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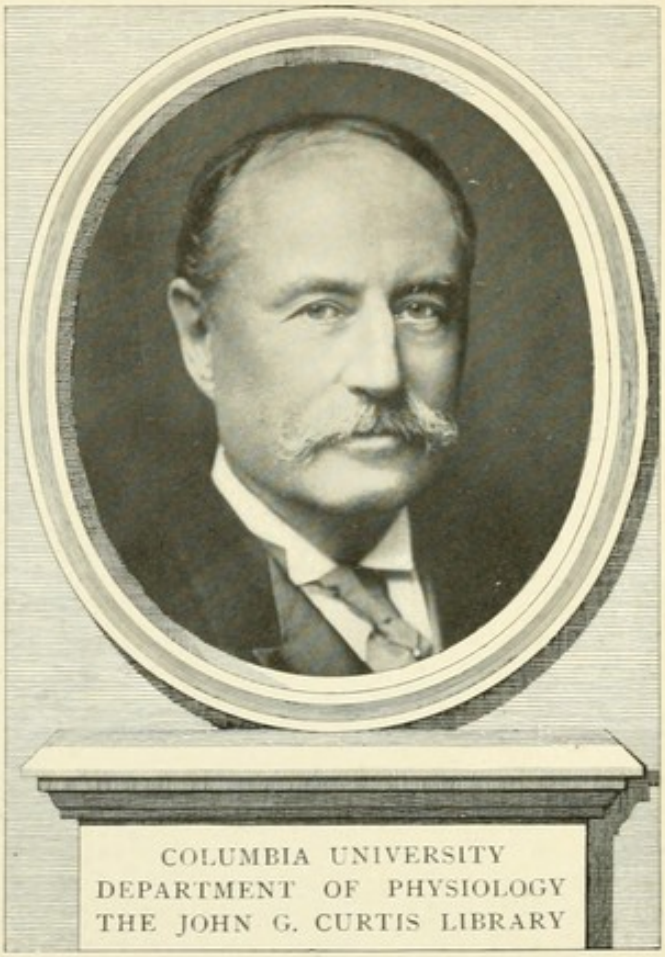
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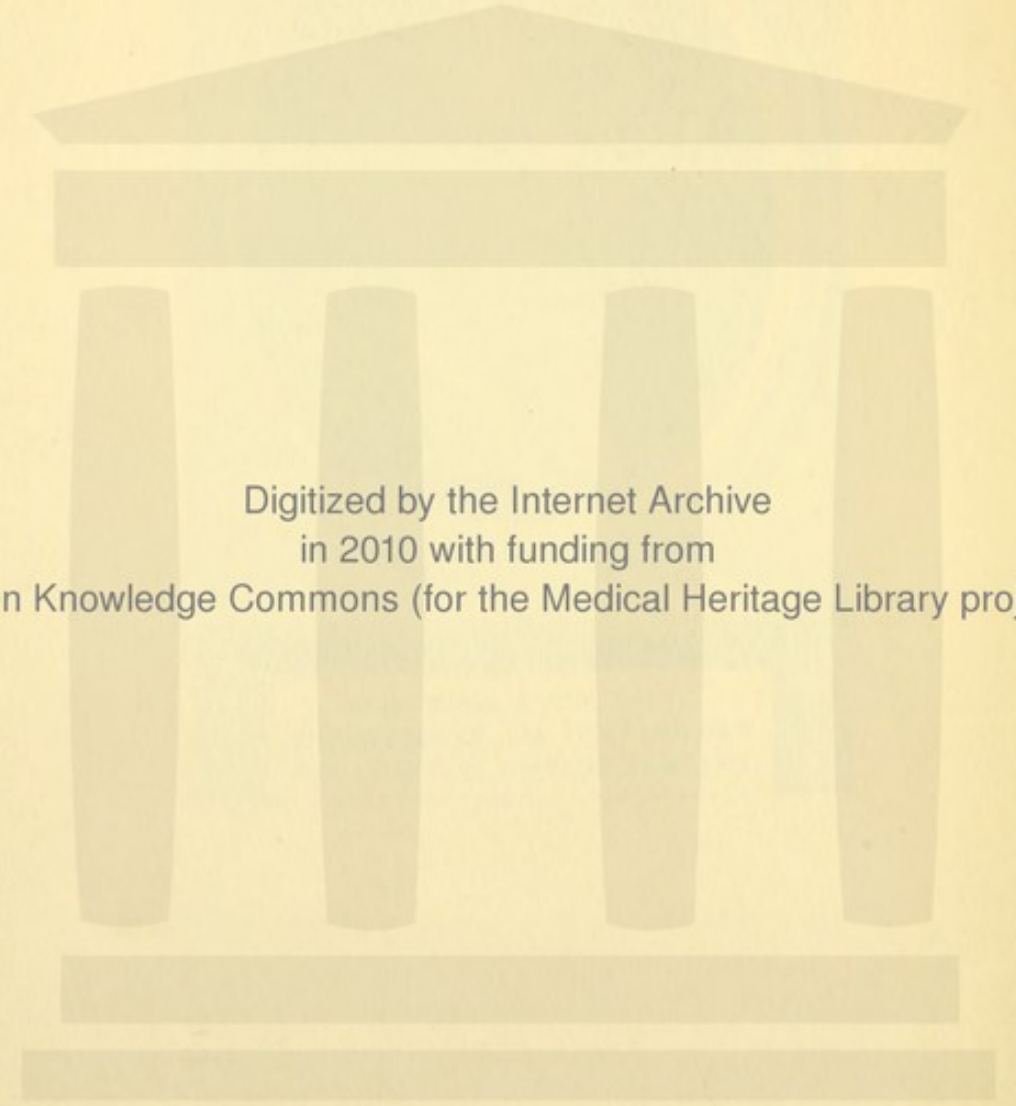

