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VARIATIONS ON A NEUROLOGICAL THEME— CORTICAL LOCALIZATION*

BY

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On another occasion (Jefferson, 1953) I traced the attempts made by many up to the mid-1880's in the study of the anatomy and histology of the brain, and by way of excisions and stimulations, in the hope of finding some local signs of function in the cerebral cortex. It was clear that clinicians 100 and more years ago had not been able to relate experimental findings with the manifest results of disease. The story was taken from about 1800 to 1884, the date of Rickman Godlee's removal of a brain tumour clinically localized in the light of the new neurology. Although electrical stimulations had been used before, success was finally achieved by Fritsch and Hitzig and David Ferrier. Either the stimulations had been confined to the wrong places or the animals' conditions had become so bad as a result of blood loss and the roughness of the surgery that the brains were inexcitable to the crude stimuli used. Or else, again, the experimenter had been so surprised (as was Robert Todd's fate) by what happened that he noted it and passed on to verify the classically accepted beliefs that no motor activity could be evoked from anything higher than the mid-brain. Everything below that level gave responses.

It should, I think, be interesting if, without covering exactly the same field again, we were to try to find whether Hughlings Jackson had had any intimations hinting that it would not be against probability if function were not as diffusely spread in the cerebral mantle as it was currently held to be, something that would encourage him to search in his clinical material for signs suggesting very strongly restricted locations of origin. Events were to prove Jackson a real discoverer. Others before him had observed the same phenomena as those he saw—Bravais for one—but had failed to draw a deduction, had been content to describe a localized or unilateral fit and leave it at that. It has to be recalled that the current theory, about the year 1865, was that the cerebral hemispheres acted as a whole through the "Will" upon the motor effector systems which were situated in the spinal cord and brain stem as high as the basal ganglia. It needed some courage to break away from this view, one that had the authority of all the great names in neurophysiology.

Jackson and Herbert Spencer

Jackson was outspoken in expressions of respect for the philosopher Herbert Spencer. In his writings he

often spoke most warmly of his indebtedness to Spencer's general concept of nature, of the evolutionary process in human races and in animals, both in a physiological and in a sociological sense. It is not recorded whether Jackson and Spencer met. Jackson certainly sent Spencer a reprint of one paper (see Spencer's *Life and Letters*, 1908, p. 227), but he does not appear in the much longer *Autobiography*, in which so many names are mentioned. Jackson was one of the 80-odd signatories in 1896, the majority Fellows of the Royal Society, proposing that he sit for the portrait which Sir Hubert Herkomer shortly painted. It is difficult, 100 years later, for us to understand the great hold which Herbert Spencer had on British and foreign thought, to accept his once immense reputation. Spencer does not rate a mention in Bertrand Russell's *History of Western Philosophy* (1949); yet that is understandable, because Spencer made no strikingly original innovations in thought; he was in the main a sociologist, what one might call a physiological political reformer basing his views on an evolutionary theory of human society and of man's mental powers. His *First Principles* (1862) was early translated into Russian. The youthful William Osler read the book as a matter of course when he entered Trinity College, Toronto, as an arts student.

We know that Herbert Spencer believed that as organisms developed they progressed from the most simple to the most complex. The concept of a passage of the plant and animal kingdoms from homogeneity to heterogeneity he had got from von Baer. This change would be the essential anatomical feature of evolution. It made a deep and lasting impression on him. Spencer made an important advance on von Baer, holding that, having reached sufficient complexity, organisms became more unstable and were liable eventually to the reverse of evolution—namely, dissolution. It was this notion that Hughlings Jackson used with such force and penetration in his study of the nervous system. It became the idea which underlies so much of Jackson's thinking and was the title of some of his famous papers—the Croonian Lectures entitled "Evolution and Dissolution of the Nervous System" (1884). Spencer believed that the instability of highly complex organisms was due to their chemistry. The nitrogenous compounds would, he thought, be especially liable to lability. Perhaps this was the source of Jackson's idea, mentioned in his studies of convulsions, that the nitrogenous components of brain cells very likely became altered if the cells were diseased. They would demonstrate their then "explosive" qualities by producing fits.

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Spencer on Localization

But had Herbert Spencer, we ask, anything to say specifically about localization? Indeed he had. We find, for example, the following clear and unequivocal statement in his *Principles of Psychology*, published exactly a hundred years ago.

