ASYMMETRY OF CEREBRAL FUNCTION*

By

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It is the custom of our times to explain neurological, and, to some extent, psychiatric disorders by reference to a static or diagrammatic conception of the physiology of the nervous system, linked with the findings of morbid anatomy. But, in the words of Riese (1950), expressed in his *Principles of Neurology:*

"Can the behaviour of a living organism be interpreted as purely mechanical? Though the organism remains submitted to the law of mechanics and physics, and though it is to the benefit of a steady improvement of our factual knowledge to explore the mechanics to the maximum possible, we must recognize that in a living organism mechanics are not left to themselves (which means to chance), but that they are at the service of a directing agency best described as the organism's welfare. The reflex must be conceived as an instrument of this agent. All disorders analysed and described in terms of reflex action are only instrumental ones. Neither the physician's task nor his possibilities extend beyond this limit. The directing forces of the organism will be withheld forever from the physician's acting power, if only for the reason that these forces are just ideas or principles of interpretation, but not perceptible realities."

Elsewhere in the same work, in one of his finest sentences, Riese criticizes the *mechanical restrictions* which present-day forms of study impose upon our attempts to *understand* the human organism:

"It remains to be seen how long the self-inflicted limitation to purely instrumental activities and the neglect of man's free decision as an inner voice (not necessarily enunciated by man's acts) will stand the test of time and the unavoidable re-awakening of the individual; man experiences himself *primarily* as endowed with will-power and judgment rather than with pathways and nuclei."

It is the intention of this paper to outline (mainly in the classical manner which depends upon the concept of increasingly complex "levels" of performance of nervous tissue running parallel with progressive achievements of perception and volitional activity), certain notions derived from clinical experience about specialized functions; to consider the relation of such specialized functions to the form of the structures of the brain; to show the importance of the development of functions asymmetrically in structures which are themselves symmetrical.

As Riese says, and as we as ordinary citizens confirm, "Man experiences himself *primarily* as endowed with will-power and judgment rather than with pathways and nuclei." In health we think of ourselves as units, single persons. We express ourselves by the use of *personal* pronouns and adjectives (and, in fact, in all grammatical forms), so to give the effect of units. Thus we say, "We are human beings". "I am talking", "They are sitting down". We are aware of the parts of the body, which we can, for some chosen personal purpose, consider

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as units in themselves. We then say, "My right hand", "My left leg", "My eyes", and so on. But we still preserve the unit concept in the personal pronoun "My".

In some of the gravest forms of mental or nervous disease, we find, not that many forms of local disability are noted by the patient, but that, without special complaint of paralysis or sensory loss, the patient is no longer able to behave as an integrated unit. Because of defects of unitary function, usually labelled as defects of judgment, memory, behaviour, the patient is no longer able to adjust himself to living, and has to be specially cared for, on the grounds of "dementia" or "psychosis". Such patients are commonly found to have damage diffusely or heavily scattered through the substance of both halves of the brain. In head injury, metabolic, infective, arteriopathic, deficiency and drug-induced conditions and probably some psychiatric conditions, the patient loses his functional identity against the background of normal social activity, and is totally disabled.

Such a patient has sometimes lost his self-awareness and appreciation of himself as a single social entity to such a degree that he does not realize that his behaviour is not normal; nor that there is anything unusual in his being confined to the ward or even to a bed in a closed mental institution, such as a mental observation ward. He will be the last person to discuss the fact of his incontinence. He will not complain. If he has some vague notion that he is not free to go about his life normally, he will take no effective action to ensure an alteration of circumstances.

Between this state of total social disability, usually called "dementia", and the total performance of the person in full possession of mental and physical health, lie those disorders which occupy clinical neurology and psychiatry. For these two specifications there are fairly well-defined extremes of clinical categories; but at the "mental" end of neurology and the "physical" end of psychiatry there is no clear point of departure from one discipline to the other. The present paper, originating in neurological clinical material, deals with neurological symptoms and signs, even though it is fully realized that often in the "functional" disorders one may have to do with problems most suitably dealt with by psychiatrists.

We have now to study the following categories of disorder of cerebral function:

(*i*) Effects of damage to either of the brain hemispheres which are not side-specific.

(*ii*) Effects of damage to one or other cerebral hemisphere, which are side-specific:

  (*a*) Signs of major hemisphere damage. Disorders of language.

  (*b*) Signs of minor hemisphere damage. Disorders of spatial orientation.