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Considerations on Flechsig's "Gehirn und Seele."

BY

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CONSIDERATIONS ON FLECHSIG'S "GEHIRN UND SEELE."[1]

By MARY PUTNAM JACOBI, M.D.

I do not this evening propose to offer either a translation or a detailed exposition of Flechsig's essay, which has already become so celebrated. For not only do I take for granted that it is, in the original German, sufficiently familiar to the members of the Neurological Society, but Dr. Barker, for the benefit of the Philadelphia Neurological Society, has already made an English translation, which has appeared in the June issue of the Journal for Nervous Disease. Dr. Barker's translation, however, is completely uncritical, and it seems to me that room remains for some modest criticism of Flechsig's large and confident conclusions.

The essay in question contains: 1st, an interesting anatomical discovery; 2d, a physiological interpretation of this, and 3d, a philosophical inference deduced from this alleged interpretation. In this inference lies the gist of the title of the essay, and the conclusions which the author himself seems to find, at this time, the most interesting. In his earliest treatise in 1876, Flechsig announced the following laws as the main results established by his discoveries upon the unequal medullization of nerve tracts:

1st. The law of organization of central nerve fibres into systems.

2d. The principle of the systematic assumption of myeline sheaths by all the nerve fibres belonging to the same system.

3d. The principle of the systematic division of the

[1] Read before the New York Neurological Society, October 5, 1897.

central medulla based upon the separate medullization of different nerve tracts.

4th. The correlation of the epoch of its medullization with that of the first differentiation, the first distinct appearance, of any system of central nerve fibres. These laws are sufficiently important and interesting and, I think, have not been controverted. But now Flechsig brings forward another law entirely new, and which is no longer, like the others, a generalized summary of the facts. He now tells us that "tracts of different functional significance ripen at different times," and that this simple fact is the keynote not only to the whole philosophy of the nervous system, but to the entire problem of the relations of brain and mind.

These are the successive steps of the demonstration. The earliest tracts to be medullated are the earliest tracts to be formed. At the time at which the mass of the cerebral hemispheres is still gray, tracts in them which have become medullated must be the oldest, and on that account presumably the most capable of function. This was said in 1876. But twenty years later Flechsig seems to infer that nerve fibres are incapable of even an embryo function until they have assumed their myeline sheaths; and, conversely, that successive awakening to function of tracts of different functional significance can be traced by the chronology of their successive medullizations.

