. PAMPAPATHI RAO, *Zoology Department*

But it is the neuro-physiologist who says that the experience at the cortical level is different from the experience of retinal level. Because the experiment of the neuro-physiologist is through the electrodes and the patterns he sees there, he has to depend on this measurable information. The neuro-

scientist has very little freedom in this respect. Experience is difficult to quantify.

DR. K. NEELAKANTAM, *Chemistry Department*

The village maid had her pitcher under the tap. The water in the pitcher was full. She saw and saw not, heard and heard not. The retina is receiving, but the cortex is not recording. This is what happens in concentration. So perception is different from reality.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

I believe certain experiments were done when the person was put under anæsthesia or some such control. But by electrical stimulation certain sensory experiences were induced, without the functioning of the sense-organs. My question is, how much of what I am going to say as a hypothesis can be upheld by the electro-physiologist. Will there be a time in the evolution of man when he can function by using only his cortex and not his sense-organs? Because it looks as though the cortical stimulation is prior to the sensory stimulation.

Secondly, again I have to quote a doctor, a neuro-physiologist who says that the patterns that are formed in the brain are two dimensional but yet the perceived experience is three dimensional. How does this happen?

Thirdly, the images that are formed on the retina are reverse images. The patterns that are formed on the brain, are they also reverse images? Or, in the process of the transition of the stimulus from the retina to the brain does some re-inversion of the image take place?

DR. K. PAMPAPATHI RAO, *Zoology Department*

About stimulating the cortex and getting sensory experience, there is a lot of work that has been done. But we can never do away with the sense-organs, because what one gets when one stimulates the cortex is only a recall of what has already been recorded by the cortex. So initially there must be information supplied to the cortex which can be recalled. The cortex cannot experience everything by itself. Penfield's experiments show that what has been experienced once is recalled. I do not know if congenitally blind and mute people's cortices have been stimulated and if responses were got. About the two dimensional image in the cortex, I thought the cortex registers three dimensional images. That is, sensa-

tion is three dimensional in the cortex as well, because we know from experience that we are aware of three dimensional space. The spatial distribution in the cortex is apparently three dimensional as far as neuro-physiological recording goes. To my knowledge the cortex registers in a three dimensional fashion and it is in the three dimensional set up that the cortex reacts.

MR. S. PARTHASARATHY, *Psychology Department*
However we are not able to locate the third dimension in the cortex morphologically.

DR. K. PAMPAPATHI RAO, *Zoology Department*
That is true. What you say is the cortex has no morphological indication of the three dimensional state, because the image received on the retina is two dimensional and the projection on to the cortex is also two dimensional. In that sense it will be only two dimensional. But in the sense of perception we have three dimensions.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
Is there no explanation of this transition from the two dimensional to the three dimensional?

DR. K. PAMPAPATHI RAO, *Zoology Department*
No. I do not think there is any physiological explanation for that. With regard to the question of reversion of the image, as far as the cortex is concerned there is nothing like the image being reversed. This reversion is a learned process. If a man were to walk on his hands from birth then it would be the correct world for him. The pattern is learnt.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
How long do these patterns persist in the cortex matter? Once a visual perception takes place, is there not a superimposition of the present images on past images and a large number of images will have to be carried by the brain matter.

DR. K. PAMPAPATHI RAO, *Zoology Department*
In a good brain it persists till death. This is called memory. How it happens we do not know. It is a fantastic filing system the mechanism of which has not yet been discovered.

MR. S. PARTHASARATHY, *Psychology Department*
I believe stronger images leave behind deeper furrows in the cortex. Does furrow retention of the image in the brain-matter cause memory recollection?

DR. K. PAMPAPATHI RAO, *Zoology Department*

Memory traces are not morphologically found in the cortex. There are two questions here. The continued repetitive input: does it result in a morphological change in the nervous system? Do cells grow slightly larger? This theory was vehemently opposed by others, who say that there is no such indication. But today the thing is changed. There is evidence that there is some morphological change. What is more amazing is, why is it that some people have certain impressions as permanent records after experiencing it just once?

DR. NAGARAJA RAO, *Philosophy Department*

Philosophers like Kant talk of apperception over and above perceptual processes. Is there any physiological or neurological evidence for this?