"Whoever calmly considers the question cannot long resist the conviction that different parts of the brain must, in some way or other, subserve different kinds of mental action. Localization of function is the law of all organization whatever; and it would be marvellous were there here an exception . . . it cannot be denied, without going in direct opposition to established physiological principles, that these more or less distinct kinds of psychical activity must be carried on in more or less distinct parts of the cerebral hemispheres. . . . Either there is some arrangement, some organization in the cerebrum or there is none. If there is no organization the cerebrum is a chaotic mass of fibres, incapable of performing any orderly action. If there is some organization it must consist in that same 'physiological division of labour' in which all organization consists, but there is no division of labour, physiological or other, but what involves the concentration of special kinds of activity in special places." There, then, we have it—special kinds of function must be localized in special places.

But how did this earnest, voluminous, and, it has to be confessed, prosy writer yet persistent and powerful thinker come to be interested in nervous activity, to have arrived at such conclusions, admirable in our day, still without complete proof in his own early period? That he was fascinated by psychology should not surprise us of this present age, since the subject has always been and remains a paradise for the amateur. In Spencer's time there was this as well—that it was still just possible for an intelligent and hard-working man to make himself familiar with many branches of science and with medical and physiological theory. Also he was a philosopher and metaphysician, and most of that is psychology disguised. But that does not tell us how it came that this son of a Derby schoolmaster, and a junior railway engineer engaged for some time on developments of the Birmingham and Gloucester Railway, should have turned away to such different pursuits. His education had been very incomplete; he never, as he admitted, passed an examination, but he grew up under his father's influence to suspect and if possible reject accepted theories, and that is good training. He was an agnostic before Huxley had invented the term.

The story of his youth and of his own evolution he told at prodigious length in his *Autobiography*, finished in 1894 but not published until 1904. From it we learn (vol. 2, p. 103) that since boyhood he had been interested in natural history and especially entomology, that he became a constant reader of medical books and journals. He attended Richard Owen's lectures on osteology and later reviewed Owen's book *Principles of Comparative Osteology* for Dr. (later Sir Ernest) E. H. Sieveking's quarterly *British and Foreign Medico-Chirurgical Review* (1858), finding fault with some of Owen's views, a feat repeated with greater pugnacity by Huxley. For the same quarterly he wrote in 1860 a 15-page critical review of Alexander Bain's *The Emotion and the Will*. Spencer attributed his success in grasping biological truths better than most people to an inherent aptitude for laying hold of cardinal facts. The reason for his absence of wrinkles, he told George Eliot, was that he never had to puzzle out a problem—the solution came to him unawares by the unconscious association of different pieces of information. Though a firm believer in what he called his "development theory" to explain evolutionary progress by the instability of the chemical structure of living organisms, he had not by 1860 hit on Darwin's revelatory deployment of the facts of observations much more extended and particular than his own. He accepted Darwin's theory at once, but thought that it needed a few touches. However, once Darwin's books began to appear and Huxley to expound and

defend Darwin's conceptions, a good deal of Spencer's glory departed, though he still held some place in the esteem of scientists.

That Herbert Spencer's sun was already setting was made plain at the time of his death. The Very Rev. J. Armitage Robinson, Dean of Westminster, replied on June 17, 1904, to the signatories of the petition for the erection of a memorial to Herbert Spencer in Westminster Abbey. He noticed that the memorialists "did not claim that Mr. Spencer has or will have a high place as a philosophical thinker. When I ask with what important achievement in philosophy, or natural science, or with what permanent contribution to thought his name is destined to be connected, I meet with no satisfactory reply."

Sir Gordon Holmes tells me it is his impression that in his later life Hughlings Jackson referred to Spencer less frequently than had been his custom in his middle period.

His turn towards an interest in philosophy Spencer attributed to his friendship from 1850 onwards with G. H. Lewes and the reading of that man's *Biographical History of Philosophy* (1845-6). Further, from 1852 onwards he had become a companion for walks and talks with T. H. Huxley and learned much from him and from Hooker, the botanist. But still we have nagging at us this question of Spencer and the source of his views on cerebral localization. The answer is eventually simple. It turns out that he was for many of his formative years a convinced phrenologist. A second clue is that he refers several times in his *Autobiography* to the deep impression made on him by a phrase of Milne-Edwards's. This he found in a book lent him by G. H. Lewes. It enumerated the principle of "the physiological division of labour" found in the more elaborate organisms—words that we have seen him quote as a feature of the nervous system in the passage reprinted above.

