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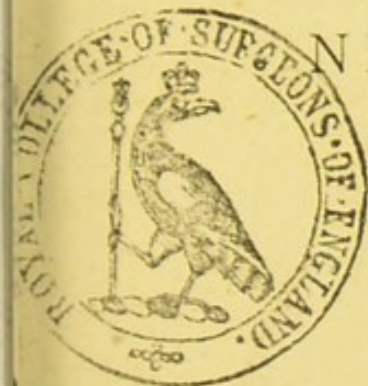
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9
CLINICAL
AND
PHYSIOLOGICAL RESEARCHES
ON THE
NERVOUS SYSTEM.



(Reprints.)

PRESENTED
by the
AUTHOR.

No. I.—ON THE LOCALISATION OF MOVEMENTS IN
THE BRAIN.

BY

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[Reprinted from "The Lancet," 1873.]

1875

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CLINICAL

PHYSIOLOGICAL RESEARCHES

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NERVOUS SYSTEM

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ON THE INFLUENCE OF MOVEMENTS IN THE BRAIN

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LONDON: J. JOHNSON, ST. PAULS CHURCH-YARD, 1800.

PHYSIOLOGICAL RESEARCHES

TO
HITZIG AND FERRIER.

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PREFACE,* 1875.

“FOUR years have elapsed since I published my opinion, supported by such facts as I could then state, that the *brain*, although the organ of consciousness, *is subject to the laws of reflex action; and that in this respect it does not differ from the other ganglia of the nervous system.* I was led to this conclusion by the general principle that the ganglia within the cranium, being a continuation of the spinal cord, *must necessarily be regulated as to their reaction on external agencies by laws identical with those governing the spinal ganglia and their analogues in the lower animals.* And I was confirmed in this opinion by finding, after the investigation and collocation of known facts, that observations and arguments like those satisfactorily adduced in proof of the existence of the reflex function of the spinal ganglia may be brought forward in proof that the cerebral ganglia have similar endowments.” (Laycock, *British and Foreign Medical Review*, Vol. xix., January, 1845, p. 298.)

This paper deals with paralysis and convulsion as the results of experiments made by disease on the Brain of Man. As the title implies, its object is to show that we may, by the study of these motor symptoms, localize movements in this part of the nervous system.

In former papers I have considered convulsion as *a symptom of disease* of the brain; and also, for the purposes of anatomy and physiology, *as an experiment made on the brain by disease.* This plan is complex. In the paper now republished, therefore, I considered convulsive seizures and

* This Preface has gradually outgrown legitimate limits, and is now larger than the paper it precedes. Moreover, it is itself in substance a reprint; much of it has appeared in some papers on Epilepsy, published in the *Medical Press and Circular.*

certain cases of paralysis with regard only to the Localization of Movements in the Brain. In this Preface I shall show that I have for more than ten years, and before the experiments of Hitzig and Ferrier were made, held that convolutions contain nervous arrangements representing movements. It is in accordance with this belief that I have long considered chorea,* and more lately convulsion, to be movements resulting from "discharges" of the cerebral cortex. The careful investigation of such motor symptoms, with a view to the localization of movements, is a subject in which I have for some years felt deeply interested. So far back as seven years ago I suggested that the facts of convulsive seizures should be used for purposes of Localization. In the *Medical Times and Gazette*, Aug. 15, 1868, I published a note on "Localization," various kinds of convulsive seizures being the facts brought forward. At that time, however, I believed the corpus striatum to be the part discharged in *convulsions* beginning unilaterally, although then and several years before I believed the convolutions also to contain processes representing movements. What at this time interested me most was, not so much the Localization of movements in the cerebral hemisphere, in the sense that, for example, the movements of the foot are localized here and those of the arm in another place, but the facts of the cases as they bore on a broad principle of Localization. I considered them as part of the evidence that the most special or most voluntary movements have the Leading Representation (see Section 10, p. 11). For in disease the most voluntary or most special movements, faculties, &c., suffer first and most, that is in an

* Thus *Lond. Hosp. Rep.*, Vol. 1, p. 459, 1864, after suggesting that choreal movements result from changes induced in *convolutions* by embolism, I write:—"There is no more difficulty in supposing that there are certain convolutions superintending those delicate movements of the hands, which are under the immediate control of the mind than that there is one, as Broca suggests, for movements of the tongue [articulatory organs] in purely mental operations." I still think to the same effect, but should not now use such vague phraseology.

order the exact opposite of Evolution. Therefore I call this the Principle of Dissolution—Dissolution as the opposite of Evolution.* It is, indeed, as illustrating this principle, that the study of convulsion still interests me most. For in Dissolution we have, I think, a principle of Classification for all kinds of Diseases of the Brain (Classification as distinguished from mere Arrangement), and therefore a means of methodical investigation. It is referred to in several Sections in the Reprint. Ferrier's experiments confirm the broad principle mentioned, so far as the onset of the simplest kind of convulsive seizures illustrates it (see Section 9). Ferrier says (I refer especially to the parts I have put in Italics)—“The proximate causes of the different epilepsies are, as Dr. Hughlings Jackson supposes, ‘discharging lesions’ of the different centres in the cerebral hemispheres. The affection may be limited artificially to one muscle, or group of muscles, or may be made to involve all the muscles represented in the cerebral hemispheres, with foaming at the mouth, biting of the tongue, and loss of consciousness. When induced artificially in animals, the affection, as a rule, *first invades the muscles most in voluntary use*, in striking harmony with the clinical observations of Dr. Hughlings Jackson.”

The Principle applies, indeed, to things so different as convulsions, cerebral palsies (hemiplegia for example), affections of speech, and to all kinds of mental disorders. It appears to me to put in a natural order the whole of the phenomena of cases of Aphasia (see Section 3), that is when they are regarded from an anatomico-physiological point of view.

The application of the principle of Dissolution to Aphasic

* I have used as synonymous with Dissolution, the expression “Reduction to a more Automatic Condition.” The phenomena of Dissolution, as seen in cases of “Diseases of the Mind,” seem to me to illustrate in a very striking way Laycock's doctrines on the Reflex Function of the Brain and Herbert Spencer's doctrines on Evolution of the Nervous System. Insanity is Dissolution, beginning in the very highest of all nervous centres, that is in the anatomical substrata of consciousness. In insanity there is always defect of consciousness. There is defective object-consciousness often along with increase of subject-consciousness.

cases (see Section 4) harmonises with one of the most important of Ferrier's conclusions from his experiments. It is a matter of extreme satisfaction to me to find that Dr. Ferrier has (at least with regard to the share the two sides of the brain have in what I call Verbalizing) come to a conclusion from the results of his experiments similar to that I have arrived at from clinical investigation of cases of Aphasia. This is important, as the phenomena of cases of Aphasia most clearly illustrate the nature of the Duality of Mental Operations. If the view I take as to the nature of the duality of Verbalizing be correct, it disposes of the statement that "cases of Aphasia give proof that we can think without words." I may here quote one of my earlier statements of the hypothesis; the following is from an abstract of a paper "On the Physiology of Language," read at the Brit. Assoc. Meeting (Norwich, 1868). I quote the *Athenæum* report.*

"* * * The author showed next that, although patients cannot *speak* when they try, they may *utter words* when excited. Now it is to be carefully remembered that these patients are speechless, because but one side of the brain, generally the left, is damaged. They do not speak with the other; at all events they do not when they try. This alone shows that the brain is not a double organ, in the usually accepted sense of the expression. But the fact that the patients ejaculate, and that they can understand what is said and what is read to them, demonstrates that there are *motor* processes for words somewhere; for there must be subjective repetition† of words when we understand what is read to us. This 'somewhere' cannot, in a person who has lost language, be the left side, as damage of that side has made the person speechless

* It will be observed that in the extract given the substrata of words are assumed to be *motor* processes; it will be seen that this also is in accord with one of Ferrier's conclusions (see p. xxvi).

† "Internal revival" I should now say, as the word "subjective" is used in several senses by medical men. (See last paragraph of Section 4.)

They cannot initiate the higher psychical *movements* ;* yet, although they cannot rouse up *motor* processes, others can. The conclusion Dr. Hughlings Jackson has arrived at is briefly this : that in most people the left side of the brain is the leading [motor] side—the side of the so-called ‘will,’ and that the right is the automatic [motor] side.”

Dr. Ferrier, however, uses the term “Driving side,” which is possibly a better expression than “Leading side.” I fear, however, that remarks on speech will not be considered to come fairly under my subject—the Localization of Movements ; but I shall shew later on that I have, as indeed the above quotation shews, long held, that the anatomical substrata of words are nervous processes representing articulatory movements, and that this hypothesis agrees with the prior deductions of Bain and with certain of Ferrier’s inductions from his experiments. Hence from my point of view the symptoms of aphasia are on their anatomico-physiological side disorders of motion ; thus they are comparable with cases of chorea and convulsion.

The results of the now well-known experiments of Hitzig and Ferrier on the brains of lower animals are, for the purposes of Localization of particular Movements, infinitely more precise than any “experiments of disease” are likely to be. The artificial movements I have seen Ferrier produce by locally applied faradaic currents to limited spots on the surface of the cerebral hemisphere of a monkey simulate the movements of health, whereas a convulsion is but a “clotted mass” of innumerable movements, produced by an excessive, sudden, and abrupt cerebral discharge. My opinion is that the experiments of Hitzig and Ferrier show, as they themselves believe, that parts of the cerebral hemispheres are centres for movements. In whatever way their experiments may be

* I do not now defend the use of such expressions as “psychical movements.” I should, however, be in very good company if I did, as I find that several distinguished physicians use an essentially similar expression, and one therefore equally open to criticism, viz., “Psycho-motor centres.”

interpreted, they are of inestimable value for the furtherance of Clinical Medicine, Comparative Anatomy, and Physiology. Nevertheless, the experiments of disease are the only ones we can observe in the case of Man. Of these the most important are convulsive seizures. So far as I know no attention has been paid to convulsive seizures in this regard. A word, as Lewes says, is not only a symbol of a thing, but is also a centre of association; the word convulsion has in most minds no anatomical or physiological associations. The statement that an epileptic discharge of a convulsion caused "convulsion of the arm," rarely rouses what is really only another way of putting the same thing, the thought that that convulsion contains processes representing "movements of the arm;" I mean not even in the minds of those who admit that movements are represented in convulsions. The convulsion shews a contention of innumerable movements; or, as I have already said in loose metaphor, it is a "clotted mass of movements." In still other words we may say that it is a sudden development in a coarse, brutal way of the functions of some part of the brain.

No one feels more than I do the difficulty of observing convulsive seizures with sufficient precision for anatomical and physiological uses, and the difficulty there is in defining at autopsies the exact parts of the brain damaged. The damage by disease is often coarse, ill-defined, and wide-spread. The facts I have up to this time obtained towards the "Localization of Movements in the Brain" of Man by observing cases of Convulsion are, I admit, very few, and of a most general character; they scarcely deserve mention along with those obtained in the masterly investigations of Hitzig and Ferrier on the lower animals. Nevertheless I repeat the experiments of disease *must* be considered in the case of Man. We cannot have clear notions of convulsion as a symptom in epilepsy until we have studied it anatomically and physiologically.

I would, therefore, entreat physicians to contribute to the more and more exact Localization of Movements in the Brain of Man by the precise study of the symptoms of cases of Convulsion* and Paralysis, and by carefully defining the position of the diseased parts found in the Brain after death. The interpretation of such observations will be very much aided by the results of the work Hitzig and Ferrier have done.

In order to render some parts of this paper intelligible, the reader must keep in mind that it is assumed throughout that the cerebral hemisphere is made up of nothing else than nervous arrangements for the co-ordination of Impressions and Movements; that, in other words, the Unit of Composition of this as of every other nervous centre (the "organ of mind," as well as the ciliary ganglion, spinal cord, &c.), is *sensori-motor*. To re-quote what Laycock wrote thirty years ago, "*the ganglia within the cranium, being a continuation of the spinal cord, must necessarily be regulated as to their reaction on external agencies by laws identical with those governing the spinal ganglia and their analogues in the lower animals.*"

Let one at once consider a possible misunderstanding. To say that the cerebral hemisphere is for Mentation, that is as a counter statement to what has just been said, is simply irrelevant; no one, now-a-days, denies that the cerebral hemisphere is for mental operations. All I have asserted is that the *substrata* of mentation are *sensori-motor* processes. It is with these, the physical side of Mentation,† that we are directly concerned.

The reader must never forget that an absolute distinction is made in this paper between mental states and their corresponding physical states, and that no attempt is made to explain

* The cases I have published have appeared in the Hospital Reports of the *Med. Times and Gaz.*, during the years 1872 *et seq.*—Reports of cases of Convulsion from Organic Brain Disease, in which the Localization of Movements is one of the objects of the Reporter, are published by my colleague, Dr. Gowers. *Brit. Medical Journal*, Sep. 26, 1874. See Appendix.

† The word Mentation was, I believe, introduced by Metcalfe Johnson.

the former by the latter. Whether there is such a distinction or not does not matter so much for anatomical and physiological purposes as may appear. As subsequent quotations will shew, such a distinction is made by most. A parallelism being assumed, all that is attempted is to discover the nature and conditions of activity of those nervous arrangements which are assumed to be the substrata of states of mind. In other words, whilst admitting, as of course, that prior psychological analysis is necessary, we are directly concerned not with Psychology, but with certain questions in the Anatomy and Physiology of the Nervous System.

The following quotation will shew what is meant by the distinction betwixt Psychology and the Anatomy and Physiology of the Nervous System:—"Physiology is an objective science; and is limited to such data as can be reached by observations made on sensible objects. It cannot, therefore, properly appropriate subjective data; or data wholly inaccessible to external observations. Without questioning the truth of the assumed correlation between the changes which, physically considered, are disturbances of nerves, and those which, psychically considered, are feelings, it may be safely affirmed that Physiology, which is an interpretation of the physical processes that go on in organisms, in terms known to physical science, ceases to be Physiology when it imparts into its interpretations a Psychological factor—a factor which no physical research whatever can disclose, or identify, or get the remotest glimpse of."

"The relations between nerve actions and mental states form a distinct subject, to be dealt with presently. Here we are treating of nerve-actions on their physiological side, and must ignore their psychological side. Doing this, we have no alternative but to formulate them in terms of motion." (Spencer, Psychology, Vol. I, p. 48.)

Tyndall writes—"* * the passage from the physics of

the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously, we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass by a process of reasoning from the one phenomenon to the other. They appear together, we know not why." This quotation is given by Lewes, in his "*Problems of Life and Mind*," Vol. 2, p. 458. Lewes adds—"To the same effect, Mill : *Logic*, ii., 436. Du Bois Reymond : *über die Grenzen des Naturerkennens*, 1872, p. 17. Griesinger : *Maladies Mentales*, 1865, p. 7. Donders in the *Archiv für Anat. u. Physiol*, 1868, p. 658. Lotze, *Mikrokosmos*, 1856, I, 161."

Mr. Lewes differs, as the following quotation serves to shew :—"That the *passage* of a motion into a sensation is unthinkable, and that by no intelligible process can we follow the transformation, I admit ; but I do not admit that there is any such transformation. When I am told that a nervous excitation is *transformed* into a sensation on reaching the brain, I ask, who knows this ? On what evidence is this fact asserted ? On examination it will appear that there is no evidence at all of such a transformation ; all the evidence points to the very different fact *that the neural process and the feeling are one and the same process viewed under different aspects*. [Not italics in original.] Viewed from the physical or objective side, it is a neural process ; viewed from the psychological or subjective side, it is a sentient process." (*Problems of Life and Mind*, Vol. 2, p. 459.)

Mr. Lewes's view does not conflict with mine *in this inquiry*.* For all I have to urge in this paper is, that we should try to determine the anatomical nature of the neural arrangement, and this can be done regardless of any hypothesis as to the

* Mr. Lewes, under the head *Psychological Spectrum*, writes : "Every psychical fact is a product of sense work, brain work, and muscle work." (*Problems, &c.*, Vol. i, p. 147.)

relation betwixt the neural process and the feeling. It is, I think, indeed convenient to make the distinction, even if it be purely artificial.

The reader will observe that I did not in the paper here reprinted try to *prove* that the convolutions contain processes representing movement. *I had for years assumed that convolutions contain processes representing movements and impressions.* In fact, I cannot conceive of what other materials the cerebral hemisphere can be composed than of nervous arrangements representing impressions and movements. I have long taken this for granted when considering what is commonly called the Physiology of Mind, especially with regard to speech, as well as when speaking of convulsions and chorea.