I. Effects of Damage to Either of the Brain Hemispheres which are not Side-specific

Under this heading are those forms of simple hemiplegic signs which are found on the opposite side of the body from the side of the brain lesion, whichever side of the brain is damaged. These signs are, for many physicians and some neurologists, the only neurological evidence upon which they rely: but such signs, which are interesting, important and essential as a basis for clinical practice, are likely, as knowledge advances, to be regarded as an expression only of the most crude forms of dysfunction. They are sometimes absent even at a late and disastrous stage of a nervous disease. Among such signs are gross alteration of behaviour, swelling of the optic discs, simple hemianopia, commonplace alterations of movement and sensation, changes in tendon reflexes and the plantar responses. Lesions producing these signs, and others of routine neurological testing, may be thought of as *situationally-specific in the antero-posterior axis of the hemisphere* (but not in the side-to-side axis of the hemisphere, that is, *not side-specific*).

From this statement there emerges, *per contra*, the suggestion that other categories (in the higher or more complex forms) of disorder will be determined by the side of the brain in which the accompanying lesion occurs. Such lesions are *side-specific about the longitudinal axis between the two hemispheres;* and at the same time, less situationally-specific antero-posteriorly than those causing the simpler manifestations of unilateral brain damage.

After this deliberately brief summary of the familiar signs of the non-side-specific effects of brain damage, we pass to the more complicated, more variable and less frequently studied matters of the *faculties in health*, and *symptoms and signs in disease*, which may be associated with specialization of brain function within each brain half.

The right and left cerebral hemispheres are *not anatomically differentiable, except for the feature of being mirror-images of each other*. That is to say, even the most expert neuro-anatomist cannot tell from a very thin vertical section of brain, whether he is looking at the front of a piece of right hemisphere or the back of a piece of left hemisphere. Yet it is our tradition to relate the establishment or possession of certain functions, such as *language*, with the "handedness" (in its broadest sense) of the person. One consequence of this idea is that, since (i) the left half-brain "controls" the right half of the body, and (ii) if what we call a right-handed person loses many of his language capabilities when he has left half-brain damage, therefore the left hemisphere is *responsible* for the maintenance of the language function. (Thus description conforms with current neurological parlance though it has been suggested (Gooddy, 1956) that some notions of cerebral localization and representation are not well founded.)

We determine a person's handedness by observing unilateral preferential use of either structure or function, after a careful survey of cultural and familial habits. But it is important not to forget that in all the activities which are used to signify handedness (writing, kicking, looking along a sight or optical tube) the whole body has to be stabilized; and often the other limbs and the trunk, as in writing or kicking, are essential for the complete act. Unilateral usage of a limb, with or as a tool, is forced upon the user because there is only one opportunity in action, though two structures or functions (left and right hands: left-handed and right-handed writing). Therefore the use of a single tool (e.g., pencil, monocular microscope) to achieve the passage of information, forces upon the person a form of competition between the left and the right. *The decision to use one side rather than the other implies the special training of the chosen side and the positive rejection of the other side*. This *selection* must have been contemporaneous with the earliest use of tools and the durable (written, painted, carved, inscribed) expression of language symbols. This neurological event, until very recently the most important evolutionary advance yet made, can be dated in the Sumerian era, about 4,000 years ago.

IIA. Language Testing and the Major Cerebral Hemisphere

Having determined handedness, we may apply tests to patients to see if the language faculty is disturbed. This subject is huge, for language includes not only the spoken and written word, but also the symbol manipulation which underlies mathematics and the special languages of other branches of science, musical notation and other art forms, dance and mime, and simple gestures.

It is our custom to test first the patient's capacity to name objects. Though some authors state that nominal dysphasia signifies damage to the major temporo-parietal region, this not very discrete localization by no means always holds good. It is perhaps easier to agree with Goldstein, that nominal dysphasia is a sign of a fundamental change of behaviour. Loss of recall of names is often purely functional, and due to stress or tiredness. It is also a form of pure memory defect, and may be seen with diffuse brain damage alone. When we carry out tests for the expression and grammatical use of the various symbols with which the patient is familiar—and then the understanding of those symbols—we are in a better position to judge whether the lesion is anterior or posterior in the major hemisphere.

Simple Scheme for Language Testing

(*i*) The patient is asked to name up to 20 objects with which he is familiar. The name of the object and the patient's answer are written down by the observer.

(*ii*) The patient's *ability to express himself in spoken words* is judged from his conversation and his answers during history-taking.

(*iii*) The patient's *ability to express himself in written words and other symbols* can be judged from his letters or from a written specimen specially requested of him.

(*iv*) *The patient's ability to comprehend spoken words* can be tested by giving him instructions of increasing complexity.

(*v*) *The patient's ability to comprehend written words* and other symbols can be tested by giving him written instructions, in words or in other symbols with which he is familiar (e.g., mathematics, musical notation).