In the cerebral hemispheres the earliest fibres to become medullated are contained in certain sensory tracts—tracts which mediate tactile sensation.

Hence, tactile sensation is the first thing produced in the brain. But the brain exactly mirrors the mind. We must, therefore, infer that mind begins in a sensation, and that other things are added as other nerve tracts ripen. "More than ever have I the conviction," exclaims Flechsig in the preface to his published address, "that the brain as organ completely and entirely coincides with the manifestations of the soul, and that we are in a position to develop the

conditions of the same as of all other natural phenomena accessible to our knowledge." And again: "We define the soul as a function of the body, mental phenomena as phenomena of life, distinguished from others by the fact that they are accompanied by consciousness. Consciousness is an accompanying phenomenon of this special process; by no means a resultant of the same in a mechanical sense."

Having said this, Flechsig then proceeds to deduce mental phenomena from anatomical facts, without the slightest further reference to consciousness. His demonstration is suggested, however, not by the anatomy which he professes, but by the metaphysics which he professes to despise. It is plainly inspired by the famous "statue" hypothesis of Condillac. To analyse the faculties of man, this philosopher imagined a statue deprived of all faculties, and then added to it (not faculties, but) sensations, one by one. He first calculated the effect of a single sensation which should exist all alone and be excited by one object only, as a sensation of smell excited by a rose in a being who had absolutely no other capacities than this sense of smell. He then added a second sensation of the same kind, as the smell of a jonquil, and demonstrated to his own satisfaction that a being who could only smell, but who had the opportunities to smell a rose and a jonquil, could develop from these two sense experiences, comparisons, judgment, passions, abstract ideas. "All the faculties of the mind," declares Condillac, "are only transformed sensations." "The mind is quite passive when it experiences a sensation." To this doctrine, enunciated in 1746, by the French Abbé, the German anatomist tries to bring the support of the anatomical science of the nineteenth century.

But this attempt is open to many objections.

1st. Except on the teleological basis which Flechsig would probably be the first to reject, the function to be performed by a completed organ cannot be counted among

the efficient causes of its mode of development. Yet there is an illegitimate emphasis in Flechsig's declaration, "Tracts of different functional significance ripen at different times." Although he does not say it in so many words, he manages to convey the impression that the tracts ripen at given epochs, because of their functional significance; or that this guided the order of medullization. Mind must be generated by sensation, therefore sensory tracts must be capable of function before any other part of the nerve centres, or, at all events, the relative precocity of their development affords a striking confirmation of the philosophical theories to which Flechsig evidently had already adhered.

But when we examine what *is* the efficient cause of the development of nerve tracts we find it in conditions with which functional significance has nothing to do. In 1876 Flechsig made the remark, which he now seems to have forgotten, namely, "that the systematic development of nerve fibres must depend on the fact that the *cells* which produce the fibres ripen at different times."[2] The contrast between the epochs of medullization of afferent and efferent tracts, upon which Flechsig so greatly insists, and which, indeed, he greatly exaggerates, depends entirely on the fact that these tracts have different trophic centres.

At eight months of fœtal life, the mass of the core of the cerebral hemispheres is still gray. At this epoch white streaks of medullization appear in the following localities.[3] The posterior central convolution and the upper half of the anterior.

The upper levels of the external nucleus of the thalamus, where fibres are received through the superior peduncles of the cerebellum from the red nucleus of the tegmentum.

The posterior three-quarter of the globus pallidus.

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[2] Leitungsbahn, page 209.

[3] Gehirn und Seele, p. 62.

Edinger[4] states the matter thus: "The tegmentum radiation (Haubenstrahlung) arises in the cortex of the superior parietal lobe and posterior central convolution, possibly in other cortical regions, reaches the internal capsule and partly passes under the thalamus to the cord, partly plunges into the inner segments of the lenticular body. Here are the fibres of the cerebral hemispheres which first become medullated. In a human fœtus of from eight to nine months, these fibres appear as thin white streaks in the internal capsule, the rest of which is gray." "They occupy," says Flechsig in his essay on Localization, "the area in the upper half of the internal capsule, immediately behind the pyramidal tracts."