In a paper (*Royal London Ophth. Hosp. Reports*, Vol. v., part 4), published as far back as 1866, it is assumed throughout.* As I am anxious to show, for several reasons, that this notion had long ago become in my mind almost automatic, I will re-quote a footnote from a paper written five years ago. It had become so automatic, that although it is implied throughout that paper that the convolutions contain processes representing movements, my belief to that effect is only explicitly stated in the part here reproduced. I mention this to account for the statement appearing in a foot note. In fact, in every paper written during and since 1866, whether on chorea, convulsions, or on the physiology of language, I have *always* written on the assumption that the cerebral

* One quotation from that paper will show this. "So far as we can know anything definite of mind [the actions of the anatomical substrata of mind, I should have said], it is made up of sensory and *motor* phenomena—the functions of a series of anatomical possibilities in the cerebrum in correspondence with its wide environment," etc. Again, page 290—"On the evolution of movements I have spoken several times, especially as regards the arm-nervous-system—*i.e.*, from nerve-trunks supplying muscles directly to the corpus striatum." As the observation of Hilton on the method of nerve supply to skin, muscles and joints, shows, there is in the ultimates of the body rudimentary or incipient co-ordination. The following is a further quotation referring to the sentence last quoted:—"If such an expression be permitted, there is a gradual increase in *intelligence* in movements from the lowest nerve trunks to the *highest centres.*"

hemisphere is made up of processes representing impressions and movements. It seems to me to be a necessary implication of the doctrine of Nervous Evolution as this is stated by Spencer.

When speaking of convulsions (a mass of movements) as being owing to discharges of *convolutions* ("Study of Convulsions," *St. Andrew's Medical Graduates' Transactions*, vol. iii., 1870), I say—"It is asserted by some that the cerebrum is the organ of mind, and that it is not a *motor* organ. Some think the cerebrum is to be likened to an instrumentalist, and the motor centres to the instrument—one part is for ideas, and the other for movements. It may, then, be asked, How can discharge of part of a *mental* organ produce *motor* symptoms only? I say motor symptoms only, because, to give sharpness to the argument, I will suppose a case in which there is unilateral spasm without loss of consciousness. *But of what 'substance' can the organ of mind be composed, unless of processes representing movements and impressions; and how can the convolutions differ from the inferior centres, except as parts representing more intricate co-ordinations of impressions and movements in time and space than they do?* Are we to believe that the hemisphere is built on a plan *fundamentally* different from that of the motor tract? What can [the anatomical substratum of] an 'idea'—say of a ball—be, except a process representing certain impressions of surface and particular *muscular adjustments*? What is recollection but a revivification of such processes, which, in the past, have become part of the organism itself? What is delirium, except the *disorderly* revival of sensori-*motor* processes received in the past? What is a mistake in a word, but a wrong *movement*—a chorea? Giddiness can be but the temporary loss or disorder of certain relations in space, chiefly made up of muscular feelings. Surely the conclusion is irresistible, that 'mental' symptoms from disease of the

nemisphere are fundamentally like hemiplegia, chorea, and convulsions, however specially different. They must all be due to lack, or to disorderly development, of sensori-*motor* processes."

In innumerable places I have written to the same effect explicitly or implicitly. To have long believed this is no proof of its truth; but I think that, to say the least, it adds something of plausibility to the evidence in favour of the interpretation Hitzig and Ferrier give of the results of their experiments. I had been driven to the conclusion that the convolutions *must* represent movements and impressions long before their experiments were made. So far as I can imagine, there is nothing else they can represent. I cannot conceive what even the very highest nervous centres can possibly be, except developments out of lower nervous centres, which no one doubts to represent impressions and movements. These are audacious expressions, and therefore I am very anxious to show that my opinions are not mere after-thoughts. Let me give another quotation. In the *Medical Times and Gazette*, November 17, 1868, p. 526, I write (italics in original), "*The psychical, like the physical processes of the nervous system, can only be functions of complex combinations of motor and sensory nerves.*" I should not now use such vague phraseology, but this quotation, like the former one, shows that I have long had no doubt whatever that the cerebral hemispheres (the "organ of mind") represent an element of movement. I shall give many quotations to the same general effect in this paper.

I found this conclusion, as I thought and as I still think, in entire harmony with the facts supplied by cases of choreal movements, convulsion, and aphasia. It is, then, something better than mere blind prejudice which leads me to accept the interpretation Hitzig and Ferrier have given of the phenomena observed in their experiments.

I am not forgetting the counter experiments of Dupuy,

and Burdon-Sanderson. There are, on the other hand, the valuable observations of Putnam in reply, to say nothing of the rejoinders of Hitzig and Ferrier themselves. It is at any rate permissible to assume as an hypothesis that the cerebral hemispheres contain processes for movements in order to investigate more methodically cases of chorea, convulsion, and other diseases of the mind—*i.e.*, diseases of nervous processes serving in Mentation. As the use of the word "hypothesis" implies, the assumption may be taken as provisional; the facts of cases of disease may lead to disproof of it, although, I think, they are entirely in support of it, and will verify it. *olutions*

To myself, who have for more than ten years been teaching that convulsions represent movements, it naturally comes easy to believe that the experiments of Hitzig and Ferrier are a demonstration that this is the anatomical constitution of certain of them. Those who have read the quotations above given, will not accuse me of affectation when I say that I was surprised that anyone hesitated to accept the conclusions of the recent experiments.

There is one objection to the conclusion which must be mentioned. It has been recently asserted that the convolutions—let us say the convolutions near to the corpus striatum—cannot represent movements, because destruction of much of them produces no loss of movement. The theory of Evolution accounts for the two superficially discordant facts. I wish to point out that I have faced this difficulty long ago, and, if I may use such an expression, I considered the objection before it was made. I raised the objection* myself. For

* In their masterly article on the Functions of the Cerebral Hemisphere in the *Archives of Physiology*, Nos. 3 and 4, 1875, MM. Carville and Duret say that all the authors, whom they enumerate, and of whom I am one, have not taken note of the law of "suppléance" of one part of the cortex for another. The quotations in the text show that I am not in fault here. I have stated the Principle of Compensation years ago. It was not possible that I could have overlooked it; for how otherwise could I have held that movements are represented

example, in the "Study of Convulsions" (1870), after adducing arguments to show that in convulsions beginning unilaterally the central discharge is of convolutions in the region of the middle cerebral artery, I write: "Although to me the above arguments seem sufficient, I will consider certain objections.

"If a small number, or let us say a square inch, of convolutions were cut away by the knife, there would be no loss of power, no paralysis. This is admitted. How, then, can discharge of this square inch produce violent convulsions? If lack of that part leads to no *loss* of function, how can discharge of that part lead to *excessive* function." I then considered the objection in detail. Whether I have succeeded in solving the problem is one thing. I wish to show by the quotation I have given that at any rate I did not shirk the difficulty.

Some time before I wrote the "Study of Convulsions" I had the objection to reply to. For as I held that choreal *movements* result from discharge of *convolutions* near to the corpus striatum, I was compelled to face the very obvious objection that parts of the cerebral hemisphere might, as I could not deny, be destroyed altogether without the production of any obvious symptoms of any sort. I stated what I now call the Principle or Hypothesis of Compensation as regards chorea in the *Edinburgh Medical Journal*, October, 1868. In all the statements I have made of the Principle, it is assumed that the cerebral hemisphere is made up of nervous arrangements representing impressions and movements.

The following is one of the earliest statements I have made of the "Principle of Compensation." I had been speaking of representation of movements in the corpus striatum, but

in convolutions near to the corpus striatum when it is notorious that these convolutions may be extensively damaged in cases where there are no symptoms whatever? I have had to consider the Principle of Compensation, as regards the question of recovery from hemiplegia when the damage causing that hemiplegia is not restored, with regard to the therapeutics of one form of syphilitic hemiplegia, with regard to chorea, epilepsies, etc.

had for mere simplicity of illustration spoken only of movements of the arm.* From this quotation, also, the reader will observe that I long ago held that the "organ of mind" consists of nervous arrangements representing movements. The arrangement of nervous elements representing increasing complexity of movement, is supposed to begin with the nerve-trunks. (See on this point also the foot note p. x.)

"Just as in the arm-nervous-system there is a gradually increasing complexity, from the delivery of nerves to muscles through interweaving of nerves in the nerve-trunks, to an interrelation so great in the corpus striatum, that damage to a small part of this organ weakens the whole of the limb, and yet destroys no single movement—so we may fairly infer that, continued from the corpus striatum, deeper in brain—further in mind—are still more complex arrangements of *motor* processes, reaching a minute degree of interrelation and a vast width of association with the complex *motives*—the sensation aspect of mind—of the hemisphere, and becoming at length so complete that a quantity of brain may be destroyed without any special [striking] mental defect resulting." (*Med. Times and Gazette*, December 21, 1867.)

I reproduce another statement of the hypothesis, somewhat differently put. It is from the "Study of Convulsions." This quotation also shews that I then (1870) believed the convolutions to contain processes representing movements, and that discharge of them produced convulsions.

"Then it may be said that one convolution will represent only the *movements* of the arm, another only those of speech, another only those of the leg, and so on. The facts above stated show that this is not the plan of structure of the nervous system. Thus, to take an illustration, the external parts *x*, *y*, and *z*, are each represented by units of the corpus

* As will be seen by later quotations, I suppose the whole of the body to be represented in the highest nervous processes.

striatum. But the plan of representation is not that some units contain x largely only, as x^3 , others y largely only, as y^3 , but that *each* unit contains x , y , and z —some, let us say, as x^3 , y^2 , z , others as x^2 , y^3 , z , &c. When we come to the still higher evolution of the cerebrum, we can easily understand that, if the same plan be carried out, a square inch of convolution *may be wanting*, without palsy of the face, arm, and leg, as x , y , and z are represented in other convolutions; and we can also easily understand that *discharge* of a square inch of convolution must put in excessive movement the *whole* region [face, arm, and leg], for it contains processes representing x , y , and z , with grey matter in exact proportion to the degree of complexity.”

The two following quotations are from the *Medical Mirror*, Oct., 1869: As in the former ones it is assumed that the cerebral hemispheres represent movements, and here the conclusion is stated that the whole of the gross movements of the body are represented in each cerebral hemisphere.

“The cerebral region, of which the corpus striatum is part, consists of units, each one of which represents movements of the whole of the so-called voluntary muscles of the two sides of the body; although, no doubt, each unit will represent a different grouping of them. Thus we have arrived at a minute degree of interrelation of movements, and it is presumable that this is carried to a still greater extreme in the anterior and posterior lobes with processes of incoming sensations.”

The following further quotation from the same article shews the application of the Principle:—“When in the cerebrum we have arrived at an interrelation so great that *each* part of that organ contains processes for movements of the *whole* of the body, we can, as aforesaid, understand that destruction of much of that organ may lead to no symptoms; but if part of the *grey matter* of the organ be not destroyed but unstable, it is plain that there must be symptoms by its discharge.”

The word "compensation" itself shows what is meant. A region of the body is not permanently paralysed when a part of the brain representing it is destroyed, because the neighbouring parts also represent the very same region. The principle applies, I believe, to partial lesions of all nervous centres, but more evidently the higher the centre. This is what we should expect on the Principle of Evolution; for the higher the centre, the greater the number of *different* movements and impressions represented in it. This implies a greater number both of nerve fibres and cells. Now, of course, the more fibres in the centre, the less loss of movement will result from destruction of part of it; and, of course, the more ganglion cells, the more over-movement from discharge of an unstable part of it. When we come to the highest centre, the cerebral hemisphere, it is notorious that destruction of much of it may occur without the production of any obvious symptoms. This is a fact which is forced on the attention of every surgeon or physician. And then, on the other hand, the discharge of a very limited part of it produces considerable external movement. I suppose I have stated the Principle or Hypothesis of Compensation a score of times, and many times before the experiments of Hitzig and Ferrier were begun. I will not, therefore, state it again here, but will refer to an essentially similar hypothesis by M. Taine.

The Hypothesis of Compensation is the result of observation of cases of disease; but the facts of experiments on animals have a similar bearing. M. Taine has, chiefly from these facts, but also from cases of disease, come to a conclusion which is very like the one I have come to. He says—"The brain is a kind of polypus, whose elements have the same functions." I think the same general truth is contained in the statement I have made of a subordinate centre, "that the corpus striatum is a mass of small corpora striata." (*Medical Mirror*, Oct., 1869.)

Referring to certain experiments by Vulpian, M. Taine says—"We see that, in the case of the frog, the *eighth part* of its brain supplied the place of the rest; a larger portion would be required in the case of a superior animal; and, when we come to the summit of the animal kingdom, the mutual dependence of the different parts of the brain is much greater. But the conclusion is the same; the brain is a kind of polypus whose elements have the same functions."

I do not think the Compensation is ever absolute (I speak of destruction of parts of the brain producing no *obvious* symptom). I think it probable that what is called loss of muscular sense in a limb is in some cases loss of the most special or, metaphorically speaking, 'most delicate' *movements* in that limb. I say 'movements,' as I hold it to be as misleading an expression to say that the convolutions represent muscles directly, as it is to say that language is made up of letters.

In the same paper I go a step further as to representation. I have long believed that not only the movements ordinarily so-called, but the movements of arteries and the viscera are represented in the cerebrum. I believe, indeed, that the very highest processes (the substrata of consciousness) are only the most multifold and complex of all sensori-motor processes, that they represent or re-represent *all* lower nervous centres, and thus the whole organism (the organism as a whole). They are the processes by which, physiologically speaking, the organism is adjusted to its environment, and, psychologically speaking, the subject to the object.*

In the *Medical Mirror*, October, 1869, I write, except for a few verbal alterations, as follows:—"We have now, then, to add to the constitution of the units of the cerebrum nerve

* The reader will observe that there is not the slightest implication from the remarks in the text that any explanation of consciousness is given by giving an account of the anatomical substrata of consciousness.

fibres to the heart, vessels, and viscera, or rather probably to regions of the sympathetic system, from which these parts are supplied. The inference we have now arrived at is that the units of the cerebral hemisphere (in the region of the corpus striatum, at least) represent potentially the whole processes of the body. If this be so we can understand how it happens that in cases of epilepsy [beginning by loss of consciousness, *i.e.*, the discharge beginning in the highest nervous processes], besides obvious convulsion, we have premonitory shivering, pallor of face, and increased flow of saliva, and in some cases vomiting. Thus, too, we see how it is that emotional manifestations accompany intellectual phenomena. Emotional manifestations are wide and yet temporary bodily states, and we have seen that the heart, arteries, and viscera, as well as the large muscles of the body, are represented in the units of the cerebrum."

The statement that muscle, viscera, &c., are represented in the "organ of mind," and in the very highest parts of that organ, at first glance, appears extravagant. It is to be noted that it is in general agreement with independent statements of Laycock, Bain, and Lewes. Laycock says ("Mind and Brain," Vol. ii, p. 144)—"The functions of the hemispherical ganglia, as the organs of thought and mental action proper, are in unity *with all the processes of life whatever, whether they be termed vegetative or animal*" (no italics in original). Bain writes that the organ of mind "is not the brain by itself; it is the brain, nerves, muscles, organs of sense and viscera." It accords with Lewes's statement that "every mental phenomenon has its corresponding neural phenomenon . . . every neural phenomenon involves the whole organism." *The highest nervous processes are potentially the whole organism.* Moreover, the seemingly extravagant statement accords closely with what disease shews. I wish to say that I have not arrived at the above conclusion

by reasoning that since emotional phenomena are (on their physical side) wide-spread agitations of the limbs, viscera and circulatory organs, there *must* be a representation of these parts in the highest centres, but from observing that gross disease, tumours for instance, of "the organ of mind," produce muscular, circulatory and visceral symptoms. Let us consider a striking case.

As it seems to me, slight cases of epilepsy, beginning by loss of consciousness (cases of *petit mal*), give almost a demonstration of the truth of the hypothesis that the highest centres represent all lower nervous arrangements, and thus the whole body. To say that an epileptic fit "begins by loss of consciousness" is a symptomatic statement, to which, anatomically and physiologically, corresponds the statement that the discharge begins in the very highest nervous arrangements. Now in such cases there is deep pallor of the face, increased flow of saliva, and a universal wave of movement. There is in the excessive and sudden discharge of the highest nervous arrangements, affection of the whole organism; moreover, its parts are affected nearly contemporaneously.*

We must bear in mind that there is a case in which it is plain that a very small part of the body (the germ cell) represents the whole of the man it is detached from; so much so that it "potentially contains" even the tone of his voice and tricks of manner.

I repeat that I cannot conceive of what other "materials" the "organ of mind" can be composed, than of processes representing both movements and impressions. Before giving the reasons for this belief, let us consider contrary views widely accepted. Let us see what are the views

* Of all facts supplied by clinical medicine bearing on our subject, there is not one more significant than that slight epileptic vertigo, which is on its subjective side a defect of consciousness, is on its objective side a disorder of motion. Such vertigo is owing to a slight discharge beginning in the highest nervous arrangements, that is in the substrata of consciousness.

“in possession” as to the constitution of the cerebral hemisphere. We can do this most conveniently by considering how mental diseases are very often studied. There is a frequent confusion of mental states and physical states—betwixt Psychology and the Physics of the Nervous Systems (Neural Physiology). I freely acknowledge that I have in my earlier papers on nervous diseases used expressions which appear to illustrate this remark ; this is an additional reason why I should point out the evil results of the confusion.