DR. K. PAMPAPATHI RAO, *Zoology Department*

It is a fact that without reference to past experience there cannot be perception.

Now the philosopher would tell us what the cortex perceives is always in relation to what it has perceived before. But it will not be true to say that an apperceptive mass influences perception. In our own system of philosophy it is said knowledge can be obtained without experience. This is what is called Revelation or Precognition. You need not have previous experience in the true physical sense for such precognition. In the yogic sense you have had previous experience and you are continuing it. In the physical, physiological and psychological senses also such experiences can be explained. On the present Einstein's theory of relativity, if time and space are to be a continuum and if space is curved, then all experience is existing already. Only we stumble upon experience on the co-ordinate of time. We come upon our experience. It is there already. But then if it is already there, if you are the receiver with a nervous system which can be tuned accidentally or purposefully by training, to resonate with that particular electro-magnetic radiation or energy that happens to be that set of knowledge, then you perceive it in the true sense not through a sense-organ but through some mechanism in the nervous system. Perhaps this is what is meant by apperception.

DR. G. SIVASANKAR RAO, *Physics Department*

1. How do we explain the reverse processes of vision? We recollect scenes that we experienced some years back.

2. I asked a question about persistence of vision. All the electrical impulses are of the order of fractions of a second. But there is the persistence of vision. How is this explained?

3. The correlation between the photo-chemical action in the retina and the photo-chemical action that we have in the photo-chemical cell and thirdly computors where the problems are stored and then handled one after the other: is there any such mechanism of storing, computing and programming in the brain?

DR. K. PAMPAPATHI RAO, *Zoology Department*

We are very much in the dark about the mechanisms of storing and recalling of information, or recollecting a vision that we have seen long before. We know very little about all these. There is very little information about memory and what little there is should form the subject matter of a different symposium altogether.

Paper 3: Psychology

DR. POTTER (*a guest from Minnesota, U.S.A.*)

I am confused about Stratton's experiment which you mentioned. I heard about it before. For an oddity to appear in perception in this connection there should be no need because everything appears upside down. So there should be no difficulty to adjust to perception in this manner.

MR. P. V. RAMAMURTHY, *Psychology Department*

Yes. I do not see it is necessary for us to assume that the first experience of an infant is an 'upside-down' experience for the infant. If we assume that, that it is 'upside down' for the infant and if it has to adjust to it (by reversing it), all these difficulties arise. What is this up and down? Up and down are learned nomenclatures. The child learns that those on the headside, skyside, are up, and those on the earthside, legside, are down. Past experience and the cues of the present sensation help us in further interpreting in terms of up and down.

MR. S. PARTHASARATHY, *Psychology Department*

In addition to these cues there is what is known as labyrinthine sensation. Even if one closes one's eyes he is aware that he is erect. Whatever might be the other situations with regard to sensations man is always aware where his head is and where his legs are. This is due to the labyrinthine sense. What Stratton wanted to know by his experiments was what would happen if normal images on the retina were reversed. So he devised glasses to reverse normal perceptions. Having created this oddity it took him another 30 days to re-learn the original positions after removing the glasses.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

What I understand to be the purpose of Stratton's experiment is that it is to illustrate that whatever is the position upright or reversed, man is capable of learning different positions and reacting to it properly. This does not help us in solving the problem raised by Dr. Potter. That is, how do we in the first instance(at birth) know which is up and which is down? With reference to what do we fix this point? If it is suggested that it is the pull of gravity which fixes this point then we have to agree that it is not the image alone that gives us the knowledge of the position of the object but there are other factors, certain physical laws such as gravity which help us in fixing the position of the objects. In the case of the man in space evidently the law of gravity is not functioning. Therefore the labyrinthine sense must tell him the position of the body irrespective of the position he occupies in space.

MR. S. PARTHASARATHY, *Psychology Department*

I cannot understand how the absence of the gravitational laws prevents a man knowing when he is in space which is up and which is down. We have no information on this from astronauts.

