BINOCULAR VISION : SOME ASPECTS IN RELATION TO AVIATION.

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Binocular vision has been defined as the co-ordinated use of two eyes so as to produce a single mental impression. In its highest development the blending of two images into one results in the acquisition of stereopsis i, e. the perception of depth by parallax. Both eyes are harnessed together by static anatomical bonds and by dynamic anatomical bonds,

Static Anatomical Bonds: In the process of evolution, from lower vertebrates to the primates, the anatomical position of the eyes have changed from a some what laterally placed direction to an almost frontal one. With the use of eyes changing from self preservation to aggression, the orbits become less divergent and the visual fields overlap. Thus resulting in stereoscopic vision. The anatomical bonds comprise the shape of the orbits, the ligaments and the muscles. This result in the anatomical position of rest, a position adopted when all other ocular muscles are completely devoid of tone and the whole visual sensori-motor area is inactive, as in deep sleep.

The dynamic physiological bonds conveniently described as the "Binocular Reflexes" are of two kinds, fixation reflexes and refixation reflexes.

Fixation Reflexes

(1) **Gravitational or Compensatory Fixation Reflex:**
This unites the labyrinth, organs of muscle sense and eye muscles in such a manner that the latter are able to keep the eyes fixed inspite of considerable head and body movements.

(2) **Orientational Fixation Reflex:** This reflex enables the eyes united by the first reflex, to follow a moving object by a slow movement of continued fixation. These two reflexes form an alliance which eventually become so powerful that even with total loss of the labyrinth, eyes are able to maintain the body right side up and properly orientated.

(3) **Vergence Fixation Reflex:** This is the physiological reaction which preserves the relationship between orientational and compensatory fixation reflexes by appropriate adjustment of the eyes so as to compensate for all distances of the orientational object or point, from the horizon up to the very snout.

Refixation Reflexes:

These reflexes relate the eyes back to the originally orientational points, (passive refixation) or to a new orientational point (active refixation).

These bonds, anatomical and physiological so harness the eyes together that they act as one in relation to a whole panorama or to any object within the panorama. With increasing acuity and stereopsis based on evolution of the fovea the bond becomes stronger until the anatomical and physiological union of the two eyes becomes so strong that their separation becomes impossible except through some major force.

Development of the Binocular Reflexes:

Reflexes which are unconditioned or automatic and peculiar to the species are developed by mere passage of time; such as the gravitational or compensatory fixation reflex. It is rudimentary at birth and almost completely developed at the age of three months. Conditioned or acquired reflexes are developed by usage. The orientational and vergence reflexes are rudimentary at birth, but if not used the rudiments are lost. Their preservation and future development are conditioned by usage.

In the new born, a distinct stimulus such as the flashing of a torch produces a following movement of the eyes or a turning of them towards the stimulus. This is not a uniocular movement but an adversion or a conjugate movement of both eyes. At two months the infant's eyes begin to follow the movements of a person. At six months he begins to fix an object for half a minute or more. At this age too extreme a convergence may be maintained for several seconds.

At two years a large proportion of the child's waking hours are spent toying with and looking at near objects. It is during this period, that a child learns not only to associate the position and size of the bi-retinal image with the direction, distance, and size of increasingly smaller objects, but also to distinguish by touch between a single object having a certain position in space and two similar objects each lying in a different direction in space. The constant handling of his toys furnishes the child with tactile and proprioceptive evidence of unity which might have been left in doubt by means of retinal impressions.

Judgements of unity, distance, direction and size, therefore, depend for their initiation and development upon the unconditioned basis of touch. Without touch, reality and illusion are indistinguishable. The structural basis of these reflexes is complete at the age of six months. The reflexes are partly developed by the age of two years and are fixed at the age of five years.

Requisites for Binocular Vision:

There are three stages in the process of binocular vision:

(1) Simultaneous macular perception (S. M. P.)

(2) Fusion of the bi-retinal images.

(3) Stereopsis or appreciation of solidity.

Conditions necessary for Binocular Vision:

(1) Proper monocular fixation with each eye.

(2) Overlap of visual fields.

(3) The images falling on the retinae must be approximately similar in shape, size and colour to avoid antagonism.

(4) There must be physiological corresponding points on the retinae.

(5) In all movements of the eyes, the visual axis must be correspondingly adjusted, so that the images remain on corresponding points of the retina.

(6) There must be good neuro-muscular co-ordination of the eyes at all times and in all directions.

Depth Perception:

This is really two dimensional, but a conception of depth is possible by a psychological interpretation in conjunction with accumulated experience of the following clues:—

(1) Apparent size of the retinal image of an object of known size.

(2) Aerial perspective by which distant objects appear blurred and more blue in colour. This is because light rays from distant objects are scattered, rays from the blue wave band being least affected.

(3) Overlapping of contours.

(4) Intersection of objects with the horizontal plane.

(5) Geometrical perspective, parallel lines appear to converge.