Flechsig rests the proof of the sensory character of the fibres in question upon two facts. First, that in the region where they enter the internal capsule, namely the posterior part of its knee, experimental section is followed by crossed hemianesthesia. This was, indeed, shown many years ago by Veyssiêre and other pupils of the Charcot school. Second, that these same fibres may be traced through the lemniscus to the medulla and into direct connection with nuclei which are the final termini of spinal sensory nerves.[5] This tract, however, is not the only sensory tract which extends between the cortex and the base of the brain. Edinger describes,[6] under the name of the "cortical lemniscus," another bundle which passes from the cortex caudad to the anterior central convolution, and which ends in the ventral nucleus of the thalamus. The same nucleus receives lemniscus fibres from below.

Now Flechsig tells us, or leaves us to infer that this upper cortical portion of the lemniscus, if it be so considered, is *not* medullated at eight months. Indeed, Flechsig divides the sensory system into three parts, of which the

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[4]Vorlesungen über den Bau der nervösen Centralorgane. 1896. P. 234.

[5]Edinger, loc. cit., p. 281.

[6]Loc. cit., p. 234.

first, as above described, begins to be medullated at eight months; but the second not till nine months, and the third not till several months after birth (Local., pp. 24 and 25). According to Flechsig's description this second division of the sensory system constitutes a special system in the internal capsule which, like the first, passes out by the lateral nucleus of the thalamus, but dorsal to the first system. It passes to the cerebral cortex, partly to the paracentral lobule, and also to the foot of the first frontal convolution; partly bends inwards at an acute angle, and terminales along the entire length of the gyrus fornicatus; partly enters the cingulum and runs towards the cornu ammonis. Towards the epoch of birth, the foregoing bundles are joined by another which runs from the lateral nucleus of the thalamus, enters the unciform convolution, and finally reaches the subiculum cornu ammonis. Another bundle passes from the median centre of the Luys nucleus to the foot of the first and second frontal convolutions. The third system becomes medullated from one to several months after birth. It passes in the middle part of the internal capsule from the anterior part of the lateral nucleus, and runs directly to the foot of the third frontal convolution (Local., pp. 24, 25). It is in a fœtus nine months old, at term, that Edinger describes as medullated, fibres in the tegmentum, the lemniscus, the brachia (bindearme), the posterior longitudinal fasciculus, and many fibres of the substantia reticularis.

Now at this epoch, nine months, or the moment of birth, Edinger finds a small bundle of medullated fibres also in the pes pedunculi, the motor tract, and Flechsig assigns the medullization of the pyramidal tract to the self-same time.

From this description it follows: First, that all sensory tracts do not "ripen" at the same times, but that an interval of about four months separates the period of medullization of the first division from that of the third.

Second, that the medullization of motor tracts is

exactly contemporary with that of several sensory tracts even if not with all. Yet Flechsig declares, "The motor tracts of the cortical sensory spheres develop without exception *after* the completion of the sensory tracts; this same law holds for all centripetal and centrifugal tracts of the cortex."[7] This is called the "fundamental law of cerebral development." The law holds whenever the trophic centre of a centripetal tract is more completely developed than the trophic centre of a motor tract, and this is frequently the case. It does not hold below the level of the hemispheres, that is exactly at the points where an external medium can alone excite afferent impressions, thus where, if alone, the process of sensation must begin.

The trophic centre of the median and lateral lemniscus fibres is in the medulla oblongata. The trophic centre of the afferent fibres passing upwards to the convolutions in the knee of the internal capsule, is presumably the lateral nucleus of the thalamus. The trophic centre of the pyramidal fibres is unquestionably the cortex of the anterior convolutions and the parietal lobule. It is inevitable that this cortex gray matter of the brain mantle, the latest in philogenetic development, should complete its structural elaboration later than the gray matter of the nuclei of the thalamus and of the medulla which are fully formed so much earlier in the animal scale. It is correlatively inevitable that the tracts which originate in this latest-formed mass of gray matter should become medullated later than those which spring from the ganglionic masses at the base of the brain. As Flechsig said twenty years ago, "The different tracts develop probably in the same order in which the centres to which they belong develop."[8] The indifference of function in the question of medullization is shown by Flechsig himself in his remarks upon the medulla oblongata. "Here," he says,

[7] Localization, p. 45.