Among those who believe that their method of studying those nervous diseases in which there are mental symptoms is anatomical or physiological, there are some whose method is neither, but practically psychological only. For they speak as if at some place in the higher parts of the nervous system we abruptly cease to have to do with impressions and movements, and begin all at once to have to do with mental states. There are motor centres, and above these are centres for ideas, for memory, volition, &c., which “play on” the motor centres. For example, there is supposed to be a centre for “memory” of words, and below that a subordinate centre for the co-ordination of the “movements” of words. Even admitting the truth of each of these statements, taken separately, the mildest criticism on the coupling of them is, that in one case psychological language is used, and in the other anatomico-physiological language. There are in use such expressions as that an “*idea* produces a movement.” It would be a marvellous thing if there were any such sudden and total change in function. Supposing that we do* *begin* in the cerebrum to have to do with mental states, does it follow that we cease to have to do with impressions and

* On the other hand it would be a marvellous thing if we began all at once to have to do with mental states. Mr. Lewes thinks there is, attending the activity of the lowest nervous centres, a “sensibility” homologous with that consciousness attending the activity of the highest nervous centres. I think this hypothesis more probable than the current hypothesis.

movements? For have we not to do with the nature of the *material basis* of the mental states? Let us consider this point—the nature of the material basis—in some detail.

To say that mental states have parallel and, so to speak, subjacent physical states, is now-a-days to utter a mere truism, which needs no comment. To say that the brain (in which physical states, having a mental side, occur) is made up of nerve cells and nerve fibres, is a morphological statement, and one accepted by all educated men, medical and non-medical—practically a truism too. Such a statement is not an anatomical, or, as it is usually called, a physiological statement. It is morphology only. So then, to speak of nervous “centres for ideas,” of “centres for memory of words,” &c., is to use not anatomical, but a mixture of morphological and psychological terms. Such statements are perfectly true, no one denies that the higher centres are for mental states; the statements are, now-a-days, mere truisms. They are, however, used as if they were anatomical and physiological statements, which they really are not. To give a materialistic explanation of mind is not to give an anatomical one. Suppose that mind *is* a force, as some say, that is only the beginning of an investigation as to lines on which this force manifests its effects. We, in our character as medical men, have to ask the further question, What is the anatomy* of the centres for ideas? The anatomical expression as to the composition of the brain is, I consider, that it, although the “organ of mind,” is, like the lower nervous centres, made up of processes representing Impressions and Movements. The co-ordinations of impressions

* Otherwise put, What peripheral parts of the organism do their nervous arrangements of cells and fibres represent or re-represent? Or in still other words, What particular adjustments of the organism to the environment, or of parts of the organism to one another, do they represent? The answer to these questions will give the anatomy, which is the Statics of the Nervous System. Physiology is concerned with the Dynamics of the nervous system, with the conditions and degrees of excitations or discharges of nervous arrangements.

and movements which the very highest centres, the substrata of consciousness, in the hemispheres effect, are only in very great degree different from those of the lowest nervous centres. This does not, as I have already remarked, exclude the other so-called "function" of the cerebral hemisphere, "ideation," "consciousness," &c. *Sensori-motor* processes are the physical side of, or, as I prefer to say, form the anatomical substrata of, mental states. It is with these substrata only that we, in our character as physicians and physiologists, are directly concerned.

Going into detail we have to find out where lie the anatomical substrata of visual, tactual, &c., ideas; and this is, as I think, finding where lie the *most special* and most widely-associated nervous processes representing retinal impressions and ocular movements, hand impressions and movements, &c. We have not to investigate *why* we obtain ideas of objects, or of words, during active states of substrata so constituted.

Let us now illustrate these principles by two cases.
 (1.) Let us consider the nature of the Substrata of Words.
 (2.) The nature of the Substrata of Visual Ideas. Repeating what I have said in other words, we are not trying to explain verbal and visual ideation; we are only trying to find out the anatomy and physiology of their material bases.

Substrata of Words. We will assume, but only for the sake of illustration, the correctness of the usual statements that there is a higher centre for "memory* of words," and that, subordinate to it, is another centre for co-ordinating the movements of words. But the psychological expression must be rendered into an anatomical one. When we "remember" a word there is an excitation or discharge of cells and fibres in

* "To remember," "to be conscious of," "to think of," "to have an idea of," are used synonymously.

our supposed higher centre for verbal memory.* That there is a discharge of nerve cells and fibres in this active mental state is a mere truism, and applies to all active states of all parts of the nervous system. So far Morphology and Physiology only. Now for Anatomy. The Anatomical expression is, I think, that the cells and fibres excited or discharged, when we remember words are components of nervous arrangements, which represent movements of the articulatory muscles, still more special, and still more widely associated, than those movements which the lower co-ordinating centre represents. The higher centre for "memory for words" is, I think, evolved out of the lower centre—out of the so-called co-ordinating centre for the movements of words; thus, it represents the same muscles, but in much more elaborate and special combinations, and in more definite associations. Briefly, the anatomical substratum of our memory of a word is, on this view, a highly special nervous arrangement representing certain definite articulatory movements; it is an arrangement so special as to have a particular organised connexion with an equally special nervous arrangement of some other series.†

I wish to shew that this view as to the nature of the substrata of words is, with me, an old one. I wish also to shew that the same conclusion has been reached by three different and independent observers.

I have urged for years (vide p. 4), that the anatomical

* I do not really believe in abrupt and arbitrary distinctions into motor and ideational centres. All nervous centres are centres of co-ordination of impressions and movements, differing only in the kind of impressions and movements they co-ordinate, and in the degree of complexity to which the co-ordination is carried.

† With, for example, the nervous arrangements forming the substratum of a visual idea. We may imagine that, during the discharge of the nervous arrangement for the word "ball," there arises an idea of that word. Next, as this word arrangement has an organic connexion with the sensori-motor arrangement for the object "ball," the latter is secondarily discharged, and we have then an idea of the object "ball,"—of the thing of which the word "ball" is only the symbol.

substrata of words are *motor* processes. Thus, in a paper read at Norwich (British Association Meeting, 1868), speaking on the Physiology of Language of the fundamental nature of the defect in cases of Aphasia, I say (*Abstract Med. Times and Gazette*)—"It is the power of intellectual expression by movements of any kind, which is impaired—those most special, as of speech, suffering most; those of simple sign-making, least, or not at all." When we have an idea of a word, either in speaking aloud or in speaking to oneself, a nervous arrangement, representing articulatory movements, energises. In fact I adopt the principle of that part of Prof. Bain's teaching which is embodied in a quotation which I shall give from one of his works.* It was quoted in a paper which I published on the "*Physiology and Pathology of Language*."—*Med. Times and Gazette*, June 23, 1866. The following is an extract from that paper. "It is not difficult† to shew that ataxy of articulation, and so-called loss of memory for words, are really defects of the same kind and that the loss of the sign the speechless patient had for the thing is the loss of power to reproduce in his organs (in health, from his brain, through series of centres, to the end of his tongue), the *movements* he has learned for that sign, or, at least the 'motor impulse.' The fact that people do not put their tongues in motion when they think may seem to be a great difficulty; but I hope to shew that it is not so great a one as is imagined. This will be but a particular expansion of the views which Bain has

* The following is a quotation from M. Fournie's work, "*Physiologie de la Voix et de la Parole*," 1866. "Idea, considered as an element of thought, is a *movement* willed, defined by the intelligence, for the purpose of submitting to the intelligence belonging to it in a sensible form, its state of being (*sa manière d'être*) at the moment when it receives an impression through the senses." "Idea is something more than sensation; it is sensation transformed by the intelligence into a willed, decided *movement*. This *movement* constitutes the element of language." "To think is to reproduce subjectively these different movements and to establish relations between them."

† I should not now say, "It is not *difficult* to shew, &c."

long taught, and which, indeed, he has applied to speech. 'When we recall,' he says 'the impression of a word or a sentence, if we do not speak it out, we feel the twitter of the organs just about to come to that point. The articulatory parts—the larynx, the tongue, the lips—are all sensibly excited; a *suppressed articulation* is, in fact, the material of our recollection, the intellectual manifestation, the *idea* of of speech.'"* (The italics are in the original.)

In an important article, *Medical and Chirurgical Review*, January and April, 1869, Dr. Bastian, referring to Prof. Bain's opinion, and to my explanation of the phenomena of Aphasia founded on it, combats the view that words are Motor processes. Dr. Bastian thinks that words are revived in the cerebral hemisphere as remembered Sounds.

Ferrier has come to a conclusion essentially like mine. He writes as follows:—"Hence I should incline to the opinion that the organic centres of word memory are situated in the same convolutions as the centres which preside over the muscles concerned in articulation. If this be so, then we ought to have a hand memory, a face and eye memory, an ear memory; and thus we may ultimately be enabled to translate into their psychological significance, and localise phrenologically, the organic centres of various mental endowments. This I put forward only as a speculation, but numerous other facts which might be mentioned in connection with the concomitants of epilepsy give to the idea a certain degree of colour."†

Indeed, my conclusion and Ferrier's are very close. Thus, in a paper read at Norwich, 1874 (See *Brit. Med. Journal*,

* "The Senses and the Intellect." Ed. 2, p. 345. The quotation does not give a full account of Prof. Bain's views on the subject. He thinks that words as spoken are remembered partly as auditory impressions, and that in written language there is the addition of visible signs.

† Experimental Researches in Cerebral Physiology and Pathology. By David Ferrier, M.D., *West Riding Medical Reports*, Vol. iii., p. 76.

Dec. 19, 1874), he says, "The mouth-centre is the centre, not only for the movements of articulation, but also for the memory of articulation. What are words? Words are merely certain articulations effected under the guidance of the ear. The memory of words is the memory of certain articulations so effected." This is in complete harmony with the independent statement quoted from the paper *Med. Times and Gazette*, June 23, 1866, and also with the following statement I have made, *Med. Times and Gazette*, Oct. 23, 1869:—"In the reproduction of a word in thought there will be, I presume, an excitation of the parts which were concerned in acquiring the word—the ear as well as of the muscles of articulation. This is the view Fournie has put forward. It is true that there is no obvious movement of the articulatory muscles, but there may be nascent movements of them, or nascent excitation of the highest of those nervous arrangements which in actual speech do move them."

Surely there is something of support to the belief that convolutions contain nervous arrangements representing movements in the fact that three persons—Bain, myself, and Ferrier—each from a totally different kind of evidence, and quite independently, come to an essentially similar conclusion on a point so special as that the anatomical substrata of words represent articulatory movements.

When we remember a word there is faint excitation in the highest centres for articulatory movements; when we remember and also say that word aloud the excitation is stronger and currents spread down to lower centres of movement, and thence reach the articulatory muscles.

Those who speak of "centres for memory of words," or of "centres for ideas" of any kind, as arbitrarily acting on and governing motor centres, are, as regards their method, essentially like those who speak of the soul producing

movements, &c. The difference is that the former practically talk as if the soul were a solid one, made up of fibres and cells. This psychologico-materialistic method practically ignores anatomy and physiology. It leads to verbal explanations, such as that an Aphasic does not speak “because he has lost the memory for words;” that “chorea is a disorder of volition;” that “ideas are formed in the cortical grey matter of the brain, and produce movements by acting on lower centres;” “that we combine two retinal impressions by a mental act;” it leads to the free use of such phrases as “volitional impulses,” “by an act of memory,” &c.*

It is sometimes objected that we cannot “understand” “how energising of nervous processes, representing *movements*, can give or share in giving us *ideas*.” This is a very *naive* objection. We cannot understand how any conceivable arrangement of any sort of matter can give us mental states of any kind. Is it more difficult to understand why we remember a word during energising of cells and fibres because we believe those cells and fibres represent articulatory *movements*?† I do not concern myself with mental states at all, except indirectly in seeking their anatomical substrata. I do not trouble myself about the mode of connection between mind and matter. It is enough to assume a parallelism.‡ That along with excitations or discharges of nervous arrangements in the cerebrum, mental states occur, I, of course, admit; but how this is I do not inquire; indeed, so far as clinical medicine

* “Again, if anybody says that the will influences matter, the statement is not untrue, but it is nonsense. The will is not a material thing, it is not a mode of material motion. Such an assertion belongs to the crude materialism of the savage.” Prof. Clifford, *Fortnightly Review*, Dec. 1874, p. 728.

† As I shall point out no difficulty is often felt with regard to the *sensory* element of nervous arrangements, although the difficulty is just the same.

‡ I may very well say that among the physical facts which go along at the same time with mental facts, there are forces at work. That is perfectly true, but the two things are on two utterly different platforms—the physical facts go along by themselves, and the mental facts go along by themselves. There is a parallelism between them, but there is no interference of one with the other.—Professor Clifford, *Fortnightly Review*, Dec., 1874, p. 728.

is concerned, I do not care. If any one feels warranted in assuming that physical states in the highest nervous centres and mental states are one and the same thing, he is just as much bound as anyone else to seek the anatomical nature of the nervous arrangements in which the psychico-physical states occur. *To give a materialistic explanation of mental states is not to give an anatomical one.* For clinical purposes it matters nothing whether we believe (1) that conscious states are parallel with active states of nerve fibres and cells, the nature of the association being unknown, or (2) that mental states and nervous states are the very same thing, or (3) whether we believe that there is a soul acting through a mere mechanism. I wish to insist that to hold any one of these beliefs does not one whit justify us in omitting anatomy. Betwixt our Morphology of the Nervous System and our Psychology there must be an Anatomy and a Physiology. Morphology has to do with cells and fibres or with masses of them. Anatomy has to do with sensori-motor processes.

I have no doubt too much "taken it for granted" that the "organ of mind" is made up of processes representing impressions and movements. Let me give a prominent example. I fear that such expressions as that (which is only another way of making the statement that the organ of mind is made up of nervous processes representing impressions and movements) "we do not make enough use of cases of *convulsions* in our physiological studies of [the substrata of] *mind*." (*Med. Times and Gazette*, Nov. 30, 1872) seem simply grotesque. But I submit that this may be owing to the prevalent confusion of Psychology with the Physiology of the Nervous System to which I have adverted.* The con-

* The expression "Physiology of Mind" is, strictly speaking, a very erroneous one, and is itself an example of the confusion spoken of. I have, therefore, intercalated the words "substrata of" in the quotation in the text. Neural Physiology is concerned only with the varying conditions of anatomical arrangements of nerve cells and fibres—with the Physics of the nervous system. Yet the expression is now almost universally used by medical men, and it is

fusion, I submit, is not necessarily on my part. The objector may be thinking of mind only, and thus necessarily any statement of connection between mind and convulsion is grotesque to him. But I am thinking of the anatomical substrata of mind, and if, as I suppose, these substrata contain an element of movement, the statement is not absurd. We will suppose that there is a strong discharge of the so-called centre for "memory of words." To say that this produces convulsion of the face, tongue, and other parts serving in articulation, necessarily sounds strange to those who have given no thought to the nature of the *anatomical* substrata of words. But on my hypothesis, even if that hypothesis be an entirely erroneous one, the statement is, at any rate, intelligible. The two statements (1) that the anatomical substrata of words are motor processes, and (2) that excessive discharge of the so-called centre for memory of words results in convulsion of the face, tongue, &c., are in complete harmony, even if they be both fictions. We shall better consider the relation of convulsions to the study of the nature of the substrata of ideas after speaking of visual ideas.

We will now consider "visual" ideas, the most important of all ideas (that consciousness formed of visual feelings, the most developed part of perceptive mind.—*Spencer*). We shall, I think, in doing this, discover how it is that the representation of movements in the convulsions has been ignored or denied by medical men; many appear to hold that the material substratum of mind is made up entirely of afferent nerves and their centres.

What is the anatomy and physiology, not of visual ideas,

hopeless to try to displace it. I am not answerable for it. Again, the term Psychology and its derivatives, are constantly used when speaking of the functions of the highest parts of the nervous system; they are used when dealing with those diseases of the *brain* which are attended by mental symptoms. There are such expressions as "Psychological Medicine," "Mental Pathology," &c. I use the term "Physiology of the Mind" because, as far as I know, *all* medical men use it.

but of the substrata of these ideas? First, what is the anatomy? I wish principally to show that, as is asserted, sect. 16, p. 24, these substrata must contain an element representing movement. "In all that regards visible movement and visible form, the muscular consciousness, it is now contended, is the indispensable element, the optical sensations merely guiding the movements."—Bain, *Fortnightly Review*, April, 1869.