(6) Reflection of light from the surface. Light and shade give the appearance of solidity. In general, if the origin of the source of light be known then the relation of the shadows indicate their arrangement in space.

(7) Apparent change in shape as the object moves e. g. a circle becomes more elliptical, if viewed from the side.

(8) Displacement (motion) parallex. If two objects at different distances are viewed with the eye in motion, the nearer object appears to move opposite to the movement of the eyes giving rise to a sense of depth.

(9) Accommodation. The effort used to focus objects clearly also provides a sense of depth.

In flying these aids form the principal clues by which a pilot, either binocular or monocular, is able to judge height and distance.

Binocular Depth Perception of Stereoscopic Vision:

This is primarily a function of binocular vision. Binocular pilots will have the following additional aids:—

(1) Effort of convergence to fixate the object. However, convergence can be abolished with prisms and depth perception may still be unaffected.

(2) Physiological diplopia.

(3) Binocular parallax - whereby the right eye sees a little further around the object to the right and the left around to the left.

Factors influencing Depth Perception:

Visual acuity: Of all attributes of the visual apparatus a good sense of form and size influences most the accurate estimation of height above ground when coming in to land. It is mainly by means of good vision that one-eyed pilots interpret all monocular clues available in terms of depth. Inspite of modern instrumental aids to flight, good visual acuity still remains of paramount importance. It is by far the chief factor influencing landings rather than ocular muscle balance. This is the considered opinion held by Air Commodore J. C. Neely - R. A. F. Consultant in Ophthalmology. Further, at the Empire Flying Schools in Canada during the last war a definite co-relation was established between failure to learn to fly and poor visual acuity.

During landing a pilot on completing the circuit, has to ultimately rely on his own visual judgement to enable him to execute the final turn into wind at the correct distance from the aerodrome. It is good vision rather than ocular muscle balance which forms the basis of this judgement and which is the sole factor upon which the one-eyed pilot relies.

Ocular Muscle Balance:

The true conception of orthophoria embraces all distances and all directions of gaze, as such orthophoria does not exist. Heterophoria is a normality. The degree of imbalance is rarely significant, being under 4 prism dioptres in 96 per cent of the population and over 6 prism dioptres in 1.6 per cent.

When dissimilar objects are presented to the eyes fusion is not possible and the eyes take up their position of rest. This wrong alignment of the eyes is not a true, but a latent squint. When dissimilar objects are removed the eyes are correctly aligned on the object by fusion sense and fixation reflexes. As such, compensated heterophoria presents no symptoms and does not affect perception of depth. Student pilots with heterophoria have no difficulty in learning to fly; and the statements that exophorics tend to flatten out their aircraft too early while esophorics are inclined to fly into the ground, is now accepted as a fallacy. In the second World War, extensive studies at the Empire Flying Schools in Canada proved that there was no co-relation between landing errors of 175 student pilots and exo and esophoria (Elliot, 1942).

The R. A. F. Ophthalmologist kept pilots, with up to 13 prism dioptres of esophoria, in the air and later obtained satisfactory reports on their flying. The visual problem, therefore, is not the immediate effect of heterophoria on flying particularly the ability to learn to fly as the remote effect heterophoria may exert in a career devoted to aviation. Fusional control may weaken and in some cases break down under strain and stress peculiar to flying. It is also affected by alcohol, debility and anoxaemia. Air Commodore J. C. Neely determined the power of compensation in twenty subjects with heterophoria of over 6 prism dioptres by examining them in a low pressure chamber at the simulated height of

20,000 feet without oxygen. His results showed an increase in esophoria and a decrease in exophoria in all subjects except one. They also demonstrated a powerful fusion faculty and the absence of diplopia in all except one subject who was suffering from fatigue and anxiety.

Neurological & Psychological Factors:

It is evident that there is little or no co-relation between various depth perception tests such as Verheoff's and the Howard Dolman test and it is common experience that individuals with a greater amount of heterophoria sometimes make better pilots than those with less. These two facts imply that psychological factors also come into play in the attainment of a keen sense of depth perception. All psychological factors being equal, individuals may yet vary in the degree of their visio-psychic powers of perception and spatial judgement. It may be that the foundation for these differences are laid down in childhood, in the period of development of acquired reflexes, when individual differences in intelligence, alertness and appreciation of natural stimuli tip the scales one way or another. It may also be that each individual uses a combination peculiar to himself, of all the available clues and aids to binocular vision. He may rely on some particular aids more than other individuals do and hence his conclusions may vary in degree from theirs. Finally, differences may exist at the perceptual level of the visual cortex in the interpretation of the data collected.

Conclusions:

(1) Good visual acuity is by far the most important factor for stereopsis; hence the necessity of maintaining high visual standards for pilots.

(1) Heterophoria only affects spatial judgement when it is not fully compensated. It is not the degree of heterophoria that matters so much as the power of fusional control, sufficient to withstand the stress and strain of Service flying.

(2) It is possible that in addition to the visio-sensory elements certain neurological & psychological factors account for differences in degree between individuals, in the accuracy of their spatial judgement.

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