his inconsistencies and eloquent even in his recantations. He adorned the calling he adopted and elevated the school he served so long. Ophthalmic surgery is lusted by the fact that Lawrence practised it and embellished it.

DISTURBANCES OF VISUAL ORIENTATION

BY

GORDON HOLMES, M.D.

(*Concluded*)

Disturbance of Visual Orientation

It must be emphasized in the first place that the symptoms presented by these cases cannot be attributed to defects of visual perception as, to the usual tests, the acuity of central vision was normal or approximately so in four cases at least, and it was certainly moderately good in the remaining two, though in these it was not possible to measure it accurately. Further, the examination of a large number of cases with central and paracentral scotomata due to gunshot injuries of the brain has shown that spatial perception is not affected by these conditions, nor is it associated with the defects of central vision produced by retrobulbar neuritis. It is, however, true that in all six cases there were some defects in the visual fields, but except in Case II, the blindness or amblyopia did not approach the region of central vision, and in three there were irregular quadrantic defects only. Here again the fact that the spatial orientation of objects seen is not influenced by the presence of hemianopia or other large losses in the fields of vision, whether they be due to cortical, subcortical, or tract lesions, is an argument that the disturbance of orientation is not due to these associated visual defects. The possible influence of the abnormalities in the movements of the eyeballs which co-existed with this symptom in all my cases, and especially the absence of accurate fixation, will be referred to later, but here it may be mentioned that each patient was unable to localize visible objects correctly in space even when he fixed them accurately, though, as in normal persons, his errors were then smaller than when the images fell on extra-macular portions of the retinae.

The affection of visual orientation was obvious in several tests; the patient was unable to touch accurately any object within his reach and vision, though the movements of one or both arms were intact; in walking he collided with easily visible objects and had difficulty in finding his way around them, and frequently he

could not recognize the relative positions of two similar objects in space. In attempting to touch an object he made mistakes in all three planes of space, that is in judging its lateral and vertical position as well as its distance, though the errors were always greater in the estimation of distance. In discussing these errors we can conveniently, on physiological grounds, deal separately with those made in the coronal plane and those due to disturbance of the perception of distance.

Our power of recognizing the relative positions of objects which throw their images on the retinae depends in the first place on the local signs of the retinal elements that are stimulated; by virtue of these we arrange our visual perceptions according to the arrangement of the excited retinal points, and judge one object to be to the right or to the left of another, or above or below it, and especially its relation to the object which is at the moment in our central vision, since it is from the macula that we most naturally measure the positions of visible objects in space. Analogous cutaneous local signs enable us to locate any point on the surface of the body which is touched. Now, we know that as a result of certain cerebral lesions the locality of a tactile stimulus can no longer be recognized, though there may be no affection of either the threshold of sensibility or of the quality of the sensations evoked; the local signs of the cutaneous surface then no longer furnish the necessary information to consciousness. Similarly, the cerebral wounds in these cases affected the local sign function of the retinae, and the patients consequently became unable to project correctly, and arrange in their proper relations in space, the images which excited vision, and to recognize the actual spatial relations of objects seen and their relative sizes and lengths.

But retinal stimuli alone suggest only the magnitudes and the relative positions of objects in a bidimensional plane. To obtain a correct knowledge of the locality of the objects in relation to ourselves afferent impressions from the ocular and neck muscles and tendons, which can inform us of the direction of the visual axes and the position of our heads, are also necessary. The squinting eye projects the images which its retina receives erroneously. Here again we have an exact parallel with somatic sensibility, for though a limb may appreciate by the local signs aroused the exact point on it with which an external object comes in contact we can, if our eyes are closed, recognize the exact position of this object in space with relation to ourselves only when those proprioceptive afferents from our muscles, tendons, and joints, that subserve the sense of position of the limb, reach consciousness. As various tests showed that in the cases described here there was inability to appreciate the relative as well as the absolute positions of objects seen it is evident that both factors were involved, or more correctly

their combination which represents the physiological correlate of the psychical judgments on which spatial localization depends.

