This suggests that such damage is associated with an oxygen enhancement ratio which is intrinsically lower than the overall ratio¹².

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PSYCHOLOGY

Ultra-kinaesthetic Judgment of Size

AN investigation has been carried out on some numerical links between visual space and a kinaesthetic sensitivity to spatial relationships. One type of experiment (purely visual) is based on Luneburg's concept of non-Euclidean visual space¹ and on its modification by Blank². I have designed another type of experiment (visuo-kinaesthetic)³ to investigate some effects of proprioception on vision. In these experiments an observer imagines himself moving towards two distant light points in the darkness and passing his forearm between them. He adjusts the gap between the two light points by remote control so that it equals the length of his forearm. The variables are C , the size of the gap between two light sources in a frontal plane, and R , the size of the forearm of the observer. (Other dimensions of the observer's body are considered in other trials.) These variables are compared with K , Luneburg's curvature of visual space, and r , the subjective distance of the stimuli from the eyes, as given by Blank in units of $(-K)^{-1}$. The experiments show that C (which is approximately equal to R close to the observer) contracts sharply in the case of negative curvature with an increasing distance from the eyes (to a value several times smaller at a distance of several yards) but remains approximately constant with $K \sim 0$ and expands with $K > 0$.

For a selected experimental condition, C and R predict K and r (and vice versa) with considerable numerical accuracy. For a wider range of experimental distances and for extreme values of K and r some of the numerical accuracy is lost. (This is related to the known difficulties in determining K and r for wide ranges.) Statistical differences between the observers, however, remain highly significant. Using a more general approximation to the curves of C against r ,

$$C \sim R(\cosh r)^{-1}$$

the meaning of C as a proportion of R can be outlined. A small C (with large $\cosh r$ and high negative curvature) indicates that an observer uses a small unit in assessing size (allowing for visual angle which diminishes with distance) so that he assesses the size as relatively large. But when for a relatively great physical distance C approximates R (with $\cosh r \sim 1$ and $K \sim 0$) an observer with poor distance perception using a large unit in his measurements assesses the size as relatively small. It is suggested that C by its proportion to R establishes a unit of visual measurements which is recalibrated for every phenomenological distance in a system characteristic for an individual observer.

An important feature of this system is that it is expressed in terms of the body size of the observer. This permits a departure from the relativity of the subjective comparisons and allows the assignment of a physical magnitude to a subjective assessment. If, for a distant object of size T , we were to write,

$$T = nR = nCf(r) \sim nC \cosh r$$

then, in the subjective counterparts of these terms, the proportion (n) would not necessarily be affected by the observer's system of measurements, that is, this proportion is most likely to be independent of the observer's personal constants, K , and the values characteristic for him of r and C for great distances. The critical condition required to estimate T correctly, however, is that the observer must place himself (R) and the object (T) at the same phenomenological distance (r) in his system, and that he must allow for the proportion (n). This, it is suggested, is a function of effective kinaesthetic activation in the whole body as well as in the eye orbits.

In an actual experiment which was carried out from an attic window with a wide view, twenty observers were asked to imagine that they were swimming through the air towards distant buildings, or climbing their walls. (Slight muscular exercises designed to promote the kinaesthetic activation within the limbs and the eye orbits were alternated with the tasks.) During certain trials each observer was asked to imagine himself clinging to the face of a chimney (9.5 ft. wide and 130 yd. distant), and to say whether his hands would grip the edges of the chimney or whether they would miss them and by how much, that is, by a hand, by a forearm or by an arm. Each observer was also asked to imagine himself climbing across the width of the Post Office Tower (52 ft. wide and 660 yd. distant) and to say how many times he would have to shift his body with extended arms across the face of the tower while doing so. Afterwards the observers were asked to estimate visually the size of the chimney and of the tower in terms of feet or yards. They also estimated the size of their body members. Finally, the anthropometric measurements of the observer's body were taken.

The results showed that the estimates based on the imaginary tasks and on the observers' size given anthropometrically were better than the visual estimates by a highly significant amount ($P=0.0006$ in the case of the chimney, and $P=0.002$ in the case of the tower). The visuo-kinaesthetic estimates were remarkably accurate in the case of several observers and, as expected, they depended neither on their perception of distance nor on K . They were also independent of an observer's knowledge of the dimensions of his body. Such proprioceptive sensitivity (probably connected with a motor type of imagery and with former visuo-motor experience) would be an advantage in survival tests, as, for instance, in space research. Its neuro-physiological mechanism (which may be linked with the activity of the muscle spindles) and its ties with the visual parameters are a matter for further investigation.

The apparatus for this investigation has been designed by Mr. J. W. Chambers and made in this department by Mr. R. J. Sloan and Mr. C. McManus. I am grateful to the Central Research Fund of the University of London for some parts of equipment, and to my colleague, Dr. Sheila Jones, for helpful suggestions.

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