[8] Leitungsbahn, p. 226.

"very early, groups of great cells of the formatio reticularis differentiate themselves,whose axis cylinder processes pass over in the fibres of the spinal anterolateral tracts; and these clearly centrifugal paths show well-developed medullary sheaths at a time when the sensitive roots are still deprived of them. Those motor cells and fibres are thus complete and capable of function at a time when the posterior roots are still embryonal. Hence, it is probable that for this lower part of the brain, not reflex, but automatic action is the primary form of the central function." Edinger (page 5) stating the same facts, gives to them an entirely different interpretation. "To the vital importance of the medulla for the existence of the animal," he says, "corresponds the circumstance that this part of the brain is the first to complete its evolution. At a time, between six and seven months of fœtal life, when there is not a single medullated fibre in the entire frontal region of the brain, the cranial nerves originating in the oblongata have already assumed their medullary sheaths; and soon afterwards their central tracts, the tractus tecto-nucleares, become medullated. At this time also is medullated the posterior longitudinal fasciculus passing from the thalamus to the anterior columns of the cord."

According to this way of looking at the matter, in the sixth month of fœtal life the ganglionic centres of the medulla begin to develop rapidly, in anticipation of the important functions they are soon to assume, and outstrip the spinal ganglia, the trophic centres for the posterior roots.

The sensory and motor roots of the spinal cord become medullated at about the same time, because their respective trophic centres, the spinal ganglia, and the masses of ganglionic cells in the anterior horns, complete their structural elaboration contemporaneously.

It may, perhaps, be said that the reference of medullization to the development of trophic centres makes no difference in regard to the inference to be drawn from it.

Whatever the cause, we must believe that a medullated nerve tract is capable of function as a non-medullated tract is not, both because its fibres must be older, and because the myeline sheath is essential to the function of the fibre. If, therefore, sensory fibres are invariably medullated first, they must invariably begin to function first, must in some way bring it about that sensations arise in the brain, or rather are passively stamped upon the brain before this organ is capable of any reaction. But it has been shown by the observations of Edinger, and even by the data furnished by Flechsig himself, that if a few sensory fibres are the earliest in the hemispheres to become medullated, the medullization of many others is anticipated by that of many motor tracts.

Further, the development of the myeline sheath is not directly an expression of the perfected function of the nerve fibre, but of the luxus nutrition permitted by complete elaboration of its trophic centre. There is no proof, and no probability, that the conducting functions of the nerve fibres begin suddenly at a certain stage of development. Rather that the germ of function appears coincidently with the germ of structural elaboration. Oscillations of blood corpuscles begin early in the vascular channels of the embryo, and constitute the first organic effort at the circulation, which is destined later to become so impetuous. Similarly feeble, it may be presumed, would be the first nerve impulses—molecular oscillations to and fro—until, as in the blood vessels, such continuity of channel had been established as would permit complete circulation.

Van Gehuchten denies Flechsig's implied assertion that the myeline sheath of central nerve fibres is essential to the conduction of nerve impulses, because, as he points out, there are many cases in which, in the absence of this sheath, function is unquestionably performed. Throughout life all the fibres of the sympathetic system, the fibres of the olfactory nerve, the central and peripheral fibres of

the cerebrospinal system at both their origin and their termination, and all the protoplasmic prolongations of all nerve cells except in cerebrospinal ganglia, remain destitute of myeline. According to Lenhossek, in mice, the entire spinal cord is still non-medullated at birth, the first medullated fibres appearing in the anterior commissure on the third day after birth. In these same animals the cerebrospinal fibres of peripheric nerves only become medullated at some little time after birth. Yet mice begin to run about at least as early as many other mammalian animals, born with medullated cords. And viable children, born at seven or eight months of fœtal life, move their limbs in a manner quite indistinguishable, except perhaps through degree of force, from movements of children born at term. The only condition indispensible to the function of nerve fibre is adequate anatomical connection between neurons. The myeline sheath simply facilitates the process of conduction, by securing better isolation of the fibre. Hence its importance for cerebrospinal nerves during their prolonged course beyond the limits of the neural axis, or even beyond the central cortex or spinal central gray matter. While within those limits the myeline sheath is evidently superfluous, for it does not exist, and perhaps might be imagined to even impede the extreme rapidity of communication required between ganglionic centres. Lenhossek thinks that the myeline is gradually deposited from the surrounding plasma upon the axis cylinder, and as in the case of all organic tissue elements, the functional activity of the fibre stimulates the attraction of the plasma and the formation of the sheath, which constitutes a species of luxus nutrition. Again, so far as we know, elementary nervous processes are always carried on in circuits, formed by an afferent channel, a central arc, and an efferent channel. Even the specific afferent impulses of the visual sense are followed by incessant motor responses through the ocular muscles. There is no precedent for the conception that definite afferent sensory impulses are transmitted to a