It is, however, in the estimation of distance that these extra-retinal afferents are most essential, since this depends largely on proprioceptive impulses from the ocular muscles, especially on those excited by convergence and accommodation, though binocular vision and judgments based on distinctness, light intensity, and the size of familiar objects, contribute to it. Retinal impressions alone can give an idea of distance only when the magnitude of the object is already known. It is consequently not surprising that the perception of distance, which is a more complicated process and dependent on the association and synthesis of several groups of afferent impressions, should have been more seriously affected than localization in a bidimensional plane at right angles to the visual axes. This we found to be so in all the cases, and in the two slighter ones it was practically the only defect demonstrable. It was to inability to estimate distance accurately that the troubles of many of the patients in walking were mainly due. They collided with obstacles chiefly because they did not recognize how near they were to them, and ran into walls and screens for the same reason, though disturbances of localization in other planes of space certainly played a part. In attempting to touch an object, whether when stationary or as they moved towards it, their hands were most generally projected beyond it, in other words, its distance was most commonly overestimated, probably owing to their failure to accommodate near objects accurately. This was the only direction in which there was a tendency to predominant error in any of the six cases.

A striking symptom in the five cases who could walk was the difficulty which these patients had in learning their way about in their new surroundings. Even after being led repeatedly along the one path some of them failed to find it again, or followed it only with hesitation as if in doubt. In this respect their condition contrasted unfavourably with that of a blind man, who can quickly learn his way in familiar surroundings.

How severely spatial orientation may be disturbed was seen in the difficulty which some of the patients experienced in making their way around simple obstacles. Case I, for instance, on running into a chair shuffled about in front of it, obviously confused and perplexed, moved towards one side and then back again, evidently failing to perceive that a single step would allow him to avoid it. Case II could not find his way back to bed when a small locker that he could easily pass around was in his path; and Case V had the same difficulty when he met any obstacle in the room.

We normally acquire our knowledge of space mainly from visual experiences, though muscular, tactile, and other impressions also

contribute to it. It is consequently probable that in these cases the cerebral mechanisms, by which the spatial percepts received through the different senses are associated and assimilated with past experiences, were involved. The inability of Case I to represent the lengths of the ordinary standards of linear measurement was evidently due to the memories of spatial dimensions being affected too.

Another symptom deserving of note was the inability of all these patients to explore a limited surface properly with their eyes, and to enumerate conspicuous objects on it. Here the defects in the visual fields may have played some part, since a man with right homonymous hemianopia generally fails to perceive objects to his right side even when his ocular movements are unaffected—for the cortically blind this portion of visual space simply does not exist. But in testing my patients care was always taken to direct their visual axes at the commencement of the examination in such a direction that the images of all the objects would fall on the seeing portions of their retinae. The difficulty in obtaining fixation was probably one factor, as when we cannot bring objects in succession into central vision we cannot so easily enumerate them, or we are at least liable to neglect those images which fall on the periphery of our retinae; this also impeded the patients in exploring even small surfaces with central vision. Further, it is obvious that when the patient cannot recognize the spatial relations of the separate objects he cannot with certainty identify those which he has already counted if they are all similar and he is consequently liable to include some of them again; this actually occurred in all the cases.

The inability to read was due to the same causes; the relative positions of the words in the page were not recognized promptly, and these were not brought in proper succession into central vision, and reading was, therefore, slow and inaccurate. The difficulty in reading was, however, generally less than might have been expected after the patient had failed to count coins and in similar tests; the appropriate movements of the eyes from left to right, which had been acquired by long training and fixed by habit, were less affected than their voluntary deviations to objects that were at the moment outside central vision.

In some of the men, as in Case II, individual words of any length or the type of any size could be read promptly when presented singly, though frequently neither these nor any other words could be picked out immediately when the whole page was visible; the wealth of visual impressions, each devoid of accurate spatial significance for the patient, then confused him and exaggerated his difficulty in fixing single words.

Another symptom which contributed to the difficulty of some of the patients in counting objects and in reading was a local disturbance

of visual attention; owing to this they failed to take notice of, or direct their attention to, images that fell on certain portions of their retinae, though retinal sensibility was there intact, or at the most only slightly affected. As a result of this they failed to observe portions of the surfaces in front of their eyes, and to perceive easily visible objects on them, or they perceived them only when their attention was called to them. Further, attention lacked its normal spontaneity and facility in diverting itself to new objects. Case I and others complained that they could see one thing only at a time; the one object arrested and claimed attention exclusively; but no matter how large it was, it was always perceived whole. One man, who had failed repeatedly to count four or five separate dots on a sheet of white paper, saw them all at once when they were connected by lines or enclosed in a circle; the connecting or enclosing lines unified the images into one figure, and attention could then take cognizance of the separate dots within it. Similarly, though the lengths of separate lines could not be compared accurately, an equilateral quadrilateral figure was always recognized as a square, and when slightly oblong figures or ellipses were drawn, they could be always distinguished from squares and circles.