Spencer's Interest in Phrenology

Spencer left it on record that when he was 11 years old—that is, about 1831—he had heard a series of lectures on phrenology given by Dr. Spurzheim, who was going round the country diffusing the ideas of Gall. In 1844-5 he had three papers published in *The Zoist*, a journal newly launched under Dr. Elliotson's editorship and devoted, as the subtitle declared, to "Cerebral Physiology and Mesmerism and their applications to human welfare," a new pseudo-science sometimes called "mesmo-phrenology." Spencer's contributions were all written in strictly phrenological terms and in his already pompous manner. The first was a new view of the functions of Imitation and Benevolence, in which he agreed with the accepted proximity of the organs of Self-esteem, Love of Approbation, of Adhesiveness, Concentrativeness, Secretiveness, and Cautiousness. His second paper, next year, was on the situation of the organ of Amativeness (sexuality), which he placed as the result of a study of amative persons (he gives no details) in the under surface of the occipital lobes and not in the cerebellum, as was the vogue at that time. The third communication was "A Theory Concerning the Organ of Wonder"; but we need not trouble to find out what it was. The clear fact is that he was so far a convinced phrenologist and therefore quite necessarily a confirmed believer in functional localization in the brain.

It is known that he had offered these lucubrations to George Combe, of Edinburgh, the chief proponent of phrenology in the British Isles and editor of the well-established *Phrenological Journal*. They had been rejected. Spencer was deeply wounded by this affront; he is known to have been, and was to remain, exceptionally sensitive to criticism, and no doubt in spite of Dr. Elliotson's friendliness he became a sceptic instead of an acolyte. He had his own head read in 1842. Firmness and self-esteem were reported as its outstanding features, and he was told that "such a head as this ought to be in the Church." Further, Spencer constructed a cephalograph, an apparatus for measuring heads accurately. It is described in the Appendix to the *Autobiography*, where also will be found another of

his inventions, a bed which is the prototype of the "heart" or modern neurosurgical bed, complete with lateral tilting movement.

He later wrote of his quondam beliefs, "Partially dissatisfied though I was concerning special phrenological doctrines, I continued an adherent of the general doctrine, not having, at that time, entered on those lines of psychological inquiry which led me eventually to conclude that, though the statements of the phrenologists might contain adumbrations of the truth, they did not express the truth themselves." Yet some small attachment remained, and was in part responsible for the perceptive statement for the necessity for nervous organization.

By the time his *Principles of Psychology* had been written he had learned more anatomy and physiology and had made friends with an exciting group of people, amongst them the household of Charles Bray at Coventry. Here he became the close friend and warm admirer of George Eliot and through friends of theirs with George Henry Lewes, George Eliot's lover, whose *Physiology of Common Life* was said by Sherrington to have turned Pavlov towards physiology and is mentioned by the character Raskolnikov in Dostoevski's *Crime and Punishment*. Odd that Lewes's dull little book should have excited so widespread an interest. Yet we have to remember that the first three-quarters of the nineteenth century was a period vibrant with interest in natural phenomena, in science in all its forms. It closely matched our own, and if their science seems easy to us so will ours appear 100 years from now. Be that as it may, it was George Eliot who persuaded Lewes to include Gall in his *Biographical History of Philosophy*.

Lewes, with Maudsley, was amongst the first in England to relate mental processes to physiology, but he was bothered by Gall's contention that the different activities of the mind could be effected by different parts of the grey matter, all of which seemed to him to be as uniform in texture as the folds of a piece of velvet. Lewes is in some degree correct here: there are differences in the structure of the grey matter, but not so many as to account for every way of thinking or every kind of emotion. Lewes was as wrong as he could have been in denying that there were any centres of any kind in the brain, though in later years he corrected himself.

Charles Bray and His Circle of Friends

We may get some further interest by visiting Charles Bray and taking note of the literary and sociological effects which the doctrines of localization of mental qualities aroused.

The reader of Lawrence and Elisabeth Hanson's admirable book *Marian Evans and George Eliot* may well have had his curiosity aroused by some early references to Charles Bray, his wife Caroline, and the household at "Rosehill," Coventry. Speaking of Marian Evans, a warm friend of and a frequent visitor to the Brays, with whom she met Emerson, who instantly admired her, the authors say of the impression that she made on Bray, "If this girl was plain—and that could not be denied—she had brains and she had humour and something else besides which made the features of little account. And her head development, he [Bray] now saw, was positively prodigious. Phrenologically speaking, she was a remarkable subject; he longed for Combe to be there, and could scarcely restrain himself from rushing his visitor off to have a cast taken" (pp. 50-1).

