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John B. Irving
B.Sc.

Abstract
A dissertation read before the Royal Medical Society on Friday, February 2nd, 1968.
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Loss of this ability, astereognosis, is usually considered as a defect in somatic sensation. A native of New Guinea, although he might be unable to recognise the objects commonly used to test for stereognosis, would not deserve to be given the diagnosis of a cortical lesion. His failure is a failure of learning. Patients suffering from dementia may show astereognosis as a consequence of a general deterioration in mental function. Learning and memory therefore play an important part in stereognosis, but in clinical practice and in physiology, more interest is taken in the function of the somatic sensory system.

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Loss of this ability, astereognosis, is usually considered as a defect in somatic sensation. A native of New Guinea, although he might be unable to recognise the objects commonly used to test for stereognosis, would not deserve to be given the diagnosis of a cortical lesion. His failure is a failure of learning. Patients suffering from dementia may show astereognosis as a consequence of a general deterioration in mental function. Learning and memory therefore play an important part in stereognosis, but in clinical practice and in physiology, more interest is taken in the function of the somatic sensory system.

Functional Anatomy

Classically, astereognosis is associated with lesions of the parietal lobe. This area is not a functional entity, being merely that part of the cerebral cortex beneath the parietal bones. A degree of functional localisation has been introduced by experiments in neuroanatomy and neurophysiology. Anteriorly, the post central gyrus is distinct on the evidence from studies of evoked potentials in animals, from stimulation experiments in conscious patients at operation and from degeneration studies in neuroanatomy. It has specific connections with the ventro-basal complex of the thalamus, the termination of the ascending somatic sensory tracts.

Posteriorly and inferiorly the lobe merges with the occipital and temporal lobes and the areas concerned primarily with visual and auditory stimuli respectively.

Between the primary sensory areas, there are the so-called "association" areas, of which the posterior parietal lobe is a part. It is often stated that this area is the centre for integration of visual and somatic sensations and for discriminative functions such as stereognosis. There is indeed evidence that somatic and visual stimuli may evoke electrical activity there. This activity however is non-specific, being of long latency and slow adaptation and similar results would be obtained by recording in any part of the cortex. Such a concept (i.e. separation of primary from discriminative or integrated sensation) cannot be tested from clinical studies since the pathological processes involved are not sufficiently precise.

The delineation of these areas in the cortex has been a consequence of the lack of accuracy in the techniques used. With the introduction of single neurone recording, it becomes necessary to look at the cortex, not as groups of independent neurones in boxes but as gradients of activity. Maximum somatic sensory sensation is found in the post central gyrus.

Having noted the anatomical bed in which

stereognosis works, the clinical aspects will be examined.

Clinical

Astereognosis is one of the agnosias, by definition a failure of recognition. Clinical examination, using such common objects as keys, coins, pen tops, is not designed to differentiate the types of agnosia. A convenient classification is into receptive (input) and executive (output). An example will show the difference.

Sperry *et al* (1962) studied patients who had undergone section of the corpus callosum for intractable seizures. In right-handed people postoperatively, astereognosis of the left hand was marked, if the responses were given verbally. However, correct answers were given when the patient selected the object from a list presented to the left eye. In other words, one side of the brain did not know what the other was doing. The agnosia was therefore due to a defect in the executive or output mechanism by virtue of the loss of connections between the somatic sensory area and the speech centre.

Geschwind (1962), in reviewing several patients with proven vascular lesions of the corpus callosum, described similar results. He went further to suggest that lesions of the posterior parietal region were equivalent to section of the corpus callosum since the only connections between the parietal lobes of each hemisphere arise in that area. Astereognosis, thought to be due to the disruption of the centre for stereognosis in the posterior parietal lobe of the non-dominant hemisphere, is more likely to be due to interruption of the connections to the speech area.

Clearly clinical tests should take account of these findings.

For example, Semmes *et al* (1959) studied a group of war veterans suffering from penetrating brain injuries of the parietal lobe. The patients, divided into groups according to the locus of the injury, as determined by X-ray, were given various tests of somatic sensory function. Results suggested that there were different patterns of localisation of function in each hemisphere. No attention was paid however to non-verbal testing so that the different patterns could be a consequence of an executive agnosia, due to separation of the somatic sensory area from the speech area in the contralateral hemisphere.

Smaller lesions, again war injuries, were described by Russell in 1945. The patients studied suffered superficial skull wounds involving only small areas of the cortex. The effects were usually transient. Several cases, in which lesions of the post central gyrus were demonstrated, showed a localised loss of stereognosis and two point discrimination in the contralateral upper limb. Tactile sense, light touch pinprick, was intact though somewhat changed in character, being difficult to localise. While this improved, astereognosis was nearly always permanent.

Stereognosis is clearly dependent on an intact post central gyrus.

In clinical practice, astereognosis is only important as part of the parietal lobe syndrome, which may be illustrated by a description of two cases with lesions of the right (non-dominant) hemisphere. Denny Brown *et al* (1952) reported in detail the case of a woman of fifty-two with a vascular lesion of the right parietal lobe. The most characteristic feature was complete neglect of the left side, especially when stimulated simultaneously on the right. The left arm was not recognised as part of her body, motor coordination was defective as shown by her dressing apraxia. Astereognosis and loss of two point discrimination was marked on the left, as also was poor localisation of site of tactile stimulation.