The clinical entities which many observers consider deserve the names of "apraxia" and "agnosia" will not be discussed here, for their nature is often difficult to define and their relationship to lesions inconsistent. Those readers who consider these conditions are associable with lesions in certain places, and also have side-specificity, have additional evidence of specialized functions derived from non-anatomically specialized structures.

IIB. Spatial Orientations and the Minor Cerebral Hemisphere

From a careful study of cases of unilateral brain damage (Gooddy and Reinhold, 1952, 1953) the writer believes it is fair to state that in the same way as we judge the major hemisphere essential for the control of language function, so we may judge the minor hemisphere essential for the perception and use of spatial information, underlying the faculty of spatial orientation. By spatial orientation is meant the person's capacity to relate:

(*i*) himself to extra-personal space;

(*ii*) one half of his body to the other; or one part of his body to another part;

(*iii*) various objects of extra-personal space one to another.

In disorders of these relationships we find geographical disturbances, so that the patient cannot use actual or mental maps and plans; he gets lost in familiar surroundings. He cannot direct people in the street and may not be able to dress himself. He cannot make letters, designs and drawings, even though he knows what is wanted of him. This last disturbance may account for some cases of "constructional apraxia" associated with minor hemisphere lesions. Other complicated "agnosias", such as "autotopagnosia" (loss of awareness of relations of parts of the body to each other), or "prosopagnosia" (loss of recognition of faces), may also be found if the right tests are used.

Of particular importance in patients with minor hemisphere lesions is the investigation of their understanding or possession of what is commonly called the sense of direction. Thus many of them are unable to understand or draw a simple arrow form (Fig. 1).

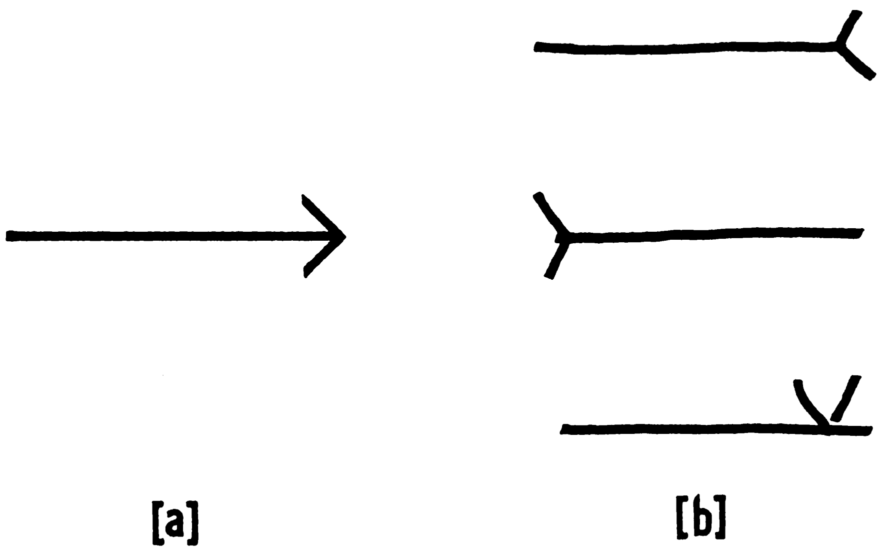

FIG. 1.—(*a*) Model for patient to copy. (*b*) Some abnormal arrow-forms drawn by patients with minor hemisphere disease.

It is implicit in the capacity to use space (*i*) to be able to *navigate* normally (which minor hemisphere damage patients cannot do) (*ii*) to have a proper awareness of the passage of personal and government time (Gooddy, 1958, 1959), because navigation is the accurate adjustment of space units to time units. The navigator in a ship or aeroplane says, "If I go in a certain direction (degrees and minutes of arc, indicated by a compass), for a certain time (indicated by a chronometer) at a certain rate (miles per hour, knots, etc., indicated by a tachometer) I shall arrive at X at noon". Human activity is identical in process, but achieved by the use of internal instruments. The well-known finger-nose test serves to illustrate the process of personal navigation; as do more obviously, walking, keeping appointments, writing, and all activities in which the body or its parts are in chosen places at the right time.