Paper 5: A Philosophical Appraisal

SRI P. V. RAMAMURTHY, *Psychology Department*

You have talked of a witness consciousness. My difficulty is to accept such a witness consciousness. What evidence is there to accept such a witness consciousness? Perhaps due to difficulty of explaining experiential phenomena it

may be necessary to postulate a witness self. Other than this what evidence is there for such an acceptance? Secondly, if witness consciousness is that through which we know the outside world, the same witness consciousness must have been present in the infant also. I do not know why we are then, unable to recall our infant experiences.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

I will take the second question first. It is true that no one can recollect the experience of their very early childhood. The range limit of recollection is different for different individuals. I have made out in my paper that the witness consciousness can never reach the object directly. It can only reach the object through the mind-brain, which is material for the Indian philosophers, and through the usage of the sense-organs. And you know the maturation of these two organs takes time. Therefore the witness consciousness is helpless during the time of infancy. Probably this is one of the reasons why recollection of childhood's experiences is not possible. I can only give this as a hypothesis.

Coming to the first question, it is a question that is asked repeatedly but the philosopher has not been able to answer it because it is something like asking to witness one's own decapitation. Perhaps I may quote Descartes and say 'I think therefore I am'. The very fact that I am conscious of my existence, that I am conscious of my perceptual activity, which is not explained by any other process, leads me to some other explanation. Therefore as a hypothesis we postulate the witness self. But for proof, everyone has to look within himself. It can only come as an introspective evidence not as an external objective evidence.

SRI M. BASAVANNA, *Psychology Department*

The author has said that mind and brain are material and the self is non-material. I would like to know how the percept that occurs in a physical medium gets converted into a non-physical or spiritual medium.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

This is a very searching question. I did not mean that mind-brain is a solid matter. All that I meant was mind, according to Indian philosophers, is of the nature of energy which may also be called matter following in the footsteps of

modern science. This energy is unconscious at a certain level and becomes conscious energy when the self is identified with the neuronal energy or whatever you want to call it, that is present in the brain. The question is why should they get identified? If we can answer this question I think we have an answer to all philosophical questions. Somehow the identification does take place. Otherwise knowledge would be impossible. But how and why, I am sorry, we are not able to answer. All experience becomes meaningless unless there is a conscious element attached to it.

SRI P. V. RAMAMURTHY, *Psychology Department*

Referring to the explanation given for the re-inversion of images in the paper I have to say that if the tumbling of electrical particles is possible at the retina why not it be possible in physical systems? For instance, if we project the similar type of light rays through a lens on to a screen why does it not get tumbled and give us re-inverted images? Hence I would like to suggest that there is no such process as described in the paper taking place to explain re-inversion of images.

DR. K. S. SWAMY, *Zoology Department*

There is evidence in biology that the image that falls on the retina is originally inverted.

SRI S. PARTHASARATHY, *Psychology Department*

The newness of the contribution that the retinal image is not inverted but erect has really tumbled us all down! This challenges the very authenticated findings of the physicists, the biologists and the psychologists. Just now the biologist Dr. Swamy has told us that from the defects in the retina, either due to injury or to atrophy, it can be determined that the image is inverted. If the quanta are continuously tumbling up and down from the moment they are received, then there should be no position where we can determine the image to be upright and where it is not so. The rate at which this happens is not given as the theory is purely a hypothesis. But it is stated that by the time quanta reaches the retina they are in an upright position. This is an amazing statement and purely speculative. I do not know how far we can agree with this even as a hypothesis. Another point of view that is taken in the paper is that mind-brain is devoid of consciousness, that self alone is conscious. Why should

you think that the mind-brain needs this consciousness for its activity? Would it not be possible that the mind-brain itself is capable of consciousness and that it need not borrow consciousness from a self which alone possesses it?