The common notion is that the anatomico-physiological process which goes on whilst we have, or let us say whilst we acquire, visual ideas of objects, is a purely sensory one. By a sensory process, however, we could only acquire a knowledge of the Secondary, or, as Spencer calls them, the Dynamical* properties of bodies. To obtain ideas of the Primary or Statical properties (size and shape) movement is absolutely necessary. Yet to some of those who have not thought on the matter it seems simply nonsensical to say that the anatomico-physiological process, which goes on whilst we obtain our visual idea of the *shape* of an object, is a motor one. It seems so perfectly clear that the shape and size of an object are known through the anatomico-physiological process of the object, as it were, printing itself on the retina, a sensory expansion continuous with higher centres in the brain. Now, I am not bound to prove that motion is really the essential thing, for that is the theory already in possession. So far as I know, it is most widely, if not universally admitted. I will simply quote Spencer's conclusion in his Chapter (Psychology, Vol. 2, p. 177) on the "Statical attributes of Body." He says, "That whether visual or

* I believe that the Secundo-primary or Statico-dynamical properties of bodies are estimated by impressions and movements represented in the cerebellum. The "impressions" here, I think, are pressures, and the movements are tonic. We have actual and symbolical estimation. For example, the superficial extension of any object is estimated symbolically, by sweeping concomitant ocular movements, actually by tactual movements. Resistance is arrested locomotion. Resistance and depth, as also distance, are symbolically estimated by convergence, &c., of the two eyes (*vide infra*).

tactual, the perception of every statical attribute of body [shape, size] is resolvable into perceptions of relative position which are gained through *motion*." Again, Vol. 2, op. cit., p. 171. "Those motions of the eye required to bring the sentient elements of the retina successively in contact with different parts of the image, being themselves known to consciousness, *become components of the perception*."

Again, p. 172, that "the primitive element out of which our ideas of visible extension are evolved, is a cognition of the relative positions of two states of consciousness in some series of such states, consequent upon a subjective motion"

If we *acquire* ideas of the primary or statical qualities of bodies by movements—if, when we "really" see an object, movement is essential—must there not be an element of movement represented in those anatomical substrata during excitation or discharge of which we see the object "ideally?"* For when we "think" of the object which is absent ("recollect" it, "are conscious" of it, &c.) we necessarily see it ideally of some shape, as well as of some colour. The inference is irresistible that there must be a motor, as well as a sensory, element in the nervous arrangement in the "organ of mind" which is faintly discharged when we "think of" an object. This notion is to many unfamiliar. It seems unlikely to be true, but apparently only because it is novel. "What can *movement* have to do with *ideas*? One is

* I beg the reader to observe that this is not an after-thought. I do not write this because Hitzig and Ferrier find that they develop movements of the eyes by electrical excitation of certain parts of the cerebral cortex. I believed that movements of the eyes must be represented in the cerebral hemispheres before their experiments were begun. Before it was surmised that movements could be produced by artificial excitation of the brains of healthy animals, I wrote as follows (*Medical Times and Gazette*, October 23, 1869) of the anatomical substrata of visual ideas:—"In the organised forms which serve as the mental representatives of objects when the objects are absent, there will therefore be comprised not only impressions of surface, *but residua of movements* The speculation supposes that we have particular visual impressions in fixed association *with particular ocular movements*." A convulsion in which the eyes are strongly deviated is owing to an excessive discharge of a part where the motor elements of the substrata of visual ideas are largely represented.

a physical process, the other a mental process." But, I repeat, that it is only said that movement enters as an element, not into ideas, but into the anatomical substrata of ideas. I merely wish to discuss the nature of nervous arrangements which all people admit to be in a state of activity when we have ideas. I do not know, nor as a physician do I care, how it is that the physiological process of nascent or strong molecular changes in a nervous arrangement representing movement or representing anything, is attended by any kind of psychical state. Clearly, however, it does not seem to those who deny, or perhaps I should say ignore, the motor element (efferent nerves and centres) a strange supposition that we obtain ideas of objects from energising of our sensory (afferent) nerves and centres. We may infer that those who say nothing of the motor element, believe that the anatomico-physiological process, which goes on whilst we have ideas of shape and size, is a sensory process merely. But we will speak of colour only. What I wish to point out is, that it is just as impossible to tell why we have the mental state, colour, during energising of certain sensory nerves and centres, as it is to tell why we have ideas of shape during energising of motor nerves and centres. It does not, at first glance, *seem so* difficult, because the word "Sensation" is often used in two senses. It is applied both to a physical state and to the mental state that occurs along with that physical state (see Mill's Logic, Vol. ii., p. 43). For example, it is used for colour (mental state), and for the molecular disturbances which occur in the optic nervous system whilst that mental state exists. This double use of the word leads to confusion.* It makes it fallaciously

* Starting only with molecular changes in nerves, we can easily build up an orderly scheme of mental operations out of "sensory units" if we use the word sensation now in one way, and now in the other. Physical states in this way evidently get so very fine that they "fine away into mental states" in the penitralia of the highest divisions of the nervous system. There is, I submit, a double error in such systems. Physical states do not *become* mental states, and the substrata of mind are *not* merely sensory (afferent) but sensori-motor centres.

easy to "understand" how it is that we have mental states "*from*" the energising of Afferent nerves and their centres, whilst no thought is given to the much simpler assumption that mental states may arise "*during*" the energising of Efferent nerves and their centres. It makes it seem easy to understand that energising of nervous arrangements, representing only a sensory element, as a retinal impression, should give us visual ideas of objects, whilst it leads to difficulty in accepting the opinion that energising of nervous arrangements, representing articulatory *movements*, should give us ideas of words. The difficulty is just the same in the two cases. The real fact is that in neither case can we tell why, during energising of cells and fibres, we have ideas. This is so whatever they represent. For mental states arise during *molecular movements* in nerve cells and fibres, and there is no more difficulty in believing that they arise during molecular movements in the nerve cells and fibres representing muscular movements, than during molecular movements in those representing peripheral impressions. The comparison is not betwixt molecular movements in a sensory (afferent) nerve and molar movement *of a muscle*.

"Sensations," in the sense of "mental states," arise, I submit, during energising of motor as well as of "sensory" nerve processes—with the "out-going,"* as well as with

* As will be inferred from these statements, I adopt, in great part at least, Bain's views on the "outgoing" current. The facts of cases of vertigo, many ocular symptoms, but most strikingly the production of "ideal" movements by faradising stumps, have led me to agree with him. I have in a former paper (in the 3rd vol. of Crichton Browne's "West Riding Asylum Reports," p. 191), tried to show two things—(1) that excitation of nervous processes representing movements, is a factor in the physical side of ideation (as, for example, in the development of ideas of size and figure), and (2) that *nascent* excitation (excitation *limited* to the centre, or, otherwise expressed, a "motor impulse,") suffices in internal speech. In the cases spoken of there are feelings of movement from excitation of motor centres when the current developed in that excitation is physically debarred from reaching the muscles, there sometimes being no muscles.—("On Faradising Stumps." See the masterly work of Weir Mitchell on "Injuries of Nerves.") The evidence from faradising stumps is very striking. A man loses his arm by amputation just below the elbow; he knows nothing of anatomy, and

the "in-going" current. I say "arise during;" I have used no expressions which imply, even remotely, that in the penetralia of the highest centres, physical vibrations, however fine they may become, fine away into mental states—such as for example that molecular changes in optic nerves and centres turn into sensations of colour.

I believe this double use of the word "Sensation" leads to errors of grave importance in Medical Science. A "sensation" attends giddiness, and thus giddiness is said to be a "sensory" symptom. Really giddiness is objectively a motor symptom, and the "sensation" it is attended by is a state of consciousness accompanying the "out-going" current. Numbness of the hand before an epileptic fit for example, coloured vision, nausea, pains of all kinds, are states of consciousness, very crude states, but as much states of consciousness as are thoughts about landscapes, or as the ^{motor} ~~notion~~ of justice is. Every one of them has physical substrata, and of these there is an anatomy and a physiology.

Now, we will take it as proved that the anatomical substrata of our visual ideas are not sensory, but sensori-motor arrangements. We may call them Retino-ocular processes. So far anatomy. Now for physiology. The study of the degrees and conditions of excitation or discharge of nervous centres is a physiological study. Physiology deals with the *functions* of nervous arrangements. We have to consider what occurs in health when we have visual ideas—that is when we either see or when we remember objects.

Most of our ideas are latent. The equivalent physiological statement is that their anatomical substrata (sensori-motor arrangements) are unexcited. But we speak now of ideas actual,

yet when the end of his ulnar nerve is faradised (the stump being healed), he describes the *movements which we should see* if we faradised the ulnar nerve in a healthy man. Obviously these "movements" of the lost limb are the results of excitation of *motor* centres roused into activity by incoming currents from the sensory nerves contained in the ulnar nerve stump.

and correspondingly of their anatomical substrata as being excited, or in other words as being discharged. First, let us observe that we have in health Vivid ideas and Faint ideas. That is to say, we have ideas in two degrees. For example, we see objects, and we can afterwards think of them when they are absent. There is Presentation and Re-Presentation. We can see them really, and can see them again ideally. First, for the vivid ideas.

When we actually see and *recognise** external objects we have *vivid* visual ideas. There is then strong excitation of the retina, thence to the highest centres in the cerebrum, and back to the ocular muscles. There is complete and strong sensori-motor (or, as we have said, retino-ocular) action. This is what is fundamental, even if only diagrammatic, however many intermediate centres we may like to suppose betwixt the afferent nerves, optic nerves and retina, and efferent nerves to the ocular muscles. Next for Faint ideas.

When we have Faint visual ideas (think of objects when they are absent—"recollect" them, &c.) there occurs essentially the very same physiological process, as in vivid ideation. There is a discharge in each case. Moreover, the discharge occurs in the same anatomical series in each case. In faint ideation there is slight or nascent excitation (discharge) of those highest centres to which, when we actually saw the objects, the molecular impulses roused by the retinal impressions came, and from which the impulses to the ocular muscles departed.

There are two differences of degree. In thinking of objects (Faint Ideation) the central discharge is (1) slight, and (2) limited to the centre. In actually seeing them (Vivid Ideation) it is (1) strong, and (2) spreads from the periphery to the centre, and from the centre to the periphery.

* If we recognise an object the very highest centres must be engaged; for Recognition is, in common with Classification, a modified form of Reasoning. (Spencer's "Psychology," vol. ii., p. 127.)

Let me state these differences in another way by considering a popular view. Some speak and write as if, when we actually see an object, there is a physical process only, a lower centre, and the periphery being engaged, and that when we think of the object (remember it when it is removed) there is a mental process only, a higher centre being engaged—a centre for ideas. There is, however, I submit, a psychophysical process in each case, and in each case a *central* change. When we see an object there is a strong and wide physical process, and an accompanying vivid mental state; when we think of it there is a weak and central physical process, and an accompanying faint mental state.*

Now we can state what is supposed to occur when the substrata of our visual ideas are strongly discharged in an epileptic seizure. In the illustrations to be given I do not speak of epileptic discharge of some *one* centre for visual ideas, because, as I shall mention later, I suppose the motor

* The following quotations from the parts of Spencer's "Psychology" refer to the physical processes occurring in recollection:—

"In brief, those *vivid* states of consciousness which we know as sensations, accompany direct and therefore *strong excitations* of nerve centres; while the *faint* states of consciousness which we know as remembered sensations, or ideas of sensations, accompany indirect, and therefore *weak excitations* of the *same* nerve-centres" (no italics in original).—"Principles of Psychology," vol. i., p. 124.

"In a voluntary act of the simplest kind we can find nothing beyond a mental representation of the act, followed by a performance of it—a rising of that incipient psychical change which constitutes at once the tendency to act and the idea of the act into the complete psychical change which constitutes the performance of the act, in so far as it is mental. Between an involuntary movement of the leg and a voluntary one, the difference is that, whereas the involuntary one occurs without previous consciousness of the movement to be made, the voluntary one occurs only after it has been represented in consciousness; and as the representation of it is nothing else than a weak form of the psychical state accompanying the movement, it is nothing else than a nascent excitation of the nerves concerned preceding their actual excitation" ("Psychology," vol. i., p. 497).

In the ideation of delirium the central discharges may be so strong that the patient believes he actually has snakes, &c., before him.

Bain writes ("Mind and Body") "Retention, Acquisition, or Memory, then, being the power of continuing in the mind impressions that are no longer stimulated by the original agent, and of recalling them at after times by purely mental forces, I shall remark first on the cerebral seat of those renewed impressions. It must be considered as almost beyond a doubt that *the renewed feeling occupies the very same parts, and in the same manner as the original feeling, and no other parts, nor in any other manner that can be assigned.*"

and sensory elements of the substrata to be represented, for the most part, widely apart in the brain.

I trust I shall now shew more clearly than in the previous attempt (page xxx), that the statement about convulsions and the physiology of mind (p. xxix) is not altogether absurd. But I must first remark that it must never be forgotten that the discharge in a convulsion is an *excessive* discharge. We shall call it an epileptic discharge. Not only is it very much more excessive than the discharge which occurs when we have faint mental states, but it is very much more excessive than that occurring in vivid mental states. Besides being excessive, it is of a limited part of the brain. It is rapid, and it is soon over. It is plain then that in such excessive discharges, as the epileptic discharge of the substrata of vast numbers of visual ideas, there could not be a development of ideas of objects; neither of such ideas as occur in health, nor even of such as occur in delirium and insanity. Such discharges of the organ of mind have only the crudest mental sides, such as "balls of fire" before the eyes, numbness of the hands, and pain from the muscular contraction. We have, however, to do with what occurs physically. We have now to do with the physical results of epileptic discharges of those sensori-motor processes which are the anatomical side of ideation. The evidence as to discharge of the sensory element is necessarily indirect. There is, in some cases of epilepsy, evidence of excessive excitation of parts of the brain representing retinal impressions, as the patient tells us that he has clouds of vivid colour before his eyes. The results of discharge of the motor elements are visible. There occurs from an epileptic discharge that clotted mass of movements of the ocular muscles which we call spasm or convulsion (for example, strong lateral deviation of the eyes). In the first case there is, I believe, a sudden and excessive discharge of

a limited part of the cerebral hemisphere, which part contains crowds of the sensory element; and in the second of a part containing crowds of the motor element. The discharge begins centrally, as it does when we have faint ideas; but the epileptic discharge, being very strong and rapid, spreads down to lower centres, and by these to the muscles; because it is excessive, and because numerous nervous elements are discharged at once it produces not successions of movements, but a struggle of many ocular movements; in the tonic stage it jams innumerable ocular movements into one sharp struggle. The most special movements determine the position of the eye-balls; there is lateral deviation of the eyes.

The same reasoning applies, *mutatis mutandis*, to the discharge of the anatomical substrata of tactual ideas, the chief of which are impressions of surface of the fingers and adjusted movements of the hand. An epileptic discharge of the anatomical substrata of these ideas would produce numbness and spasm of the hand and arm.

Similarly, an epileptic discharge of the so-called centre for "memory" of words on the left side of the brain results, I consider, in convulsion of the articulatory muscles. So, of course, would discharge of the corresponding part on the right side, for, as I have urged (see Section 4), there are motor processes for words on both sides of the brain.

The remark that lateral spasmodic deviation of the eyes, that spasm of the hand and arm, drawing of the face, and torsion of the tongue, represent in a brutal way a development in vast numbers of the motor elements of the anatomical substrata of visual, tactual and verbal ideas, will seem, I fear, mere extravagance to some of my readers. For it amounts to saying that convulsion is as much a symptom of disease of the "organ of mind" as delirium is. I have long thought so. I repeat what I said five years ago—

“ Surely the conclusion is irresistible that ‘ mental ’ symptoms from disease of the hemisphere are fundamentally like hemiplegia, chorea and convulsions, however specially different. They must all be due to lack of, or to disorderly development of sensori-*motor* processes.” (See pp. xi and xii.)

In Section 16, p. 23, I have spoken of the “ translation ” of visual into tactual ideas. Few things are so interesting physiologically and, indirectly, psychologically, as the illustration which certain cases of hemiplegia, and certain cases of convulsion, give of the organised anatomical relations in the higher parts of the nervous system betwixt movements of our eyes and movements of our hands. Again, the relation of the sensory element of the substrata of visual ideas to the sensory element of the substrata of touch may be best studied in the corresponding cases of hemianæsthesia with hemiopia (see second paragraph of Sect. 16).

I wish now to remark briefly on what is *most general* in Localization of the motor and sensory elements of the substrata of mind, that is of the two elements anatomically corresponding to what are psychologically the primary and secondary qualities of bodies. I wish to show first that there is here also a harmony with Ferrier’s conclusions.