So far we have been considering matters generally familiar to advanced neurologists and psychiatrists, even though there may be some variation of opinion about details. We have found unequivocal evidence that *in, or by means of, identical-but-for-their-mirror-form hemispheres, damage to one will produce certain effects which are not seen when the other is damaged—that is to say, the achievement of localization of special functions in structures which are not themselves specially differentiated anatomically.* We find we are studying the effect of asymmetrical function in symmetrical structures. According to communications engineers, "asymmetry conveys information". Dr. Robert Tschirgi, of the Department of Physiology, University of California, Los Angeles, first drew my attention to this concept. There is not space here to give detailed explanations and complicated examples, but the statement can be shown to be true. It may be understood by considering the number of items of information necessary for constructing a model from a pattern. For a rectangle of 9 squares, one needs to know only the size of one square. (Fig. 2a). For a plan composed of 9 squares arranged in a certain pattern, very numerous details are required (Fig. 2b). For a pattern of assorted shapes vastly more items of information are

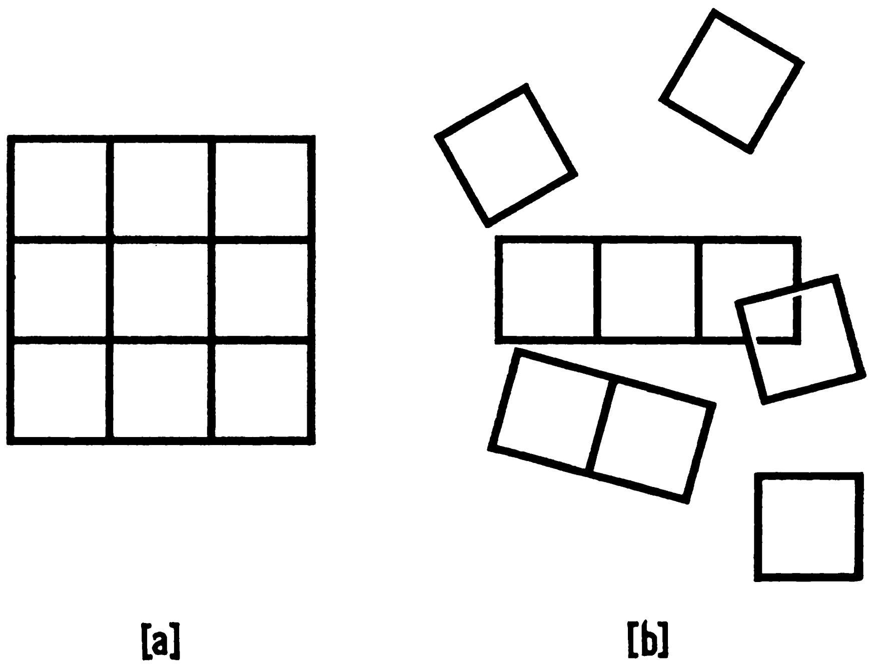

FIG. 2.—(*a*) Nine rectangles forming one larger rectangle. (*b*) Nine rectangles of same size and shape as in (*a*), but arranged asymmetrically. Very much more information of the relations of the rectangles is needed for reproduction of this pattern than for the reproduction of the pattern of (*a*).

required. If this theory is accepted, the human development of highly specialized functions of language and spatial orientation—the features by which we most clearly are superior to monkeys, dogs and birds and fishes—should be those which depend on the establishment of asymmetrical physiological mechanisms—even though we are still confined to the form of mirror-half-brains forced upon us by evolution.

Clinical studies have been providing the proof of this theory for the past hundred years.

There is other evidence of an attempt by the human being to escape from the limitations of anatomical structure, which require such immense periods of time for the evolution of new characteristics. We see in the ceaseless advances of scientific technology a process of extension of the range of human faculties. Perhaps the most important feature of such developments is the "building-in" of flexible time-range mechanisms into devices primarily designed for the utilization of space. Such mechanisms vary from the simple and well-known to the very complex and abstruse. Examples are again to be seen in the development of language, by which a group or historical memory become available to any individual of a civilization. The general application of printing has had profound effects on everyday life; the effects of radio and television have yet to be calculated. Each of these technologies is a form of sensory extension, in the auditory and visual sphere in the macrocosm, comparable with the extension into the microcosm by the microscope and the electron microscope. Aviation technology now accurately extends the range of vision through distance, darkness and cloud, and enables the human operator to achieve miracles of navigation. The transistor valve begins to approximate to the neuronal unit of the nervous system. The electronic computer provides, in a time-compressed scale, results which obviate the similar more flexible but very slow processes of certain brain functions.

It is, in the writer's opinion, extremely important for the gap between neurology and technology to be closed; and it is right for the neurologist to be positive in proclaiming that studies of the nervous system in health and disease are fruitful means of improving existing scientific equipment, as well as being essential for the devising of new instruments (Gooddy, 1959). For however elaborate and intricate the new products of scientific technology, and whatever colossal purposes of exploration of space and time such vehicles and instruments subserve, they are created for but two purposes—that in whatever circumstances the human observer may find himself, he will be able to preserve the integrity of function of his brain stem (by which, finally, he keeps alive): and upon that living basis he will be able to perceive what there is to be known, and to use what he knows for his total welfare.

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