The second case, a patient of Dr. Jellinek, Northern General Hospital, is a fifty-six-year-old lorry driver. He was admitted to hospital following two accidents within one month, both involving cars parked on the left side of the road. Investigations showed that he had a large bronchial carcinoma with a single metastasis in the right parietal region. On clinical examination, he showed neglect of the left side. Astereognosis, loss of two point discrimination and poor localisation were noted. There was mild slurring of speech, marked motor incoordination as shown by his inability to walk and dressing apraxia. In hospital his condition deteriorated and he was discharged to terminal care. When re-admitted two months later, his condition was improved, clinical signs were much less marked and investigation with radioactive scanning showed that the parietal lesion had been reduced in size.

What conclusions can be drawn from these cases? Astereognosis is only important in clinical work as part of the parietal lobe syndrome. Present evidence does not allow

accurate localisation although the post central gyrus must be intact.

The second conclusion is that stereognosis and two point discrimination seem to be linked. Denny Brown, noting this, suggested that the function of the parietal lobe somatic sensory areas is to integrate spatial information — a process he called 'morphosynthesis'. It is not surprising that the two functions are linked since stereognosis is only a quantitative extension of two point discrimination plus information from joint receptors. The additional essential feature of morphosynthesis is coordination of movement. This is recognised from personal experience — one normally identifies objects by rolling them in the hand, and from experience of hemiplegic patients who show astereognosis on the affected side.

Neurophysiology

The concept of morphosynthesis is attractive when considered in relation to neurophysiological findings, on which further study of the processes of integration must depend.

Mountcastle *et al* (1957, 1959, 1960), using microelectrodes, studied single neurones in the somatic sensory areas of the cortex in cats and monkeys. Two distinct populations of cells were found. Group 1 were more numerous. The characteristic property was the response, of short latency and rapid adaptation, to a stimulus in a specific small receptive field. The stimulus was either hair bending, light touch or gentle joint rotation and the response could be inhibited by stimulating areas round about the receptive field. Cells in the ventrobasal complex and in the gracile and cuneate nuclei of the dorsal columns of the spinal cord had similar properties, suggesting that information is transmitted in independent channels to the cortex. Integration relies on surrounding inhibition to make the stimulus discrete. Secondly, movement is important because of the property of rapid adaptation. In other words, when the object remains in one part of the hand, the initial activity, signalling that the object is present, would rapidly fade and no recognition would be possible. Movement reinforces the neuronal activity.

The presence of an object appears to be appreciated in the form of neuronal activity in anatomically fixed parts of the somatosensory cortex. The evidence for this fixed pattern is that:— there is an accurate point-to-point representation of the body surface in the post central gyrus; all cells recorded in one vertical tract of the microelectrode have receptive fields in one area of the body, the size of the field depending on the concentration of receptors in that part of the body; neuroanatomical studies show that the cortex is organised in a vertical direction; and studies in monkeys showed that no learning nor behavioural changes were detected after multiple sectioning of the somatic sensory cortex in small vertical planes, i.e. intercortical connections were not important, at least in tactile conditioned behaviour. Microelectrode studies in the visual cortex have shown a similar pattern of organisation.

The second group of cells tended to be recorded from random depths in the cortex, in contrast to Group 1 which tended to be found most often in the IVth layer. The responses to stimulation were characteristically sensitive to depth of anaesthesia, slowly adapting and of long latency. The receptive fields were large, at times ipsilateral and labile. Such properties are characteristic of a multisynaptic pathway.

Neurophysiological-Clinical Correlations

Clearly this activity would be too imprecise for the type of sensation required for stereognosis. The two groups of cells appear to be mutually antagonistic since activity in Group I inhibits that in Group II. This may be important clinically since the two systems resemble the characteristics of the two types of sensation proposed by Head and Holmes (1927) i.e., epicritic (Group I) and protopathic (Group II). Following cortical lesions, the character of tactile sensation appears to become more protopathic. Is it possible that cortical lesions selectively destroy Group I cells? This might be true for ischaemic lesions which result in pronounced necrosis of the IVth layer of cells, but it would be difficult to explain the gunshot injuries on the same basis. Such a hypothesis would be worthy of investigation, considering the nature of the residual sensation i.e., poor localisation and defective stereognosis.

Group I cells seem well designed to carry out the process of morphosynthesis, the initial step in stereognosis, taking place in the post central gyrus. The cells respond to light touch, hair bending and joint rotation, partic-

ularly if the stimulus moves so that no one group of cells are active for a long period. Joint sensation seems to be particularly important for posture, for knowing where the body is in space and for recognition of three dimensional objects. This could be demonstrated in the experiments of Provins in which he injected local anaesthetic into the joint capsules of the interphalangeal joints (1958).

Conclusion

In summary, therefore, the physiological processes underlying stereognosis have been examined, with particular reference to clinical observations of patients with parietal lobe lesions. Little attention has been paid to the psychological aspects of such lesions, to the influence of learning and to the extent of adaptation to a disability.

The evidence suggests that stereognosis requires an intact post central gyrus in much the same way as peripheral sensation requires intact spinal nerves. The rôle of the posterior parietal region is less well defined. In clinical practice however, astereognosis is only important as part of the parietal lobe syndrome.

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