I long ago reached the conclusion that the anterior is the chiefly motor, and the posterior the chiefly sensory region of the cerebrum. The sentences italicised in the following quotation state this belief. The first part of the quotation refers to the mode of representation of the optic, and inferentially of all the sensory nerves. I give it not only as an introduction to the sentences spoken of, but because it shews that I have looked full in the face a difficulty—a very superficial one, I think—in the way of the speculation, that the posterior part of the cerebrum is the “ chiefly sensory ” region. I have long insisted on two things apparently contradictory (1) that no kind of disease of any part of the cerebral hemis-

phere directly* produces either loss of sight or loss of hearing. Nevertheless, I have stated (2) my belief that these two nerves are represented in the hemispheres. For besides other reasons, we have evidence of activity of sensory processes in the coloured vision, &c., attending what all would admit to be epileptic discharges. Why there should be no loss of sight from *destruction* of any part of the brain and yet that there should be development of sight (coloured vision) from discharge of some parts of the brain is explainable on the Principle of Compensation (see p. xvii). It is as to the *mode* of representation of the optic and auditory nerves that I now wish to advert. I wish to point out that I have suggested that disease of the posterior lobes, chiefly of the right one, although it does not produce loss of sight, does produce loss or defect of visual Perception (Imperception); or, as I now prefer to say, Defect of Recognition.† Unless this be borne in mind it might be supposed that certain of Ferrier's conclusions do

* Observe that I say *directly*. It is well known that tumours and other adventitious products in the cerebrum produce blindness. But such kind of disease produces blindness in a very *indirect* way; leads it to acute changes in the optic *nerves*, on which blindness may or may not follow. There is not from clinical medicine a particle of evidence, so far as I can judge, to prove that *destruction* of any part of the cerebral hemisphere produces defect of sight. I do not speak of the optic nervous system (corpora quadragemina, optic thalami, &c.) It seems to me to be, *a priori*, as unlikely that destruction of any part of the cerebral hemisphere should produce loss of sight, as that destruction of any part of it should produce inability to talk from mere lack of power to move the tongue, lips, and palate. Dr. Ferrier, however, finds that destruction of certain parts on the two sides of the brain in animals produces *loss of sight*. This is, I admit, strong evidence against the view I take. But I repeat, so far as I know, there is *no clinical* evidence against it. It is irrelevant to reply that tumours of the brain nearly always produce defects of sight. I know it well, and have been insisting on it for many years. Were it that Ferrier's experiment produced *loss of Perception*, or loss of Recognition, the result would be quite in agreement with the results I have come to from clinical observations. I may fairly give the conclusions I have deduced from observations of cases of disease. I make four statements—
 (1) Destruction of no part of the cerebral hemisphere produces loss of sight.
 (2) *Discharge* of parts of it (I think posterior part chiefly) produces coloured vision.
 (3) Tumour in it leads to changes in the optic nerve (optic neuritis), in consequence of which defect or loss of sight may or may not follow.
 (4) Disease of the Posterior lobe (right) produces defect of Perception.

† Because it implies duality in that process, of which the end or second half only is Perception.

not agree with mine. So far as I can judge some of them harmonise closely.

The quotation is from an Abstract of my second Gulstonian Lecture (*Brit. Med. Jour.*, March 6, 1869). "He does not think it, *à priori*, likely that the optic nerve, any more than the radial nerve, would be represented in any *one* part of either or of both the cerebral hemispheres, but in every part of each of them; and, excepting to an inconsiderable extent, only indirectly. Taking illustrations from disease, the kind of 'sensation disorder' we should expect from disease of the cerebral hemisphere would be spectral illusions—a disorderly reproduction of *very complex impressions*, which differ from defects of sight as a mistake in a word does from a cramp in the tongue. On this higher level, however, there will, doubtless, be some kind of localisation, and its most general character may be inferred. Since—as Lockhart Clarke has pointed out—the structure of the anterior convolutions does differ from that of the posterior, they must serve differently in mind.

"Facts seem to show that the fore part of the brain serves in the motor aspect of mind, and we may fairly speculate that the posterior serves in the sensory."

This speculation seems to me to accord with one of Ferrier's conclusions from his experiments. The following is a quotation from a summary of his most recent researches (*Med. Record*, March 18, 1874):—"The whole brain is considered as divided into a sensory and motor region, corresponding to their anatomical relation to the optic thalami and corpora striata and the motor and sensory tracts."

It will, I think, be seen that there is no discrepancy so far betwixt my speculations and Ferrier's conclusions from his experiments.

The following is an earlier statement of my hypothesis.

The quotation refers also to differences in the two sides of the brain :—

“ If,” as suggested (*Med. Times and Gazette*, Aug. 15, 1868, p. 179), “ both sides of the brain are educated in Expression, although the left is the Leading side, I would still advocate the view I brought forward in the *Lancet* [Nov. 26, 1864, that the right cerebral hemisphere is the seat of Perception], with the important qualification that the right may be the *Leading* side for perception—educated sensations.

* * * * *

“ It would seem by certain observations of Gratiolet—which are embodied in the following extract from M. Bailarger’s address before the Academy of Medicine—that there is ‘crossed development of the brain,’ if we may take the corpus striatum and thalamus as fixing the (chiefly) motor and sensory regions. The first part of the quotation refers to M. Trousseau’s views on the possible explanation of the rightsidedness of the paralysis of speechless patients. [I omit this part of the quotation.]

“ Le second fait a été signalé par Gratiolet, ce professeur si éminent, dont la science déplore la perte récente.

“ Il m’a semblé, dit-il, par suite d’une série d’observations consciencieusement étudiées, que les deux hémisphères ne se développent pas d’une manière absolument symétrique. Ainsi le développement des plis frontaux paraît se faire *plus vite à gauche qu’à droite*, tandis que *l’inverse* a lieu pour les plis des lobes *occipitaux et sphénoïdaux*.” (Leuret et Gratiolet, “Anatomie du Système Nerveux,” p. 241).—*Med. Times and Gazette*, Aug. 22, 1868.

The following quotations from some remarks of mine in the Hospital Reports of the *Medical Times and Gazette*, May 4, 1872, states the opinions I hold as to the motor and sensory regions of the brain, by detailing the general con-

dition of the Aphasic patient, in contrast with that of the patient who has Imperception (loss of Recognition). One is damaged in the motor series, and the other in the sensory series. The object is to show that the two conditions are complementary. It will be observed that in this quotation the substrata of words and of images of objects are assumed to be *sensori-motor*.

“ We have many facts as to the kind of mental affection (aphasia) which so often attends lesions in the region of the *left* corpus striatum, and it is legitimate to inquire if there be not symptoms as *special* from lesions in the neighbourhood of the *right* optic thalamus. The former, when speech is *lost*, consists in an inability to reproduce words and to reproduce them in propositional order; but in cases of loss of speech—in chronic cases at least—there is no difficulty in the reproduction of images of objects. The patient can recognise handwriting, although he cannot read; he can copy print into writing, but cannot express himself in writing; he may be able to play at dominoes or cards. In these operations speech is not concerned; the operation of *another* series of *sensori-motor* processes is required. Dr. Hughlings-Jackson believes his patient has, or has had, defect in this other series—in the *sensori-motor* processes concerned in the *recognition* of objects (not in *seeing* objects), and in putting images of things in ‘propositional order,’ so to speak. Such a defect, when extreme, would pass as one of imbecility, and in a minor degree as one of ‘loss of memory.’ Obviously the investigation of such cases will be very difficult indeed.”

I wish now to consider what this geographical separation means physiologically, and then what is implied by it psychologically. In all centres the connexion of sensation and motion is, I think, necessary.

In the lower centres there is a direct adjustment of few and simple movements to few and simple peripheral impressions.

In the very highest centres also there is a similar adjustment but then it is of exceedingly special movements (representing movements of the whole organism) to the most special of impressions from the environment. So far for resemblances; there is reflex action in each case. Now for certain differences. The difference is not that reflex action is the characteristic of the lower centres, but that exact and perfect reflex action is characteristic of them. In the highest centres, as Laycock long ago insisted, reflex action occurs, but it is imperfect. In the simple reflex actions of lower centres the movements follow the afferent incitations with no or with little delay. In the highest centres, if my speculation as to the motor and sensory regions be correct, the movements will not be immediate. For the speculation is, that there is in the cerebral hemispheres wide geographical separation, and thus probably delay in action. Again, in the lowest reflex action some particular movement is fatally necessary, and occurs rapidly after some particular impression. But in the highest centres it may be that there is not this absolute connexion. This remark brings me to consider what is implied psychologically by the geographical separation. I believe it implies that the sensory and motor elements which enter into the physical side of what is, psychologically speaking, our perception of the statical and dynamical qualities of objects, can be, so to speak, transposed, can enter into new combinations. After seeing a red circle and a blue square, we can think of a red square and a blue circle. The separation is never absolute. It is impossible, for example, to think of redness. In accordance I speak of the *chiefly* motor and sensory regions. Yet we can think of red things of innumerable forms.

The principle is, I think, capable of extension in various degrees to all the higher mental operations—to all complex states betwixt the organism as acted on (chiefly sensation

side), and the organism as reacting (chiefly motion side),* and accounts for what takes place, anatomically and physiologically, during the mental process, which beginning as metaphor ends in abstraction.

The separation betwixt processes representing sensation and those representing motion and consequent delay of action, or, generally speaking, imperfect action, in the very highest centres, seems to me to accord with certain speculations by Herbert Spencer. I intercalate some words in square brackets.

“For since all modes of consciousness can be nothing else than incidents of the correspondence between the organism and its environment, they must be all different sides of, or different phases of, the co-ordinated groups of changes, whereby internal relations are adjusted to external relations.

“Between the reception of certain impressions and the performance of certain appropriate motions there is some inner connection. If the inner connection is organized [lower centres] the action is of the reflex order, either simple or compound; and none of the phenomena of consciousness proper exist. If the inner connection is not organized [higher centres], then the psychical changes which come between the impressions and motions are conscious ones; *the entire action must have all the essential elements of a conscious action—must simultaneously exhibit Memory, Reason, Feeling, and Will; for there can be no conscious adjustment of an inner to an outer relation without all these being involved.*” (Psychology, Vol. I, p. 495.)

The following paper was occupied almost solely with a consideration of the representation of movements in the Cerebrum. I believe, however, that all the muscles of the body are represented in the Cerebellum, as all are in the cerebrum but in different order. I spoke chiefly of the representation in the

* All modes of consciousness can be nothing else than incidents of the correspondence betwixt the organism and its environment.—Spencer.

cerebellum of movements of the eyes, and at the same time for the sake of contrast of the representation of ocular movements in the cerebrum. I quoted Adamük and Donders to show that the parallel* movements of the eyes which Hering and Donders think are for direction, are represented in parts of the corpora quadrigemina different from those parts of these nervous centres, where movements of adduction and abduction of the eyes, which they suppose to be for estimating distance, are represented. I suggested that the former, which I consider to be the movements for estimation of extension are *re*-represented in the cerebrum. It has, indeed, long been well known that lateral movements of the eyes are represented in the cerebrum (Vulpian, Prévost, &c.). I suggested also that the movement for distance,† and I would now add for depth and resistance, are re-represented in the cerebellum (see Section 17).‡ These two orders of movements occur together in health, but disease separates them. Thus there is loss of the lateral movements of the eyeballs in some cases of disease of the cerebrum; from extensive disease of one side of the cerebrum we have loss of *one half of* the lateral movements of the two eyes. In order to understand loss of one half of the ocular movements for estimation of distance by disease of one side of the cerebellum, we must note that there is something more than mere convergence. The movement of the eyeballs in estimating distances is a complex one. Besides alteration in the size of the pupil, and difference in tension of the ciliary muscle, there is

* Unfortunately I said "side to side" movements; instead of "parallel."

† Ferrier's experiments seem to me to shew that this speculation is correct.

‡ These ocular movements are supposed to be *symbolic* of distance, depth, and resistance (statico-dynamical property), estimated by locomotor movements. I use the word locomotor in an unusually wide sense. When I put out my hand to feel the surface of a book, my putting forth the hand is, I consider, an act of locomotion, and it is, I think, a cerebellar movement. The movements of my finger ends over the book (tactual) are cerebral movements, and serve in the physiological process of giving me notions of superficial size and shape. The former go with an act of convergence of the eyeballs, the latter go with the concomitant sweeping movements of them.

convergence and divergence of the visual lines.* It must be particularly noted that in convergence the eyes are directed slightly downwards, and in divergence upwards. Now it is an old-established fact that, as is stated in Section 17, in lesions of the (right) middle peduncle of the cerebellum there is a skew deviation of the eyes. The right eye is turned upwards and outwards, the left downwards and inwards. This seems to me to be loss of *one half* of the movement for the estimation of distance. Only one half, for there is a one-sided lesion only. It will, I think, be seen that the speculation as to the representations of these ocular movements (see Section 17, p. 24) is verified by some of the results of Ferrier's experiments on the cerebellum. And the further speculation (Section 17, p. 25) that these movements are by nervous arrangements in the cerebellum associated with movements of locomotion goes also with Mr. Spencer's hypothesis that the cerebellum is the organ for doubly compound co-ordination in Space.

* It seems to me that Loring's experiments demonstrate that the external recti are *in action* in looking into the distance. Indeed, it would be a very exceptional thing if there were not action of both external and internal recti, both in divergence and in convergence. There is, as Duchenne points out, a co-ordination of antagonism as well as a co-ordination of co-operation.

ON THE
ANATOMICAL AND PHYSIOLOGICAL
LOCALISATION
OF
MOVEMENTS IN THE BRAIN.

(1) *Paralysis and Convulsion are not only "Symptoms of Disease," but supply evidence bearing on the Localisation of Movements and Impressions in the Brain.*

(*Lancet*, January 18th, 1873.)

For some years I have studied cases of disease of the brain, not only for directly clinical, but for anatomical and physiological purposes. Cases of paralysis and convulsion may be looked upon as the results of experiments made by disease on particular parts of the nervous system of Man. The study of palsies and convulsions from this point of view is the study of the effects of "destroying lesions" and of the effects of "discharging lesions." And for an exact knowledge of the particular movements most represented in particular centres, we must observe and compare the effects of each kind of lesion. It is just what the physiologist does in experimenting on animals; to ascertain the exact distribution of a nerve, he destroys it, and also stimulates it. Indeed, this double kind of study is essential in the investigation of cases of nervous disease for physiological purposes. For limited *destroying lesions* of some parts of the cerebral hemisphere produce no obvious symptoms; whilst *discharging lesions* of those parts produce very striking symptoms. By this double method we shall, I think, not only discover the

particular parts of the nervous system where certain groups of movements are most represented (anatomical localisation), but, what is of equal importance, we shall also learn the order of action (physiological localisation) in which those movements are therein represented.

I. MOVEMENTS LOST FROM "DESTROYING LESIONS."

(2) *The Order of Loss of Movements, Faculties, &c., is from the Special or Voluntary to the General or Automatic; Illustrated by Hemiplegia.*

I begin by speaking of destroying lesions, and take the simplest case—hemiplegia of the common form from lesion of the corpus striatum. A blood clot which has destroyed part of the corpus striatum has made an experiment, which reveals to us that movements of the face, tongue, arm, and leg are represented in that centre. This is the localisation of the movements anatomically stated. Physiologically we say that the patient whose face, tongue, arm, and leg are paralysed, has lost the most voluntary movements of one side of his body, and it is equally important to keep in mind that he has not lost the more automatic movements. The study of cases of hemiplegia shows that from disease of the corpus striatum those external parts suffer most which, psychologically speaking, are most under the command of the will, and which, physiologically speaking, have the greater number of different movements at the greater number of different* intervals. That parts suffer more as they serve in voluntary, and less as they serve in automatic operations, is, I believe, the law of destroying lesions of the cerebral nervous centres.

* I shall use (and, after the physiological definition, without any psychological implication) the words voluntary and automatic. It is not to be implied that there are abrupt demarcations betwixt the two classes of movements; on the contrary, there are gradations from the most voluntary to the most automatic.

It may be illustrated in the hemiplegic region itself: that limb which has the more voluntary uses—the arm—suffers more.

I have illustrated by a case of hemiplegia of limited range from a lesion of moderate gravity. But from lesions of different degrees of gravity we have hemiplegia of very different ranges, varying gradually from palsy of the face, tongue, arm, and leg of one side, to universal powerlessness.* Or, physiologically speaking, there are all degrees, from paralysis limited to the most voluntary parts of one side of the body to paralysis of the most automatic parts of the whole body. The movements of the heart and respiration are less frequent, and the temperature is abased (soon after the seizure, of course, is meant). The patient, to put it in the shortest way, *is reduced to a more or less automatic condition*, according to the gravity of the lesion.

It must be added, that degrees of hemiplegia are not simple degrees; that is to say, they are not either degrees of more or less loss of power only, nor degrees of more or less range only, but of both. They are Compound Degrees. For example, if there be paralysis not only of the *most* voluntary parts of the body—face, tongue, arm, and leg—but also of those next† most voluntary, viz., loss of certain movements of the eyes and head and side of the chest, we find that the most voluntary parts (face, arm, and leg) *are very much paralysed*. In other words, the graver the lesion not only the more are the most voluntary parts paralysed, but the further spread to automatic parts is the paralysis.

From these facts, supplied by cases of destroying lesions of the centre producing *loss* of movements, we may conclude

* Of course, the term "hemiplegia" becomes a misnomer when there is universal powerlessness. I shall have more to say of the universal powerlessness which occurs from disease of but one side of the brain when I consider convulsive seizures.