This disturbance of visual attention, which has been referred to by several authors, is so commonly associated with loss of visual orientation, that it might be included in the syndrome, but the two conditions do not appear to be interdependent or closely related; visual inattention often occurs as a unilateral phenomenon as a result of parietal and lateral occipital injuries when spatial orientation is not affected.

Stereoscopic vision was probably intact in all my patients, except perhaps in Case V; but in Case III the co-existence of motor aphasia made it impossible to determine this with certainty. Case I not only recognized tridimensional objects in their natural form, but also such illusions as the truncated pyramid. Case II saw test figures in perspective in the stereoscope, and Cases V and VI stated that all objects appeared in natural perspective to them. Riddoch has, however, published the interesting case of a patient with a perforating gunshot wound of the head, and disturbance of visual orientation who was unable to appreciate depth and thickness in objects by vision, and everything, consequently, appeared to him flat and bidimensional. In other recorded cases line drawings could not be pictured in perspective, but illustrations and photographs conveyed the intended impressions to four at least of my patients.

Tactile contacts always gave the patients a correct knowledge of the position in space of the objects felt, and an accurate idea of the spatial relations of two objects touched simultaneously or in succession, provided that the sensibility of the arm was not disturbed by injury of the postcentral cortex. The ability to localize sounds

was unfortunately investigated in three patients only. Case I always walked towards anyone who called his name, and moved in the proper direction to pick up a coin dropped noisily on the floor when his eyes were bandaged : Case II also seemed to project sounds as accurately as the average normal person, but Case V rarely searched in the proper direction for coins dropped on the floor beside him ; this may have been, however, due to his dull and inattentive mental state rather than to inability to localize sounds.

Ocular Symptoms

The ocular symptoms include the difficulty which all the patients had in fixing objects visible to them, their failure to accommodate and to converge their eyes on near objects, and absence of the blinking reflex.

The disturbance of fixation was the most prominent of these symptoms. When spoken to or asked to look at anything, each patient generally stared for a moment in a wrong direction, usually in that towards which his eyes had been previously turned, and then rolled them about awkwardly till he found, often as if by chance, the point he sought. Yet there was no evidence of palsy of any of the ocular movements, and the fact that correct fixation could be eventually obtained, argues against this as a possible explanation. Case I, who had also the symptoms of bilateral motor apraxia of his limbs, was, unlike the other patients, unable to move his eyes correctly to order, though none of their muscles were weak ; this symptom, as well as his difficulty in obtaining fixation and accommodation, was originally regarded as due to apraxia of the ocular movements.

This impairment of fixation would naturally result from defective spatial orientation, as when the position of the object which throws its image on the retinae is not correctly appreciated, the eyeballs cannot be rotated so as to carry the exciting image to the macula. The fact that Case V could turn his eyes immediately to his own left hand, that is, to a point in space which he recognized correctly, shows that the affection of fixation may be dependent on this. van Valkenburg's patient, also, could fix her own finger accurately. But the fact that my Cases I and II, as well as those recorded by Riddoch and Förster, could not fix their own fingers, or bring their visual axes promptly to points of their own bodies which were touched, proves that in these patients, at least, the central innervation of the eye movements had suffered directly, and that the affection of fixation was not due to the perceptual disturbances only.

Similarly, with accommodation and convergence of the eyes. Though Case IV accommodated for his own finger accurately, and Case II could do so occasionally though not constantly, the other

cases in which the test was made failed even when, as under such conditions, they were aware of the nearness of the object. The absence of appropriate accommodation in these cases can consequently not be due to loss of the perception of distance alone.

Now, in all these cases the wounds involved the angular gyrus or its neighbourhood, a region of the cortex in which it is generally admitted that centres for ocular movements exist; it may be consequently assumed that one function of this part of the brain is the reflex adjustments of the eyes to peripheral stimuli, or the co-ordination and integration of the afferent impressions which, through these efferent centres, evoke appropriate ocular movements in response to retinal excitation.

It might be suggested that it was to absence of accurate fixation and accommodation that the disturbance of visual orientation was wholly due, but as normal persons can locate approximately, and certainly much more accurately than any of my patients could, the position in space of objects when their images fall only on extramacular portions of the retinae, this hypothesis is untenable. I recently saw a man in whom a midbrain and pontine tumour abolished practically all the ocular movements and accommodation, but his attempts to seize my hand were much better than those of the patients whose cases are recorded here.