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

Even when I made the suggestion with regard to the tumbling of the energy units I did say it was a crack-brained suggestion. I have also said that I have no experimental evidence for this. Philosophers can only throw about suggestions for scientists to experiment upon. However, physics does say that light is in the form of quanta and the movement of light energy is a random tumbling movement. From this we can deduce that since these quanta do not occupy a fixed position at any time, it is quite possible for the images to be formed and re-formed in various positions. But then exactly at the retinal position why should it be erect and not upside-down is the question raised. I can only hypothesize about this. If we know the rate at which quanta travel and if we can correlate all the physical and the biological evidence in the light of this hypothesis, perhaps we may know why the image is erect at the retina. All these are mere hypotheses. And you can reject them if you do not agree. I can only say that there is nothing absolutely definite about the knowledge given by either physics, biology or any science or even philosophy. All that we can do is to put forward logically consistent hypotheses. Another idea is helpful here. It is that the light quanta are not qualitatively different. This was supported by Dr. Pampapathi Rao in his paper. When any sensation leaves any sense-organ there are no qualitative differences in the impulses before they reach the cortex. They are all alike. But the qualitative differences arise only when they reach the cortex. Here comes my theory of the difference between the mind-brain and the self. If it is necessary to have a differentiating agent then such an agent cannot be, as per evidence, within the physiological field. Therefore, there has to be something which is beyond these, which is capable of correlating. If we deny this then we cannot depend upon our knowledge. I said that the mind-brain is equatable to the neuronal energy that is present in the cortex and this has to be activated by the consciousness

which we call as the self. So all the three things, the object, the process and the self are all present throughout. The self identifies itself with the neuronal processes and activates them.

For the last question the answer is: since the mind is material for the Indian philosopher it is not different from the brain in the modern sense of the term. But such a mind is not gross matter. It is a fine matter of the nature of light as the word Sattvika means. This becomes energized and activated by contact or identity with the witness self.

SRI P. V. RAMAMURTHY, *Psychology Department*

You raised a question in your paper about continuity of perception. We know from all physical evidence that a transmission of light quanta is discrete. The nerve impulses are also discrete. But yet we have an apparent experience of continuity. All that I want to suggest is that this experience of continuity is a construct of the brain. That is, it is a quality of the brain itself.

Secondly, it is known that when the reticular formation is destroyed there is coma. From this as well as from the fact that a percept has to be registered on the brain there is necessity for the impulses to go from the reticular formation to the brain in all directions. From these evidences I am led to believe that consciousness again is due to the brain itself and the answer to consciousness is to be found in cerebral activity. Therefore consciousness is a function of the cerebral activity.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

The question of continuity being a construct of the brain is acceptable because the brain constructs with the help of the conscious element that is there. Otherwise construction by matter itself is impossible. This has been proved. Brain does not construct by itself. Experiments have been done to show that sometimes brain activity goes on without any conscious knowledge being produced. Therefore the constructions are not done by the brain there. Even if such construction takes place it has no meaning till consciousness becomes identified with it. It does not matter what words are used as long as we recognize that some construction goes on which we understand as knowledge.

Paper 6: Extra-Sensory Perception

SRI P. V. RAMAMURTHY, *Psychology Department*
How does the philosopher explain the phenomena of extra-sensory perception?

DR. P. NAGARAJA RAO, *Philosophy Department*
Indian philosophy accepts that it is possible to acquire knowledge without the use of normal sense-organs. The prevailing view that what the senses do not give is not knowledge, is not right. But we can have knowledge without the use of the senses.

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
This statement that we can have knowledge without the use of the sense-organs is partly right and partly wrong. It is partly right because while extra-sensory perception is taking place there is no activity of the external sense-organs and then again for extra-sensory perception to occur there must have been at some prior time, the activity of the external sense-organs which should have registered these impressions on the brain. Without such impressions according to Indian philosophy no extra-sensory perception can take place.

SRI S. PARTHASARATHY, *Psychology Department*
Is it then necessary to explain all extra-sensory perception phenomena including precognition in terms of previous experience? Is there a causal relation between the two?

DR. MRS. CHENNAKESAVAN, *Philosophy Department*
There are two points which we have to take into consideration here. As far as telepathy and clairvoyance are concerned it is recognition of the patterns that are made in one person's sense experience and in that person's brain matter, by another person's mind. The contact with the object is not direct but through the brain of the person who is directly in contact with the object. Because the minds of these two persons are in tune they are able to consciously sometimes and unconsciously sometimes attune their minds to each other's and thus receive the impressions made in each other's brain. In this manner retrocognition can be explained. I do not know how precognition can be explained on the same lines unless we include the metaphysical theories which may not be acceptable to everybody. There is also a sort of physical

explanation given for precognition by the physicists, specially from Einstein's theory. This was discussed a few days back while discussing Dr. Pampapathi Rao's paper.