† Or, in equivalent terms, of those next least automatic.

that the physiological order of representation of movements in the corpus striatum is such that action in health spreads from the automatic to the voluntary; or rather (the unit of action of the nervous system being a double unit—a molecule of two atoms) that there is *first* action spreading from the automatic to the voluntary, and then action spreading in the reverse order.* The spreading of healthy movements is best illustrated by degrees of “effort,” as in lifting weights. There is first fixation of the more automatic parts of the arm, side of chest (and still further in automaticity according to the preconceived degree of heaviness of the object), before the most voluntary part, the hand, grasps the weight and then lifts it. The heavier the weight, not only the more strongly are the most voluntary parts used, but the further does the movement spread to the more automatic parts. This compound spreading of healthy movement corresponds to the compound degrees of hemiplegia.

(3) *The Order applied to the Movements and Motor Impulses of Speech (Applied to Cases of Aphasia).*

I will try now to show that the physiological order of gross movements applies to the movements of speech. I say *movements* of speech advisedly, as I think the abrupt distinc-

* That the Unit of Action of the nervous system is double the Unit of Composition is inferable from the fact that the whole nervous system is double. This conclusion runs physiologically parallel with the psychological law that all mental operations consist, fundamentally regarded, in the double process of tracing relations of likeness and unlikeness. The lower parts of the nervous system are plainly double in function, and it would be marvellous if the higher parts were not so too. The most automatic of the visible movements of the body “practically” constitute a single series, although we see that they are in duplicate. The two sides of the chest act so nearly together in time and so nearly equally in range that there is “practically” but one movement. But the very highest movements—those for words—are *apparently* in single order too, but for the very opposite reason. It is because we only consider the *end* of word processes (speech), and neglect altogether the prior automatic reproduction of words. In the double action, of which the second part is speech, there is first, I suggest, the automatic and unconscious reproduction of words. Later in this paper will be given facts which tend to show—(1) that the unit of action of the nervous system is double the unit of composition; (2) that the higher the nervous processes are the more unlike become the two components of the unit of action; (3) that the unlikeness is first in time, one acting before the other; and second in range, one being in stronger action than the other.

tion made in the expressions "loss of memory for words" and "ataxic affection of speech" is arbitrary and misleading.

The physiological order applies to the classification of the whole of the phenomena of cases of so-called aphasia: to the positive—the inability to speak; and to the passive—the ability to understand speech. Taking an ordinary case of entire *loss* of speech, we find that the patient has lost the most voluntary form of expression (speech), and has not lost the most automatic (emotional manifestations). We find that pantomime, which, bordering on gesticulation, stands half-way, suffers little. We find that the exception to the statement that the patient is speechless (for he can usually *utter* some one or two words) is frequently the exception proving the rule. He has lost speech altogether, *except the most automatic of all propositions—"yes" and "no."* Even these real words are often only of interjectional value; they can often be used only along with emotional manifestations—can be used, that is to say, automatically only. And, curiously, we find occasionally that the patient who can *reply* "No" correctly may be quite unable to *say* "No" when told. Another occasional exception proves the same thing: He may *utter* oaths or other ejaculations when excited which he cannot *say*—cannot repeat—when he tries to do so. Occasionally he gets out ejaculations of a less automatic character (less general in the sense of being suitable to fewer occasions). Thus he may say "Thanks," "Good-bye," on fit occasions, but not when he tries. In a narrow corner we see the same thing: he may be unable to put out his tongue when he tries, and yet move it well in all automatic operations.

(4) *The Order accords with the Hypothesis that the Left Side of the Brain is the Leading Side for Words, and the Right the Automatic Side.*

But there is a far wider and far more important illustration to be given.

Coining the word "verbalising" to include all the modes in which words serve, we see that there are two great divisions or rather extremes of verbalising: one is the voluntary use of words (speech); the other is the automatic use of words, as in receiving speech of others. Now in the ordinary "specimen" of loss of speech the former is lost, and the latter is intact. The patient cannot speak at all, but understands all we say—on simple matters, at any rate.

That he cannot write is simply loss of speech in another form. For the physiological reality of speech it matters nothing whether the proposition be uttered aloud or to ourselves; it is enough that certain nervous processes *be excited, and excited in definite order*: if they be strongly excited, there is external speech; if slightly, there is internal speech. So that internal speech and internal reproduction of words are not synonymous: there is a voluntary internal reproduction of words in new and propositional forms (as occurs when we write); and there is an automatic internal reproduction of words in old and acquired forms, or in forms given us, as when we receive and understand words in propositions spoken to us.

(5) *The Order applied to Mental Symptoms.*

This physiological order will, I think, be of great use in the investigation of Mental Diseases proper. It seems to me to apply, at any rate, to some comparatively simple mental symptoms which occur in a general physician's practice. After some epileptic or epileptiform seizures, the patient becomes strange or outrageous, and acts queerly or violently. My speculation is, that in these cases he is reduced by the fit to a more automatic mental condition. Thus I have recorded the case of a man (the *Lancet*, March 18th, 1871) who walked eight miles in a state like that of somnambulism. He was subject to fits, beginning by a subjective sensation of

a disagreeable smell, and depending on (as, I suppose, *petit mal* always does) changes in the region of the anterior cerebral artery. Now, just as after a fit of unilateral convulsion a patient is often reduced to a more automatic condition, so far as his *physical* state goes—he is paralysed of one side,—so I suppose this patient was reduced to a more automatic condition, so far as his mental state was concerned.*

(*Lancet*, Feb. 1, 1873.)

Possibly it will be objected by some readers that I speak in one article of several things which are very different. The reply is, that the same principle is displayed in each of them. That a hemiplegic patient's arm suffers more than his leg; that an aphasic patient cannot put out his tongue when he tries, although he moves it well in swallowing; that he cannot speak, and yet is able to understand all that we say; that a patient in *petit mal* loses consciousness and behaves strangely and outrageously,—these are evidently facts of different kinds, but they are all facts of the same order. In each instance there is Reduction to a More Automatic Condition.

II. MOVEMENTS DEVELOPED BY “DISCHARGING LESIONS” OF CONVOLUTIONS.

I pass now to speak of symptoms resulting from “discharging lesions” of the brain. The movements in chorea, as well as those in convulsion, are the result of abnormal discharges; but I shall speak in this paper only of convulsions ordinarily so called. Here, again, it may be objected that I consider still another topic; but I think it will be seen that

* In cases of slow deterioration of brain, the disposition “alters;” I fear it is that the natural disposition has its way, and that our more animal, our more instinctive habits and desires are no longer subordinated. There is reduction to a more automatic condition; there is dissolution, using this word as the corresponding opposite of evolution. The weaker the mind the more do the more automatic desires have their own way. In a few cases of intracranial hæmorrhage the patient becomes violent and swears; resembles the “drunken man,” whose “natural disposition comes out;” the condition expressed by the proverb “in vino veritas” is equivalent to a Reduction to a More Automatic Condition in which the natural impulses have freer play.

the facts to be pointed out illustrate the same principle as do the symptoms already spoken of as resulting from "destroying lesions."

(6) *The Nature of the Morbid Discharge in Convulsion.*

The nervous discharge in a convulsion differs from the discharge which occurs in a healthy movement in that it is sudden, excessive, and of short duration. The discharge being of the grey matter of processes for *movements*, there is caused by it a development of movements in the related and connected external regions. But the development of the movements is so abrupt, and the number of movements developed at once is so great, that the visible result is apparently a mere heedless struggle of muscles, in which at first glance it seems unlikely that we shall trace any kind of order. If we take for first investigation cases of *general* convulsions (such as are sometimes called "idiopathic epilepsy"), we shall, I believe, make little out. The paroxysms are too sudden, too quickly universal, and of too short duration for precise investigation. But if we take simple cases we shall, I think, accomplish a great deal. Most unquestionably the simplest cases of convulsion are those in which the spasm begins deliberately on one side of the body and affects that side only, or affects it more than the other. Such fits are often very limited in range, and then the patient is not unconscious, and can describe the seizure. As they begin deliberately, and as they may last many minutes, we are able, if we are present at a paroxysm, to note the place of onset and the order of spreading of the spasm. But even these simple convulsions represent the healthy movements contained in the region discharged only in outline and, so to speak, in caricature. For besides the facts already mentioned (that the discharge is sudden, excessive, and soon over) the discharge is of a *limited part of the brain*—of a part picked out, as it were, somewhat at random, by

disease. The presumption is that there are no more isolated discharges of parts of the brain—an *excessive* discharge of a small part—in *health* than there are movements of single muscles in health. (Movements of single muscles, except perhaps in the face, are, Duchenne insists, only producible artificially—that is, by galvanism.)

(7) *Convulsion beginning Unilaterally, the Mobile Counterpart of Hemiplegia.*

These seizures I used to call unilateral convulsions, but since the spasm (although it affects one side first and most) may *become* universal, it is more correct to call them “convulsions beginning unilaterally.” Indeed, as is well known to careful clinical observers, they occur in all degrees, from twitching of a finger to universal convulsion. It is important to bear this in mind, especially as the same patient may have fits of several degrees; unless we do, we may erroneously suppose that he has several *varieties* of convulsions. Convulsions beginning unilaterally depend on disease of the same *cerebral* region as does hemiplegia of the common form, but hemiplegia depends on “destroying lesion” of the corpus striatum, the convulsion on a “discharging lesion” of the convolutions near to this body—convolutions in the region of the middle cerebral artery. We have, indeed, not only “a corpus striatum paralysis,” but a “corpus striatum convulsion.” To prove that the convulsion is one of the mobile counterparts of hemiplegia, we find both in the same case. After a severe fit which has begun in the hand, we occasionally find hemiplegia like that which is so often produced by a clot in the corpus striatum, like it in degree and in range, but unlike it in being transitory. When the convulsion is partial, the palsy left by it is partial too. Thus I have recorded the case of a patient who had paralysis limited to the arm after a convulsion of that limb dependent on tumour in the hinder

part of the first (superior) frontal convolution.* (There was a tumour in each lobe of the cerebellum as well.) There can, in short, be no doubt that these convulsions are the mobile counterparts of hemiplegia.

(8) *The Convulsions near the Corpus Striatum re-represent the Movements represented in that Centre.*

When in such cases we do discover disease of the brain, we do find it in the region of the corpus striatum, but occasionally no local morbid change is found in any part of the brain. Nevertheless, the very fact that the convulsion has been one-sided or has begun on one side, warrants the inference that there *is* in such cases also a local lesion, although we are unable to detect it. The lesion—when a lesion is discovered—involves more or less of convulsions which are near to, and, I suppose, *discharge through* the corpus striatum. I suppose that these convulsions represent over again, but in new and more complex combinations, the very same movements which are represented in the corpus striatum. They are, I believe, the corpus striatum “raised to a higher power.” *Discharge*† of the grey matter of these convulsions *develops* the same groups of movements which are *lost* when the corpus striatum is *destroyed*.

* See “Medical Mirror,” September, 1869.

† It is supposed that in the part which is occasionally discharged the grey matter is highly unstable. This, indeed, seems to me to be a truism; the difficulty is to discover the *pathological process* by which that instability results. In the cases I shall mention later on it has been *associated with* tumour; the tumour does not discharge, but in some way it leads to changes involving instability of grey matter. My speculation is that, speaking in chemical language, the highly unstable grey matter of disease remains of the same Constitution as the comparatively stable grey matter of health, but that it is of a different Composition; and a further speculation is that the phosphorus ingredient is replaced by its congener nitrogen—that the nervous matter is more nitrogenised, and therefore more explosive. If this be so, we see that although the nutrition of grey matter is carried on abnormally, in cases of convulsion, chorea, &c., we cannot say without much qualification that its nutrition is *defective*. The supposed therapeutical value in nervous affections of the other member of the group of triads (arsenic) is significant.

(9) *The most Voluntary or most special Movements first and most affected by the Discharge of Convulsions.*

But there are several varieties of convulsions beginning unilaterally. They may be classified according to the places of onset of the spasm. There is nothing more important than to note where a convulsion begins, for the inference is, that the first motor symptom is the sign of the beginning of the central discharge.

There are three parts where fits of this group mostly begin—(1) in the hand; (2) in the face, or tongue, or both; (3) in the foot. In other words, they usually begin in those parts of one side of the body which have the most voluntary uses. The order of frequency in which parts suffer illustrates the same law. I mean, that fits beginning in the hand are commonest; next in frequency are those which begin in the face or tongue, and rarest are those which begin in the foot. The law is seen in details. When the fit begins in the hand, the index-finger* and thumb are usually the digits first seized; when in the face, the side of the cheek is first in spasm; when in the foot, almost invariably the great-toe.

(10) *Leading Movements; Compound Order of Spreading of Spasm.*

In each of these varieties there must be some difference in the situation of the grey matter exploded. In one part the movements of the hand have the leading representation, in another part those of the cheek and tongue, and in a third those of the foot. I say *leading* representation because spasm of the hand, &c., is only the *beginning* of the seizure.

* Perhaps it may be well here to mention again that the word "voluntary" is used for a part like the hand, which has the greater number of different movements and the greater number of different intervals of movements, and that the word "automatic" is used for a part like the chest, which has the greater number of nearly similar movements and the greater number of nearly equal intervals. The hand is a more "voluntary" part than either the cheek (or articulatory organs altogether) or the leg. Indeed, the hand is the most important part of the body from any point of view. Hence the significance of the fact that in disease of the highest centres it usually suffers first and most.

I had under my care a patient whose fits always *began* in his left thumb. [Case recorded *Med. Times and Gazette*, Nov. 30, 1872.] We found, after death, a tubercle the size of a hazel-nut in the hinder part of his third right frontal convolution. Now in this case the most that one could say was, that in the convolution or region first discharged there lay processes for movements in which the thumb had *the leading part*. For although the spasm *began* in that digit, it went up the arm, and at length probably all over the body.

Besides, since the movements of the thumb and fingers could scarcely be developed for any useful purpose without fixation of the wrist (and of parts further and further in automaticity according to the force required), we should *a priori*, be sure that the centre discharged, although it might represent movements in which the thumb had the leading part, must represent also certain other movements of the forearm, upper arm, &c., which serve subordinately. These remarks have partly anticipated the next topic—the march of the spasm.

(11) *The Order in which Movements are Developed by Discharge of Convulsions. The March of Spasm.*

After noting the part in which the fit begins, we have to observe how the spasm spreads (the “march of the fit”), and this for two purposes. We have not only to learn *how much* of the body is ultimately involved by the spasm, but also to note the *order* in which the several parts involved are affected. For example, we have not only to report of a case that the spasm “affected the whole of one side of the body,” but also that “the spasm began in the hand, spread *up* the arm, next took the face, and then passed *down* the leg.” We have to note not only the range of a fit, but the *order* of development of movements one after another in that range. Or, speaking now of the nerve-centres, we have to study convul-

sion not only to learn what particular movements are represented in a nervous centre (anatomical localisation), but also to learn the particular order in which those movements are therein represented (physiological localisation).

As already remarked, the movements first developed in a fit probably represent those which take the lead; those next developed are, we may suppose, the subordinately associated movements. Let me illustrate by a healthy movement. When we grasp strongly, although the flexors take the lead the extensors must be in subordinate, and yet in associated action, or the grasp would not be vigorous; and the more strongly the hand is used, the farther up the arm does the movement spread. The observation therefore of the order of development of spasm will enable us, it is reasonable to hope, to determine the association of leading with subordinate movements. For example, if a fit begins in the thumb and index-finger, there will probably* be developed as the spasm spreads that series of movements which in health serves subordinately when the thumb and index-finger are used. Of course we can only make very rough observations, as in a convulsion a great number of movements are developed all at once.

It is to be observed that, just as degrees of hemiplegia are compound degrees, so the order of development of spasm is a compound order. For example, when the fit begins in the hand, the spasm does not leave the hand when it involves the rest of the arm. Two things occur: the spasm of the hand becomes more powerful, and the spasm spreads up the arm. This compound order—as are degrees of hemiplegia (*ante*, No. 2)—is roughly in accordance with the order of development of movements in increasing strains, as in lifting things of different weight (in what is technically called “effort”). It is important to note this compound order, especially when we consider that it implies that increasing discharge of a

* In the case mentioned we had no opportunity of noting the march of the spasm.

centre has not only the effect of intensifying movement, but also the effect of increasing the range of movement. It has an important bearing on the method of mental operations. For brevity and clearness, we shall, however, in what follows, speak of the spreading of spasm as if it were simple.