Four years later, in July, 1844, Bray succeeded in interesting Marian Evans sufficiently for her to have the cast made by James Deville in the Strand whilst they were in London. Combe declared it to be like a man's. Miss Evans's head circumference measured 22½ in. (56 cm.) (which is not very remarkable). Bray himself had already had his head shaved, and rushed off to London to have a plaster cast struck. Writing of this event long after, Bray (1884) said: "I found afterwards that having my head shaved was quite unnecessary, as the hair when properly dressed for taking a cast interferes very little with the taking of the development; making no greater difference than there is sometimes between

the external and internal plates of the skull, viz. for one-tenth to one-eighth of an inch, while the difference between a large and a small organ of the brain is from an inch to an inch and a half."

Charles Bray was by all accounts a remarkable man, the friend of Robert Owen, filled with that moral earnestness and conviction of the perfectability of man that animated the early Victorian scene and made it so vital a period. He was warm-hearted, impetuous, intelligent, talkative, sincere, high-minded, honest—the most flattering adjectives pour out to describe him, and deservedly. Yet he was certainly naive, for listen to him describing his honeymoon in North Wales with the 21-year-old Unitarian of the Priestley school—Caroline (Hennell). He expected, he said, to convert her to his own Evangelical Methodism. "Consequently I had provided myself with Mirabeau's *System of Nature*, Volney's *Ruins of Empires* and other light reading of that sort to enliven the honeymoon. But again I was mistaken and only succeeded in making my wife exceedingly miserable." He had to admit that although she had very large reflective faculties her perceptive faculties were small.

This girl, Caroline Bray, was the "Dearest Cara" to whom George Eliot was more devotedly attached than to any other woman throughout her life. It was here, as well as in frequent walks on the terrace of Somerset House, that George Eliot became so close and so welcome a companion to Herbert Spencer that the waning of their friendship hurt her deeply. It was, one can well imagine, a blessing in disguise: Spencer, though he liked the society of women, never loved anyone as much as himself, and retired into a permanent hypochondriacal bachelordom, his "head symptoms" and insomnia brought on, he thought, by the poor oxygenation of his brain, for which his small lung capacity was responsible. He had a theory for everything. He, perhaps, as was said of a Canadian Prime Minister, knew more answers than there were questions belonging.

George Eliot

Deep traces can be found in the writings of George Eliot of her interest in science and also of the differences in character upon which the phrenologists had insisted. Not only are there many playful references to phrenological characteristics in her enchanting letters but there are more in her novels—she takes the greatest care to describe the appearances and characteristics of her dramatis personae. Her great art, as in that of Trollope, was that her characters always behave "in character," unlike those of Dickens, in so many of whom cold or even ruffianly behaviour masked an unexpectedly warm and generous heart.

What has come of this kind of cerebral localization to-day, this localization of such attributes as love of children, of music, capacity to remember, veneration? All gone, of course. But not without leaving its traces on neurology by the paths sketched at the beginning of this paper. And never again completely lost. Phrenology has given place to the studies of the shapes of people's faces, their expressions, the contours of their bodies, their muscular development. Kretschmer did this service to psychiatry by describing the schizophrenic and manic types. More recently, Sheldon in the U.S.A. and Parnell at Oxford have worked out somatotypes dividing humans into three main types—the endomorphs, mesomorphs, and ectomorphs—the last the most linear in shape, the endomorphs rounder. The mesomorphs, those with most bone and muscle development, comprise the majority of undergraduates who achieve a good all-round performance at sport as well as work. They do not (or may not) reach the highest academic level in first-class honours, but they seldom get a third class or less.

Real Physiology of the Brain

Was Herbert Spencer right in declaring that special function must be concentrated in special places? Yes, of course. But we see to-day that this, once so satisfactory, is an insufficient explanation of how the brain works. It tells us

nothing of relationships, for which a knowledge of the harmony and co-operation of the units which comprise it is essential. This is the real physiology of the brain, the subject on which Hughlings Jackson himself expended so much of his hardest thinking. Jackson's knowledge of cortical function was inadequate, but that did not prevent him from the formulation of a majestic conception of the brain's actions. Since his day we became too engrossed by the cortex. In recent years attention has shifted back again, none too soon, to the subcortex—to the brain stem and basal ganglia—in a way that earlier generations would have recognized as a search for integration along paths fainter in their day but nevertheless familiar. The new work has come largely from the Canadian school led by Wilder Penfield and Jasper, the Americans led by Ranson and Magoun and their many pupils, and also from Adrian in England and Bremer in Brussels.