SRI R. SOUNDARRAJAN, *Philosophy Department*

Scientists have found great reluctance in accepting such phenomena, because it is very difficult to give a physical model for them. For example, precognition. If we have Newtonian ideas of time we cannot fit in modern theories of science about space-time as one continuum. The present conception of time is one-dimensional. If the present is, the future IS NOT. No philosopher has worked out a theory of time adequate to precognition, whereas the scientists have done so at least recently. Referring to Minkowaski's geometry of world lines, if this is accepted, then there could be something like precognition. But the relation between the present and the future within a frame of reference is absolute. It is only from a different frame of reference that what is present now be also the future or vice versa, whereas in precognition we are speaking in a single frame of reference. How would the relativity of time explain precognition within a single frame of reference?

DR. MRS. CHENNAKESAVAN, *Philosophy Department*

The question is how can the one-dimensional frame of reference of time help us to understand precognition which can only be explained in a frame of reference which uses two dimensions for time? The answer is the same as I gave before. We have one frame of reference with regard to ordinary perception, there is another frame of reference when the physicist talks of atoms and electrons etc. Just as we can reconcile these two frames of reference, here also we have to reconcile between these two in some form or other. Otherwise we can never explain precognition. I am not saying how these two are to be reconciled but only that they have to be reconciled somehow.

SRI S. PARTHASARATHY, *Psychology Department*

It is difficult to reduce the occasions when extra-sensory perception occurs, to laboratory conditions. Control of the experimental conditions is almost impossible where extra-sensory perception is concerned, since extra-sensory perception is unique. All the evidence we have is only based on statistical

evidence. Hence to explain such evidence in a causal way is impossible.

SRI P. V. RAMAMURTHY, *Psychology Department*

If precognition means knowing events that occur in the future then it means the order of occurrence of all events is already pre-determined. Otherwise there can be no precognition of them. I wonder if this is acceptable.

8

Conclusions

DR. SARASVATI CHENNAKESAVAN

THIS BEING a seminar organized from a philosophical point of view, it is necessary that we try to hypothesize certain conclusions from all the discussions we have had so far. I say advisedly 'hypothesize' since the knowledge that is given by the sciences is like the ever-flowing river, never static, never dogmatic and not empirically conclusive. It is from such foundations that the philosopher has to provide a passable structure of theories which would serve the limited purposes of man.

We have had, before this seminar, three fundamental questions viz.: (1) what is the nature of the object that is known in visual sense perception; (2) what is the nature of the visual sensations which account for the common man's knowledge of the object as a real existing object; and (3) is there something over and above the sensations, sense-organ and the cortex which is responsible for this knowledge. In providing answers to these three questions we have come across a highly fundamental conclusion that things are not what they seem. For practical purposes, from the point of view of the common sense approach, the differences between a scientific analysis and an empirical experience may seem negligible. But, for the philosopher, they constitute the core of the problem.

In answer to the first question the physicist would emphatically state that what we perceive is only light quanta presented in the form of wave motions. As usual the physicist can only start the questions but he cannot provide the answers. One such question that comes out of the physicist's position is with regard to the continuity of the perceptual knowledge. That continuity of visual experience is a fact and that it has to be explained by any theory of perception cannot be gainsaid. But if the electrical stimulus that is responsible for perception is itself in the form of discrete quanta, it is evident that no continuous knowledge is possible. The second question that still remains unanswered by the physicist is how we are able to see a solid, three dimensional coloured object when

all that is vouched for is only electrical impulses. If we are prepared to accept a dichotomous division of the world into what is appearing to sensations and what is *really real*, then these problems need not be answered.