(12) *The same Muscles represented in Different Order in several places.*

To show, further, the importance of noting sequence as well as range, I would mention that there are two varieties of fits, in each of which, so far as I can learn, the same muscles are involved, but in each they are involved in a different order. The range is the same; the sequence is different. Thus one man's fits begin in his hand, go up his arm and down his leg; another man's begin in his foot, go up his leg and down his arm. But, though the same muscles are in action in each of the two fits, the fact that parts of both limbs are involved in different order and probably in very different degrees, renders the inference irresistible that the two fits depend on discharge of two different centres. For the nervous centres do not represent muscles, but very complex movements in each of which many muscles serve. In each of the two centres discharged the *very same muscles* are represented in two different orders of movements. In one there are represented movements in which the arm leads and the leg is subordinate; in the other, movements in which the leg leads and the arm is subordinate. The very same notes are made up into two different tunes; in chemical metaphor, the fits are isomeric.*

My impression is, that the face is differently affected according as the spasm *begins* there and then goes to the arm,

* I have recently had two patients under my care whose fits begin in the foot. When the spasm does get to the arm in these cases, it begins in the fingers and goes up the limb; but even in these cases the centre discharged must be a different one from that discharged when the fit begins first of all in the hand.

or comes there after the arm has been first seized. In the former case the spasm, I believe, begins in the mouth (both sides of the lips, or in the cheek near the angle of the mouth), and spreads all over the face. When the spasm begins in the hand, I believe the orbicularis palpebrarum is the part of the face first in spasm. If the order be as I suppose, the muscles of the face will be represented in movements of different orders, and therefore in several parts of the nervous system.

Thus, then, the three fits may be looked upon as experimental stimulations, each of some different part in the region of the corpus striatum, and as showing us (1) what movements have the leading representation in each part; (2) the movements which are sequent and subordinate to those having the leading representation. It is freely granted that no definite results have as yet been obtained on the second point. Very few cases have been carefully observed, very few autopsies indeed have been obtained on cases which *have been* observed carefully; and, lastly, as I shall point out very prominently later on, there are complications which impede our attempt to draw exact conclusions. It is for the very reason that so little has been done that I urge the careful investigation of these seizures.

(13) *Movements of the Two sides of the Body represented in Each Side of the Brain.*

(*Lancet*, February 15th, 1873.)

We have now to consider the method of representation of movements on the largest scale. Just as there are from *destroying lesions* of different gravities in the region of the corpus striatum ranges of paralysis from weakness of the face, arm, and leg of *one* side to universal powerlessness, so from *discharging lesions* in this region there are all ranges of spreading of spasm from the most local to universal convul-

sion. Let us consider a severe convulsive paroxysm. The spasm begins, we will suppose, in the right hand, affects the *right* side (the face, arm, and leg), then *both* sides of the trunk, and next the face and limbs of the *left* side. What I wish to draw attention to prominently is, that from destroying or discharging lesions of but *one* side of the brain there results paralysis or convulsion of *both* sides of the body. This seems to me to warrant the inference that movements of the *two* sides of the body are represented in each side of the brain. Some years ago Dr. Broadbent put forth the hypothesis that the bilaterally-acting muscles of the two sides are equally represented in each side of the brain. That this is so I have proved by observations on cases of convulsion; and, as above stated, I believe that the muscles of the *limbs* of both sides—the muscles of those parts, that is to say, which can act independently of their fellows—are represented in each side of the brain.*

I must consider both the *universal powerlessness* from a

* My colleague, Dr. Gowers, has kindly drawn my attention to the following remarks by Sir Charles Bell:—"It is a fact familiar to pathologists that, where debility arises from affection of the brain, the influence is greatest on those muscles which are, in their natural condition, most under the command of the will. We may perceive this in the progressive stages of debility of the drunkard, when successively the muscles of the tongue, the eyes, the face, the limbs, become unmanageable; and, under the same circumstances, the muscles which have a double office—as those of the chest—lose their voluntary motions and retain their involuntary motions; the force of the arms is gone long before the action of breathing is affected." ("Nervous System," 3rd edit. p. 165.)—With regard to one point in the above, it is interesting to observe that in some cases of hemiplegia the two sides of the patient's chest move equally in quiet breathing, whilst in voluntary breathing there is less expansion of the paralysed side. As to another point, we have to account for the *increase* of power (the excitement) in the drunkard who has lost *voluntary* power. I believe it to be a fact of the same order as the increased excitability of a nerve after its division, and of the same order as the increased reflex excitability of the lower segment of the cord when cut off from the brain. (The last-mentioned fact has been used by Dr. Thompson Dickson to illustrate his views on epilepsy, the paroxysm of which, he believes, results from a loss of control.) I believe that the outrageous and violent conduct which occasionally occurs in an epileptic patient who *has lost consciousness* is a fact of the same order—that after *sudden* loss of voluntary power there is an increase of *automatic* action. In hysteria there is loss of voluntary power, and yet there is often excitement. The contradiction disappears if we can establish that the excitement is of lower and more automatic processes from lack of inhibition by the higher and more voluntary.

destroying lesion of one side of the brain, and the *universal spasm* from a *discharging* lesion of one side of the brain. (We shall, for verbal convenience, suppose, throughout these remarks, that the left is the side of the brain damaged.) I begin with *universal powerlessness*. I believe this to be really two-sided paralysis. (That the right side should be paralysed presents no difficulty, of course.) Universal powerlessness is the result of a grave* lesion. Now this grave lesion is usually a bulky clot, and thus it may be said that the palsy of the left side of the body results because the clot on the left side of the brain squeezes the opposite side of the brain; or again, that, as the patient is deeply insensible, the left side of the body only *appears* to be paralysed. I confess that I have no satisfactory proof that the left side of the body has been palsied from a hæmorrhage limited to the left side of the brain in a patient who was conscious at the time I examined him. I have, however, only to show that the left side is *weak*, not that it is as much palsied as the right. For whilst wishing to prove that movements of the left side of the body *are* represented in the left side of the brain, I wish also to prove that they are *less* represented therein than are the movements of the right side. It is only to be expected that the left side will suffer for a short time. There is an order of recovery in cases of hemiplegia, and I suppose in all other palsies; it is that the more automatic movements are regained first. Thus, in hemiplegia (right side, we suppose), the leg recovers before the arm, and if there be at the outset a further degree of paralysis—viz., lateral deviation of the

* The word *gravity* is used as inclusive of two factors, *quantity* of nerve-tissue destroyed and *suddenness* of destruction. Suddenness is a most important factor; hence a difference betwixt cerebral embolism and cerebral thrombosis; betwixt the symptoms of cerebral hæmorrhage and cerebral tumour; betwixt bleeding an animal to death slowly and suddenly (in the latter there are convulsions). It *seems* to make a difference even in the *kind* of symptoms, for as Prévost says of the lateral deviation I have so often mentioned in this paper, "C'est surtout dans les attaques brusques que s'observe cette déviation." Of a large clot we have to observe that it destroys, that it destroys suddenly, and that it squeezes widely and suddenly.

eyes and head—these deviations are usually transitory. It is then only reasonable to suppose, when there is yet a further degree of paralysis—namely, of limbs of the left* side, that this will pass off first of all.

But there is proof that fibres pass from the left corpus striatum down into the left side of the cord, as well as into the right side; there are “direct” as well as “decussating” fibres. That there is a “decussating paralysis” from lesion of the left corpus striatum, no one doubts; but the existence of direct fibres, I think, supports the inference that there is also a transient “direct paralysis” from extensive lesion of that centre. After old lesions of the left corpus striatum there is Wallerian wasting of nerve-fibres, traceable from the seat of disease not only down into the *right* side of the cord, but also into the left. This splitting of the bundle of wasted fibres on entering the cord is, I think, demonstrative evidence that *both* sides of the body are represented in the *left* corpus striatum. Does it not show that movements of the *left* face, arm, and leg, are represented in the *left* corpus striatum by the *non-crossing* fibres, as well as that movements of the *right* face, arm, and leg, are therein represented by the *crossing* fibres? It may, however, be urged that these non-crossing fibres are solely for the bilaterally acting muscles (“muscles of the trunk”). But if now we consider the phenomena of a severe convulsion, and find that from a discharging lesion

* Here it may be well to advert to a difficulty, a very superficial one, in the use of the words voluntary and automatic; one which would equally attend the use of the words special and general, independent and dependent. Perhaps the best words would be, varied and similar. Those movements of the left side of the body which are supposed to be represented in the same (the left) side of the brain (and from *sudden* lack of which there results transitory left-sided palsy) are called automatic. It seems contradictory to call movements of the *limbs* automatic. The speculation is that those movements of the left side which are represented in the left side of the brain are automatic, or subordinate to those of the right side of the body, which also are represented in that left side to the brain. Put otherwise, the muscles of the limbs of the left side are, in the right side of the brain, represented in movements from the voluntary to the automatic, and in movements from the automatic to the voluntary in the left side of the brain.

of the left side of the brain the muscles of the face, arm, and leg of the left side are convulsed (after those of the right side), it is, I think, most reasonable to conclude that the non-crossing fibres are for the movements of the muscles of the left face, arm, and leg, although perhaps chiefly for those of the left side of the trunk.

(14) *Nature of Duality of Brain—the two Halves not mere Duplicates (see Section 4, p. 5, on Leading and Automatic sides of Brain).*

From these facts we may conclude that the movements of both sides of the body—those of the limbs as well as those of the trunk—are represented in each side of the brain. The inference is that the units of the nervous system are double units, as the whole nervous system itself is double. In chemical metaphor, the unit of action is a molecule of two atoms. But it is not meant that the double unit is a mere duplicate. For, again referring to the *whole nervous system*, we see that *its* highest halves are not *mere* duplicates. Saying nothing of right-handedness, of the fact that disease of but *one** hemisphere can make a man speechless, and of the statement of Gratiolet that the left frontal and right sphenoidal and occipital convolutions are developed earlier than their fellows, there is the striking fact that the convolutions of the two hemispheres are not symmetrical. These differences in form

* The fact of most significance is, not that disease of the *left* hemisphere mostly makes a man speechless, but that disease of but *one* hemisphere can make him speechless. I have suggested that one hemisphere is for the automatic, and the other for the voluntary and automatic, use of words. It is well known that speechless patients may sing; on this point, and on the singing of imbecile children, I have remarked in the "Mirror" of this journal, February 17th, 1866, and again in a subsequent "Mirror," where I quote Dr. Langdon Down. There is in this month's number of the *Edinburgh Medical Journal* a valuable paper by Dr. Ireland, in which he says that in mere taste for music idiots are not much behind other children. Music is probably one of the most *automatic* of higher mental operations; hence the significance of the existence of musical faculty in those who have little higher mental faculty. It is a fact of the same order as many stated in the text. Spencer (*Psychology*, vol. ii., p. 471) says (when speaking of inherited experiences) that faculties, *as of music*, which scarcely exist in some inferior human races, become *congenital* in superior ones.

imply differences in function.* This is the more significant when we find that the asymmetry becomes greater the higher we go in the animal kingdom, not only from lower to higher animals, but from the lower to the higher races of men. According to Dr. Todd, there is greater asymmetry in the convolutions of intellectual men. We see, then, that the higher in the scale of intellectual life the less of a duplicate are the two halves of the highest and most important divisions of the nervous system. It is reasonable to suppose, then, that the two elements of the units which enter into the composition of the highest centres are not mere duplicates.

(15) *Movements of the Two sides of Body represented in Different Order in each side of Brain (?)*.

Whilst insisting that movements of the two sides of the body are represented in the left side of the brain, it has been pointed out that they are not equally represented; the movements of the left side are *less* represented in the left side of the brain, for they suffer less from a destroying lesion (and, as I have said, it may be urged that they do not suffer at all), and they suffer less in convulsion. The fit which begins in the right side, and passes at length to the left, affects that second side less, and for a shorter time, and, I believe, the parts of this side are affected more contemporaneously. But besides this difference in *quantity* of representation, there are other differences. The left side suffers *later* than the other. This difference is quite as important as any. It is as necessary to know that in certain centres movements of different parts are represented in different order as it is to note that they are represented in different degrees.

* It is possible that the asymmetry may be such that whilst the third left frontal convolution is, so to say, the "yellow spot" of speech, some other convolution on the right is the chief seat of word-processes. I think this is probable because in one seizure dependent on disease of the third *right* frontal convolution, the discharge was *first* on the muscles of the thumb, and not on the parts for the exteriorisation of speech.

We have, then, two things to bear in mind—(1) that movements of the right and left limbs are represented in the left side of the brain; and (2) that the right are represented more than the left, and so represented that they are developed at a different time. Are there other differences? Other facts supplied by the Wallerian wasting, already spoken of, warrant us in seeking further differences. For descending wasting occupies different tracts of the cord. The fibres wasted in the right side of the cord (crossing fibres) are those of the posterior part of the lateral column, those in the left side (direct fibres) are in the anterior column near the middle line (as before stated, the lesion is supposed to be of the left corpus striatum). These facts justify the inference that the two sides of the body are not represented in each half of the brain in the same way. To suppose otherwise would be to hold that the two different parts of the cord had the same function. We have already spoken of difference of quantity of representation (the left side being less represented). Will not the difference we are now in search of be one of *order* of representation? We find that, speaking generally, the order of representation in the right side is from the voluntary to the automatic movements.* Is the order on the left side from the automatic to the voluntary? It will be observed that it is not supposed that the two different strands of fibres in the cord represent different *muscles* on the two sides of the body; but that each strand represents the corresponding muscles of the two sides of the body, but made up into movements of different degrees and orders. Thus, to put it roughly, the speculation is, that on the right side the order is from the limbs to the trunk, on the left from the trunk to the limbs.

I have, I regret to say, no useful observations of the order

* Strictly this is the order of the *loss* of movements from breaking up of nervous processes. The representation of movements in the healthy organ will be in the reverse order.

of spreading of spasm on the *left* side. As I think it very important to make observations thereon, I will write down certain questions. 1. Does the spasm of the left side begin in the leg? 2. Does it go *down* or *up* these limbs? 3. Does it affect the extensors more than the flexors, or *vice versa*? 4. Is the spasm more tonic than on the other side? (The fit is supposed to begin in the right hand.)

Of course, since our object is to learn the plan of representation of movements, we must also study healthy movements, taking the simplest of these. I have several times spoken of "effort," using the word in its technical sense. In lifting objects of increasing heaviness with the right hand we bring into play movements spreading from the most voluntary to the most automatic. At a certain stage the left limbs are engaged; the left arm is lifted away from the side, the forearm is more or less extended, and the hand is open; the leg is held off the ground somewhat stiffly from the hip. I think it probable that the spreading of spasm to the left side will conform roughly to the spreading of movement in effort to the left side. We shall be assisted in investigating the order of representation of movements by considering the play of the limbs in walking. Thus, when the right leg comes forward, the right arm goes backwards and left forwards. Probably, however, these movements have their representation in the cerebellum; but somewhere the order, as well as the degree, of these movements will be represented.

(16) *Certain Correlations of Movement—Lateral Movements of Eyes and Movements of Tactual Organs represented in the Cerebrum.*

Both in hemiplegia and in convulsions beginning unilaterally we note certain associations—*e.g.*, affection of the orbicularis palpebrarum along with affection of the limbs. Donders' researches give an explanation of this association.

The most important, however, is the association of affection of *certain* movements of the eyes with affection of those of our limbs. Significantly (and in accordance with the principle spoken of throughout this paper) the movements of the eyeball which are first affected are the *lateral*. We can overcome a prism of from 20° to 30° with its base placed outwards, and one of 6° to 8° with its base placed inwards ; but few persons can overcome more than a prism of 1° or 2° with its base turned upwards or downwards. There is then greater variety or independence in the lateral movements of the eye. (The internal rectus is the strongest of the ocular muscles.) In association with this greater independence of the lateral movements we may note that the sensibility of the retina diminishes less rapidly outwards than upwards and downwards. That the movements of our chief tactual organs should have close and direct associations in the *highest* nervous centres with certain movements of the eyes is what one would expect if, as Spencer says (Psychology, Part 24, p. 358), "tactual impressions are those into which all other impressions have to be translated before their meanings can be known." I suppose visual impressions and ocular movements may be said to "stand for" tactual impressions and movements in the sense that the strong excitation of the nervous processes of the former leads to *faint* excitation of those of the latter (movements of the hands, &c.). The study of cases of hemiplegia and convulsion shows us, not only that there is an association, but the *order* in which eye movements and limb movements are associated. Of course a coarse lesion of a nervous centre, or a sudden discharge of one, is not a very neat experiment. In hemiplegia the parts suffer in degree, I believe, in the following order: arm, leg, side of face and tongue, orbicularis palpebrarum, lateral movements of eyes, lateral movements of head. The difficulty obviously is that several systems are

damaged all at a blow—the movements of lifting, by which we have ideas of weight, the eye to hand movements of writing, the movements of speech, &c.

I have observed cases of hemiplegia complicated with hemiopia. I have as yet had no autopsy on a case of this kind; but I think it important to draw attention to the association because I think it is a very significant one, especially as there has been a very persistent and a very unusual amount of loss of sensation in the hemiplegic region; and in one case under my care the power of estimating weights is very much affected. I believe the lesion to be in the thalamus opticus. It is very significant that a *lateral* loss of vision occurs with hemiplegia. In these cases the patient cannot *see* to the paralysed side; his condition is the sensory analogue of that of the hemiplegic patient who, having lateral deviation of the eyes, cannot *look* to the paralysed side. Since the sensori-motor processes which form the anatomical substrata of our ideas of objects are [highly special arrangements representing] retinal impressions and ocular movements, the study of deviations of the eyes and corresponding limitations of the fields of vision has an important bearing on mental physiology.