The first five patients did not blink or otherwise respond to any threatening action, as when a hand or other large object was suddenly swung towards their faces. Blinking, therefore, seems to be a forebrain reflex dependent on the functions of centres which were injured by the lesions present in these cases. Case II, however, blinked normally when his own hand was passively jerked towards his eyes, which suggests that the absence of the reflex may be sometimes due to disturbance of perception of the distance of the threatening object.

Positions of the Lesions

The exact sites of the cerebral lesions which produced these symptoms can be determined in the two patients only (Cases II and V) who died while under observation, but in the others it is possible by careful measurements to obtain at least an approximate idea of the portions of the brains which were injured.

It may be assumed with considerable probability that when a missile of high velocity has traversed the skull its course through the brain is represented by a straight track connecting the entrance and exit wounds; this is the common experience, and it was found to be so in the two cases which came to a fatal termination. In Case VI, in which the wound was inflicted by a small-arm bullet, and in Case I, where the shrapnel ball fractured the skull and

made a wound of exit, the missiles were probably not deflected by any of the structures through which they passed. It is possible, however, that in the remaining two cases the fragments of shell, which had evidently lower velocities and remained within the brain, rebounded from the inner surface of the opposite side of the skull, and were reflected from it at an angle corresponding to that at which they struck it, producing further laceration and destruction, and it is consequently less easy to estimate the damage they produced. Further, without careful anatomical examinations it is impossible to determine, even approximately, the extent of the injuries, as small missiles often produce an extraordinary amount of damage to the tissues, and the haemorrhages, softenings, and the inflammatory and septic changes that frequently occur around their track may affect the anatomical integrity and functional capacity of portions of the brains that were not directly destroyed. An attempt to ascertain the probable positions of the lesions in the unverified cases deserves, however, a little space.

In Case II, we found that the entrance wound produced a small lesion on the lateral surface of the right occipital lobe, while there was a larger area of softening in the left angular gyrus where the bullet made its exit; in its course through the brain it injured the dorsal portions of the sagittal bundles of each hemisphere, and passed through their mesial surfaces posterior to the splenium and dorsal to the calcarine fissures, in the region of the parieto-occipital sulci.

In Case V, the entrance wound in the left hemisphere destroyed the supramarginal gyrus and produced a softening which extended forwards to the central fissure, while the exit wound involved the right angular gyrus. On the mesial surfaces of both hemispheres, the track lay immediately above the splenium of the corpus callosum. It seems probable that the large abscess in the central white matter of the left side, to which death was due, played no part in the causation of the symptoms, as these had persisted for more than nine months, and the signs of abscess formation developed only a short time before death. An exact histological examination of these two brains has not been yet possible.

Craniometric measurements make it probable that in Case I, the shrapnel ball entered in the upper part of the right supramarginal gyrus, passed above the posterior margin of the splenium, and made its exit on the surface of the left hemisphere in the inferior part of the supramarginal gyrus. In Case VI, the entrance and exit wounds were probably in the left and right supramarginal gyri, and the missile in its course must have passed close to the splenium of the corpus callosum. The entrance wound in Case III corresponded with the lower and anterior part of the right gyrus supramarginalis or of the first temporal gyrus, while the missile, which probably

rebounded forwards from the inner surface of the skull, lay in the left inferior parietal lobule a short distance behind the lower end of the fissure of Rolando.

The localization of the lesion in Case IV is more uncertain, as there were two wounds of entrance in the left side of the head and two small fragments of metal near the inner surface of the right side of the skull. It is probable that the more posterior missile had entered through the posterior entrance wound, and, by analogy with the other cases, it seems likely that it was to the injuries produced by it that the symptoms were due. The entrance wound would then correspond to the angular gyrus, while the missile, possibly after rebounding from the skull, lay in the lower part of the right supramarginal or in the first temporal gyrus.