The next two problems are the problems which the biochemist and the neurophysiologist have answered. They continue from where the physicist leaves off, namely from the retina. There is no doubt that the papers on these subjects are very erudite and thought-provoking. However, we are still in as great a quandary as before. It is a fact that perception cannot take place if the retinal chemical changes do not take place. Taking for granted that there is a relation between the point of impact and the method of excitation of the rods and cones and that the subsequent chemical reactions that take place lead to the excitation of the cortex, still the philosopher's problem persists viz. is that all? The physicist says an image is formed on the retina. What happens to this image during the chemical processes that take place afterwards? Is the image somehow reformed in the cortex? If not how can we say that the resultant knowledge is in the form of images? Coming to the cortex itself, it is agreed generally that the potentialities of the whole of the cortex are not known. It is also accepted that the activities of the cortex are so important that without them there can be no perception of visual objects. The neurological activities in the cortex prior to the arising of the perceptual judgment are taken for granted, since they are experimentally established. But a total view of their activity reveals certain logical lacunae which have to be met if we are to have a satisfactory theory of perception. One important difficulty has already been expressed in my paper. A still more fundamental difficulty is " what is the relation between these cortical processes and my judgment 'This is a table'?" It has to be explained how, if the physical world is in no sense 'perceived' in the chemical and neuronal processes, we are still assured of the fact of the knowledge of the object. The event of 'seeing' does not seem to occur, when conceived in terms of neuro-physiological-chemical changes, either where the visual object is seen, or where the real object is assumed to be. To quote the American logician Lovejoy: " A happening inside of a given body, somehow achieves the presentation, in the individual stream of experience connected with that particular body, of an entity

outside the body ".[1] This riddle is the crux of the problem. Following close upon its heels is the doubt cast upon the immediacy factor of perceptual knowledge. The one fundamental factor which separates perception from inference is the factor of immediacy. But is there such immediacy in perceptual knowledge? There is now a familiar fact established by physiological psychologists that there is an infinitesimal time lag between any given pair of retinal images and the transmission of the neuronal impulses to the cortical centre. If both the physicists and the physiologists are right, then the datum that is presented can only be a symbol of, or, at best a messenger, more or less suspicious, from the object which is supposed to be known. The fact of immediacy, therefore, cannot be said to be an invariable character of perception. According to Indian logicians such immediacy is a *sine qua non* of perceptual knowledge. Hence they maintain that the self comes into actual contact with the physical object through the mind and the sense-organs. This is achieved, according to their theory, by two facts. One is the invariable concomittant relation of inherence between mind and self and the other is the fluid nature of mind which is fundamentally a material thing. However absurd such a theory may sound from a scientist's point of view, it is the most logical solution that can be offered from a philosophical point of view.

There is no doubt that neurological and psychological presentation of perceptual facts require philosophical criticism and analysis. Amongst Western philosophical theories of perception two broad trends can be seen. One that is pro-scientific and tending to limit perceptual activities to behavioural patterns resulting from neuro-physiological patterns. The other is the phenomenological school which asserts with authority that the mind (which is also the self for these people) and the object are the dual realities which come into contact with each other through that most elusive entity known as sense-datum. If both these can be brought together, then we may have a plausible theory of perception.

The classic Indian philosopher agrees with the scientist that no ordinary perception is possible unless the physiological processes are present. To say merely that behavioural patterns are the only basis for all perception is something which they cannot accept. That behavioural patterns are only patterns of a *meaning* is what is

[1] Lovejoy, A. C.: *Natural Dualism*, p. 98.

more important for them. In an enquiry on perception, it is this something non-physical meaning that is the object of their enquiry. Whenever we experience an external behaviour, there is also a corresponding conscious state existing over and above the former. It is this felt correlation between the physical and the mental that makes us seek their counterpart where one of them is present. This in itself is the cause for the faith that we have in the existence of other minds.

That mind is separate from self and that mind is material is another important postulate of the classical Indian philosophers which makes their theories of perception very plausible. The Vedantin maintains that the self which is pure consciousness vitalizes the material mind which then flows out through the sense-organs and assumes the shape of the object that is perceived. When this happens, there is immediate knowledge. That the object is known as a whole pattern and not as individualized particular excitations is the theory of the famous *Gestalt* school of psychologists. This *Gestalten* is close to the theory of perception of the object as a whole given by the Vedantins. The core of the problem is how a transition from the subjective consciousness to the objective reality can be explained. The object is reducible to either sensations or images. If we can maintain that the stuff of the images is mental stuff and this is the mediating principle between the pure consciousness which is the self and pure object which is gross matter then it becomes possible to explain the transition. Mind is material, but of such fine and pure matter that it is capable of containing within itself the conscious principle. Being matter it is able to relate itself to matter in the form of the object, being light and fine, it is able to establish a relation with consciousness which is always defined in terms of light and purity. If somehow, this can be established empirically by the scientist, the Indian philosophers' theory would stand vindicated.