(17) *Certain Movements of the Eyes for Estimation of Distance represented in the Cerebellum along with Locomotor Movements.*

There are other conjugate deviations of the eyes besides lateral. Thus in lesions of the right middle peduncle of the cerebellum the right eye is turned upwards and outwards, the left downwards and inwards. Just as there is an association of lateral movements of the eyes with movements of our tactual organs for ideas of objects, so we may suppose that there will be associations of ocular movements of convergence and divergence (the former especially downwards, the latter

especially upwards) with those movements of the spine, legs, and arms in locomotion, represented in the cerebellum, for ideas of distance; hence the importance of studying particular ocular deviations in association with accompanying disorder of movement. That the two sets of ocular movements are to a large extent separately represented seems clear from the researches of Adamük. He finds that the anterior tubercles of the corpora quadrigemina rule the side-to-side movements of the two eyes, whilst irritation of the posterior part of either the right or left eminence produces strong convergence, lowering of the visual lines, and contraction of the pupil. The cerebrum contains processes of eye movements and tactual movements for seeing objects; the cerebellum, we may suppose, contains processes of the eye movements and locomotor movements for estimation of distance. I shall shortly try to show that facts of disease and experiment support this inference. The association of ocular deviations with circus movement, rotation, and rolling, is well known, and is obviously very significant with regard to what has just been

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APPENDIX.

CASES OF CONVULSION FROM ORGANIC BRAIN-DISEASE.*

By W. R. GOWERS, M.D. Lond.

(Assistant-Physician to University College Hospital and to
the National Hospital for the Paralysed and Epileptic.)

My object in this paper will be to lay before you the details of some convulsive seizures of local commencement and deliberate march in which there was found after death a naked-eye lesion of the brain, the position of which could be determined with accuracy. It has been shown by Dr. Hughlings Jackson† that the study of such convulsions affords one of the chief practical means of ascertaining the precise motor relations of many parts of the human brain, and of extending to it the conclusions reached by experiments on the brains of lower animals.

CASE I. *Unilateral Convulsion beginning in both Frontal Muscles, in a Case of Renal Disease, with an old Hæmorrhage into the opposite Cerebral Hemisphere.*

A little girl, aged 8 years, was admitted into University College Hospital, under the care of Dr. Wilson Fox, on February 7th, 1874, with slight œdema of the legs and

[* A paper read before the Medical Section at the Annual Meeting of the British Medical Association in Norwich, 1874, and published in the "British Medical Journal," September 26th, 1874. I reprint this by Dr. Gowers' permission. J. H. J.]

† In many places, and especially in his article on the "Localization of Movement in the Brain," in the "Lancet" for January 13th, 1873.

albuminuria. The dropsy had existed for two months. One day, about the time of the commencement of the dropsy, she had been seized with severe pain in the head and vomiting; and, next morning, a series of convulsive attacks commenced, which lasted for thirty hours, the headache and vomiting continuing for some days. A few weeks afterwards, a second similar attack occurred. On admission, the child presented no evidence of cerebral mischief; she was cheerful, quick, and there was no discoverable paralysis. The ophthalmoscope showed well marked albuminuric retinitis. One day, about a fortnight after her admission, she suddenly, without obvious cause, vomited, and, a few hours afterwards, was seized with a convulsive attack, involving the left side only. A similar attack was repeated every ten or fifteen minutes for about twelve hours, when she died, the temperature rising before death to 107.2. I was able to watch carefully several of the attacks. In the first two which I saw, the earliest spasms appeared to be at the angle of the mouth, on the left side; but, in all that followed, this was preceded by movements in the frontal muscles; and I think it probable, therefore, that all the fits began thus, but that, in those first seen, the earliest movement was overlooked. The spasm in the frontal muscles, with which the fit commenced, was clonic, and occurred simultaneously and equally in the two frontal muscles. In a few seconds, clonic spasm set in in the orbicularis of the eyelids, on each side, but greater on the left than on the right. The left angle of the mouth was then twitched outwards, apparently by the action of the zygomatic muscles, the right side being quite motionless. Next the left arm began to jerk, apparently as a whole, and soon afterwards the left leg. The muscles passing from the limbs to the body were involved, and also the muscles of the abdomen—certainly of the left, and I thought also of the right side. No tonic spasm was observed. After lasting about a minute, the spasmodic contractions sub-

sided, lasting longest in the zygomatic muscles and in the muscles of the left arm. When the movements were at their greatest intensity, there was a little contraction of both *levatoros menti*; but, with the exceptions mentioned, there was no affection of muscles on the right side. I was informed that, in some of the earlier fits, there had been some jerking of the right limbs; there was none in those which I saw. During the fits, and also in the intervals between them, the eyes were directed to the right, the axes remaining parallel, and were not moved to the left. During the fit, the pupils were widely dilated.

In the intervals, there was no return to consciousness; then, in emotional movements, the *right* side of the face alone moved.

At the *post-mortem* examination there was found an old clot, apparently of at least several weeks' duration, which was situated above the right lateral ventricle, just inside the convolution of the corpus callosum, the white matter of which it involved. In size the clot was about as large as a walnut, and its centre was about midway between the anterior and posterior extremities of the corpus callosum. The clot itself did not extend outwards beyond the middle of the roof of the ventricle, but adjacent softening reached as far as the junction of the roof and outer wall, so as to approach within one-sixth of an inch of the outer part of the corpus striatum. The softening had extended irregularly to the surface of the convolution of the corpus callosum, opposite the clot, so as to involve the grey matter at this spot. Some minute extravasations over the right parietal and occipital lobes, beneath the pia mater, constituted the only other lesion to be found in the brain. The heart was much hypertrophied. The kidneys presented extreme and old-standing disease.

Remarks.—A convulsion affecting one-half of the body, as far as our present knowledge extends, always owns as imme-

diate cause an organic change in one-half of the brain. As the only considerable lesion, we are justified, then, in regarding the clot as the immediate cause of the fits in this case. There was, further, that condition predisposing to convulsion which accompanies grave organic renal disease. Of the systemic influence of the renal disease, the existence of albuminuric retinitis furnished a sufficient proof. The presence, however, of this additional predisposing cause does not interfere with the interest which attaches to the character of the convulsion and to the position of the lesion causing it. The rule is, as Dr. Hughlings Jackson has shown, that, in unilateral convulsions, or in general convulsions beginning unilaterally, the fit begins in the side which is first or only affected, and in some muscles on that side which are usually put into unilateral action—at the angle of the mouth, the hand, or the foot. In this case, however, the fit, which was essentially one-sided, deviated from the rule, in beginning simultaneously on the two sides, that is, in the two frontal muscles; and in this deviation it is, so far as I am aware, unique. It is interesting, therefore, to observe that it began in a muscle which is rarely, if ever, put into unilateral action. Few people indeed possess the power of moving the frontal muscle on one side only without that on the other. The orbicularis of the eyelids were next involved, but less equally than the frontal muscles, that of the left side being slightly affected. The orbicular muscles have a greater power of unilateral contraction than the frontal muscles, but the power is limited, is to a considerable extent acquired, and it is difficult for many persons, and especially for young children, to put one orbicularis into any contraction without causing some contraction in the other. The muscles drawing outwards the angle of the mouth were affected on one side only. Although those of the two sides are often moved together, they possess the power

of perfectly separate action. The same is true of the arm and leg, in which the convulsion was strictly limited to one side. We thus see that the distribution of the convulsion in the muscles of the two sides, as far as observation went, corresponded closely to the degree of associated bilateral action of the muscles concerned, to the uniformity with which the muscles of the two sides habitually act together.

The relation between this distribution of convulsion and the distribution of the paralysis in an ordinary case of hemiplegia a little time after the onset, will probably have already struck you. In hemiplegia, there is, with severe affection of the arm and leg on one side, moderate affection of the straight muscles which go to the angle of the mouth, much less affection of the orbicularis of the eyelids, and scarcely any perceptible paralysis of the frontal muscle. In proportion to the bilateral association in action, the muscles of the affected side escape in the paralysis, and those of the unaffected side are involved in the convulsion.

It is commonly admitted that the hypothesis of Dr. Broadbent* explains best the escape of the bilaterally acting muscles in hemiplegia, and it furnishes an equally good explanation of their involvement in spasm.† The theory is, that the muscles acting bilaterally have such commissural connections of their motor centres, or partially-undecussating motor tracts that the muscles of both sides are connected with each side of the brain in proportion to their bilateral use. The effect of this is, that, if a lesion cut off the higher centres on one side of the lower, the bilateral muscles are in such connection with the lower, and therefore also with the higher, centres on the unaffected side of the brain, that those on the side which would be paralysed are affected but little, or not at all. It is evident that the same commissural connection which ensures the escape of one side in

* "Medico-Chirurgical Review," April, 1866.

† See Hughlings Jackson ("Medical Times and Gazette," August 5th, 1868).

paralysis permits the involvement of both in spasm. The discharge of a higher centre in one hemisphere will involve the lower centres, and therefore the muscles, on the two sides in more or less equality, the degree of that equality being proportioned to the completeness of their bilateral representation in the brain—that is, to the degree with which they are associated in ordinary action. This was precisely the condition present in the case described.

It is true that in some unilateral fits the muscles which act bilaterally are affected on one side only. Of this the case I am about to relate affords an example. The difference probably depends on the position of the lesion, and many more careful observations on the relation between position of disease and character of fit will be needed before the difference can be explained with confidence.

CASE II. *Convulsive Seizure beginning unilaterally by a Co-ordinated Movement of the Left Hand, and due to Thrombosis in Veins on the Right Frontal Lobe.*

A man, aged 30, in University College Hospital for phthisis, of which he was in the last stage, after a day or two of mental dulness, was suddenly seized with a convulsive attack, which lasted about a minute and was repeated every ten or twelve minutes, until his death, about two hours afterwards. After the first fit, no manifestation of consciousness could be obtained. Two of the attacks, which I was able carefully to watch, and which were said to resemble the others, were of the following character. While lying still, with his head in the middle line, and his eyes directed forwards, his left hand was slowly raised to his head, the forefinger being extended and the whole arm being stiff. Just after the movement commenced in the hand, the left angle of the mouth was drawn outwards, and the head and eyes turned to the left; the hand was then slowly lowered to the chest, the

fingers being bent inwards. The mouth meanwhile was drawn more to the left. Presently, the tonic gave place to clonic spasm, which involved the head, side of the face, arm, and leg, all the muscles of that side of the face, and of that side only, being at first convulsed, the left half of the occipito-frontalis jerking and the right half remaining still. Next, the right arm began to twitch, and then the right side of the face. The mouth became equal, the lips being closely pressed together. In a few seconds more, the spasm was slighter on the left and more severe on the right side; the mouth was drawn to the right, and the eyes and head slowly turned over to the right side, the eyes maintaining their parallelism. The left side ceased to move; then the jerkings on the right side also became less frequent, until they ceased altogether, and the fit was over. He lay perfectly still until the commencement of the next fit.

At the *post mortem* examination, the whole length of the superior longitudinal sinus contained an old, discoloured, and partly granular clot, which did not quite fill it. It did not pass into the lateral tributaries of the sinus, except in front, where it extended on each side into a vein from the surface of the frontal lobe. The clot on the left side extended for about two inches outwards, and was *not* accompanied by marked hyperæmia of the convolutions. That on the right side, however, extended across the frontal lobe to its outer surface, as far as the short anterior limb of the fissure of Sylvius, and crossing the anterior portion of all three frontal convolutions. The veins plugged were widely distended by clot, which was dark red, mottled irregularly with paler portions. Several small branches from the right vein were also plugged for about three quarters of an inch from the vein itself. Over the area corresponding to the blocked veins, the pia mater covering the convolutions was intensely hyperæmic and dotted over with small extravasations. On section, the

grey matter of the convolution was much more vascular than that of the opposite side, but was not softened. The exact area of the hyperæmia extended in the form of a band across the three frontal convolutions, involving the greatest area of the superior and the least of the inferior convolutions, and ceasing in front half an inch from the anterior extremity of the hemisphere. There was no abnormal appearance in the rest of the brain.

Remarks.—The convulsion in this case, in its general character, its commencement in part capable of the fullest unilateral use, its extension to the other muscles of the same side, the deviation of the head and eyes to that side, the extension of the convulsion to the muscles of the opposite side in the same order, its subsidence on the side first attacked as it became more severe in the other, and its final gradual cessation: in all these points, the attack corresponded perfectly to the common character of a convulsion due to the disease of one cerebral hemisphere. There can be little doubt, therefore, that it is to be ascribed to the disturbance of the grey matter of the frontal lobe consequent on the venous thrombosis; and, as the visible alteration in the hemisphere was circumscribed and distinct, and the movement with which the fit began was special and uniform, the locality of the lesion becomes interesting in relation to the motor points which faradisation of the brain has revealed in the lower animals. It would seem that the locality of the disease in this case is anterior to the spot assigned by Dr. Ferrier for the movement of the arm in monkeys. It would cross, I think, the points for the deviation of the head and eyes, and the movements of the mouth; but, as those movements in this case only correspond to what is seen in the evolution of every severe convulsion of unilateral origin, however it may begin, I do not think they can be regarded as specially related to the situation of the disease.

CASE III. *Tumour of Left Hemisphere associated with Fits, which were preceded by an Aura in the Left Wrist; the Aura, when arrested by a Blister, being transferred to the Opposite Side.*

The case is that of a girl, aged 18, who died of acute phthisis in the National Hospital for the Paralysed and Epileptic, having suffered for six years from convulsive attacks. None occurred while she was in the hospital, and their exact character could not be ascertained, but they were accompanied by loss of consciousness and preceded by a sensation in the left wrist. This aura preceded even the earliest attacks. About two years after their commencement, by the direction of Dr. Buzzard, whose out-patient she then was, a blister was applied to the left arm above the point in which the fits seemed to begin. For a time, they were less frequent, and those which occurred commenced by a similar sensation in the *right* wrist.* Afterwards, however, the aura again returned to the left wrist. Attacks occurred once or twice a week, in spite of treatment, and maintained the same general character, and only ceased when the decided phthisical symptoms manifested themselves. At no time was headache a prominent symptom.

After death, the sole lesion discoverable in the brain was a small tumour, about the size of a walnut, situated in the white substance of the *left* hemisphere, above the middle of the lateral ventricle. Its outer boundary was even with the junction of the roof of the lateral ventricle with the corpus striatum. Internally, it extended as far as the grey substance of the convolution of the corpus callosum, which was much thinner opposite the tumour than in front or behind it, and the upper part of the convolution, contiguous to the calloso-marginal fissure, was somewhat softened. A thin

* See Dr. Buzzard, "On the Arrest of the Epileptic Aura by Blistering" (*Practitioner*, October, 1868).

layer of white substance lay beneath the tumour, forming the roof of the lateral ventricle. The substance of the growth was soft, vascular, having a reddish, semitranslucent aspect. Its inner boundary was well marked, but there was no limiting capsule or adjacent softening. In its centre were two calcareous masses irregular in shape, each about the size of a bean. The microscopic characters were most nearly those of a glioma. No structural lesion could be found elsewhere in the brain.

Remarks.—That the tumour was the cause, direct or indirect, of the convulsive attacks must be regarded as highly probable. It was the only cause discoverable. Its duration was evidently considerable, and may well have corresponded with the duration of the symptoms. Calcareous nodules of such a size rarely form in a tumour of that character, except after a long period of time. The points of chief interest about the case are:

1.—The aura existed, and probably, therefore, the convulsion commenced in the arm of the same side as that on which the tumour was situated.

2. The aura was arrested by a blister above its position and then transferred to the opposite side. The arrest by local treatment of the local commencement of a convulsion due to organic brain disease is, of course, common enough; but migration of the aura to the opposite side in such a case is certainly a rare event.

A fit commencing by motor or sensory alteration in one side of the body must (according to our present pathological knowledge) be due to changes taking place in the opposite hemisphere of the brain. Hence the commencing convulsion in this case cannot have been due to the immediate local effect of the tumour, but must have been produced by its influence on the distant grey matter of the opposite hemisphere, probably by means of the commissural fibres, in the midst of which, it should be noted, it was placed. When, by a

peripheral impression on the left wrist, such an influence was exerted on the right cerebral hemisphere as to restrain the development in it of the convulsive tendency, the influence of the tumour on the hemisphere in which it was situated was such that that hemisphere then led the way in developing the convulsion in a similar manner, by producing the same symptoms on the opposite side of the body.

The length of time which the tumour had existed without causing other symptoms is worthy of remark. It is no doubt to be accounted for by its distance from the motor tract, and by its tendency to degeneration rather than to growth.

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