It may be remarked in the first place that in all my cases both hemispheres of the brain were injured by perforating missiles; and as I have not seen similar symptoms result from a unilateral lesion, though I have examined a very large number of men with head injuries, it may be assumed that bilateral lesions are necessary for their appearance. In the second place, the available anatomical facts indicate that in all cases the lesions on the lateral surfaces of the hemispheres lay within a zone which included in its centre the angular and supramarginal gyri, and extended into the adjoining occipital, temporal, and parietal convolutions. The structures injured by the passage of the missiles are more uncertain, but the wounds on the mesial surfaces of the hemispheres probably all lay in the region of the splenium. The fact that in four of the cases there was some affection of the lower quadrants of the visual fields also indicates that the upper fibres of the optic radiations were injured on one or both sides, since recent experiences have demonstrated that these serve the upper portions of the retinae. The homonymous hemianopias in the two remaining Cases (III and VI) must be attributed to injury of the optic radiations under the supramarginal and angular gyri.

In the two other cases of this syndrome, due to gunshot wounds, with which I am acquainted, both hemispheres were also injured by perforating missiles. In Inouye's patient, who could not seize visible objects accurately, and, in walking ran into obstacles and could not find his way about, the entrance and exit wounds were symmetrically situated on the parietal eminences, corresponding approximately to the angular gyri. In Riddoch's case, which has been already referred to, the localization of the lesions was somewhat different, as the entrance wound was in the left fronto-central region, and the shrapnel ball was removed from an abscess near the tip of the right occipital lobe, but the possibility that it had rebounded from the inner surface of the skull, and that a line between these two points would not consequently represent its

track, must be borne in mind. It had apparently not fractured the skull near the point at which it was removed.

From these findings it is, however, impossible to conclude whether the damage to the lateral surfaces of the hemispheres, or of the cortex on their mesial aspects, or the interruption of bundles of subcortical fibres by the lesions, were wholly or mainly responsible for the symptoms. But a certain number of recorded cases which suffered from a similar condition, and in which the lesions were due to vascular disease, throw some light on this point. In Pick's first case the supramarginal gyrus was involved on the one side, and the supramarginal and angular gyri on the other. In Bálint's patient both the supramarginal and angular gyri were destroyed on both sides; and in van Valkenburg's the right angular and the left first temporal, angular, and lateral occipital gyri. As in these cases the mesial surfaces of the hemispheres were free from gross damage, it may be assumed that it was by the lesions of the lateral surfaces of the hemispheres, or of the subjacent fibre systems, that the characteristic symptoms were produced.

Certain experimental observations also support this conclusion. Ferrier found that monkeys from which he removed both angular gyri rarely seized objects with precision, "groping at them with the whole hand, and reaching short, over, or to the side," but he attributed this to defects of central vision. Similarly, Schaefer observed that after extirpation of the same gyri the monkey "would evidently see and run right up to a raisin, but then often fail to find it," but he also ascribed this to blindness in portions of the visual fields. Munk also noticed after removal of both "eye regions," which included the angular gyri, that monkeys usually failed to take objects accurately with their mouths or hands. And, finally, Franz after dividing the association tracts between the occipital lobes and the rest of the cortex found that the only permanent defects were a disturbance of the spatial localization of retinal impressions, and a disharmony between the movements of the eyes and of the hands.

We cannot, however, assume that there exist in the regions of the angular and supramarginal gyri centres which subserve the spatial orientation of retinal impressions and allied functions. Spatial localization, as Berkeley originally pointed out, is not a simple visual perception but must depend on complicated association processes. It is generally accepted now that, as Starling has so concisely put it, "the projection and localization of visual impressions are not intuitive or innate qualities attached to the stimulation of each point of the retina, but are the result of experience, the testing and comparing of visual sensations with tactile and muscular sensations from all parts of the body"; the association fibres between those portions of the occipital cortex

concerned in visual perception and the rest of the brain must be the main anatomical basis of this psychical synthesis. When they are interrupted spatial orientation is affected, though visual perception may be intact.

The angular gyri contain centres from which the movements of the eyes can be elicited, and it may be to damage of these portions of the cortex that the disturbance of ocular fixation, the failure to accommodate near objects, and the absence of the blinking reflex were due, in so far as they were not a direct result of the defective recognition of the position of the object in space, and especially of its distance.

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OBSERVATIONS ON EYE CONDITIONS MET WITH IN MALTA, 1916-1917,

Occurring among British troops in the Balkans and Malta
Garrison

The Montgomery Lecture, 1916-1917 *

BY

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(*Concluded*)

C.—Sunlight.

The pathology of sunlight is not apparently completely understood. A difference in action between the thermic and actinic rays is generally recognized, but observers differ as to which are the more deleterious.³ The result of the recent researches of Verhoeff and Bell,¹⁷ suggest that the actinic rays may have an irritative action upon the conjunctiva and cornea, but that, owing to their ready

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