Our current knowledge of the cortex and its deeper connexions has been made possible by modern technical inventions. If the conception of the centrencephalic system, to use Penfield and Jasper's term for a lower level integrating centre—a concept not, it is true, accepted by all—runs counter to Jacksonian levels, if higher levels physiologically seem to be lower anatomically, and therefore not to fit very well, we have no right to say that the proposition is necessarily wrong. It may not indeed be the last word, yet it fits well with neurosurgical clinical experience. We see the powers that reside in human minds called into being along the ancient pathways which man shares with the animals—but with a final result so different because of the immense potential cellular wealth of the cortex and the vast richness of its relays and communication systems. We see them destroyed by lesions at mid-brain level more completely than anywhere else.

This is the crux of the new plan of integration in which cortical localization has its proper and honoured place. If we no longer believe that such things as love and loyalty, tenderness and friendship and happiness, have special abodes in the brain, yet we know that some such attributes exist, fictitious as definite entities though they may be, and that they are the by-products of the harmony of body and brain.

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The annual report of the Marie Curie Memorial Foundation for 1954-5 records the continuing progress of this organization and the excellent work it is doing. Some interesting details are given of the cancer talks which were available through the Hull Phonodiary Service (see *British Medical Journal*, October 2, 1954, p. 802). Three recorded talks were made lasting for 2½ minutes each. The first was on signs and symptoms, the second on methods of treatment, and the third on progress of research. The first talk was available to subscribers on the Hull telephone exchange for 12 weeks, and the average number of those who listened to the talk each week was 429. Thirty-two trunk calls were made during this period from inquirers living outside Hull. The second talk was available for 15 weeks, and 369 people listened to it on an average each week. The third talk was apparently not so popular, the average number of listeners per week being 221. It is considered that the main advantages of this method of health education by telephone are that the person making the inquiry remains anonymous and that it is possible to check the number of inquiries made without destroying this anonymity.

FLUOROSIS IN NALGONDA DISTRICT, HYDERABAD-DECCAN

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Fluorine is one of the trace elements normally present in the body, and, in small amounts, exerts a beneficial influence on the enamel of teeth. Fluorine is found in most foodstuffs and in drinking-water in areas of endemic fluorosis. Fluoridation of public water supplies has lately been undertaken in the United States, so that to-day nearly sixteen million people in the U.S.A. are drinking fluoridated water, and a marked reduction in dental caries has been noted (Ast *et al.*, 1950; Schlesinger *et al.*, 1950; Heyroth, 1951, 1952, 1953). Stones (1954) has reviewed in detail the subject of fluoridation of domestic water supplies so far as it controls dental caries.

The amount of fluorides required for industrial purposes exceeds 500 million pounds (226,796,000 kg.) (Largent and Ferneau, 1944). Industries such as mining, and the conversion of phosphate into superphosphate, a common fertilizer, and the manufacture of glass, enamel, and aluminium, expose workers to appreciable dangers of excessive fluoride intake. Industrial exposure to fluorine is now known to produce a form of osteosclerosis, to which its Danish discoverers, Møller and Gudjonsson (1932), have given the name fluorosis.

Adequate research on the industrial and experimental aspects of fluorine intoxication has been carried out in Britain, Europe, and the United States. In India the pioneer work on endemic fluorosis was done by Shortt and his collaborators (1937a, 1937b). In Hyderabad-Deccan this field has so far remained unexplored from a clinical point of view, although fluorosis is prevalent in many parts. This paper therefore proposes to bring forward in detail the various clinical features of the disease, with special reference to attendant neurological manifestations, both in human subjects and in animals.

The Investigation

The villages of Kamaguda, Yedvelli, and Yellareddyguda were chosen for investigation. These villages lie close to each other, about 50 miles from the city of Hyderabad, in the Nalgonda District. The climate is hot and in summer the temperature touches 115° F. (46.1° C.) in the shade. The average annual rainfall is 25 in. (63.5 cm.). The soil is sandy and consists of granite associated with fluorite. Work on tobacco plantations is the main occupation of the people.

The populations of Kamaguda, Yedvelli, and Yellareddyguda are 95, 813, and 1,100 respectively. The general standard of living is low, the hygienic conditions are poor, and the system of disposal of sewage is inadequate. There are 2, 13, and 84 wells respectively. Twenty-eight samples of drinking-water were analysed for their fluorine content—2 from Kamaguda, 13 from Yedvelli, and 13 from Yellareddyguda. The concentration of fluorine varied between 9.2 and 11.8 parts per million in Kamaguda, between 5.5 and 6.8 in Yedvelli, and between 2.5 and 7.5 in Yellareddyguda. The concentration of fluorine in the water used by the patients, and in the mud samples obtained from these wells, is shown in Tables I and II.