nerve centre, there to accumulate until the centre and its centrifugal tracts had become sufficiently developed for response. The statue of Condillac was a pure fiction, and a rather clumsy one at that. Dare we say the same of the daughter hypothesis of Flechsig?

On the supposition that embryonal conducting function begins in embryonal nerve fibres; and that the appearance of the myeline sheaths is not essential to function, but an incident to the nutrition of the developing fibre, the dramatic contrast between sensory and motor tracts "of different functional significance" disappears. The brain is not found to be absolutely passive at one time of its existence any more than at another.

It is curious to note that in his earlier book Flechsig expressly observes that the medullization of a nerve tract cannot be accurately determined by its white color. Myeline sheaths may be fully formed, and yet, until they have reached a certain size, the tract will remain gray. This, he tells us, is the case with the columns of Goll. Yet no more exact test than that of color seems to have been applied in tracing the medullization of nerve tracts in the hemispheres. And Flechsig's own data leave room for the possibility that myeline sheaths are formed at various points of the hemispheres, where as yet white streaks have not appeared.

Thus, as it seems to me, even the histological details described by Flechsig lack sufficient support, and still more his physiological inferences. But the philosophical conclusion which we are asked to accept on this tottering basis is really amazing. An afferent neural impulse, said to be transmitted to a nerve centre so imperfectly developed that it has not yet secured the medullization of its efferent tracts, is treated as a sensation. It is said to precede the first appearance of consciousness, and yet to be the corner stone upon which all consciousness is built.

But a sensation includes much more than an afferent neural impulse. At the very least it includes the central

excitation of gray matter in the brain cortex. It does not precede consciousness, for it constitutes one of the phenomena of consciousness, often of peculiar vividness. There may be, and there are many nervous excitations of which the individual remains entirely unconscious, but an unconscious sensation is a contradiction in terms. Consciousness corresponds to the total activity of the brain cortex, and necessitates the completion of its circuits. It probably depends upon much else besides, but certainly upon this. According to Meynert's picturesquely described scheme, partial revivals of different memory residues occur, coinciding with local affluxes of blood to different cortical areas; and thus the general stream of consciousness is reinforced at different points somewhat as a continuous murmur in the carotid receives systolic reinforcements. But until or unless the general stream exist, there can be no partial reinforcement, no individual phenomenon of consciousness, no sensation.

An afferent neural impulse is not a sensation, but expresses one form of the general susceptibility to external excitation, which is characteristic of all organized beings. Because, even before a nervous system is developed, such excitation is always followed by an organic reaction; so, when the nervous system begins to be organized, and external impressions are made upon afferent nerve tracts, the reaction is effected through efferent nerve channels. There is always a circuit, and the nervous reflex is, admi - edly, the general type of nervous action at all levels of the nervous system. Flechsig professes to find additional proof of the reflex action of the hemispheres in his new data of the precocious medullization of sensory tracts. But there can be no reflex without the coincident function of centrifugal tracts, and this latter, according to Flechsig, is for many weeks in complete abeyance. The more Flechsig's theory on this matter is examined, the less it is found in agreement with anything which is known or admitted

about the correlation of function with organic structure. Nowhere else has it been suggested to dissect the complete function of a developing organ and assume that one-half of this function could be completely performed while the other half could not be. As well assume that there could be a systole of the heart without a diastole, an inspiration without expiration, glandular elimination without excretion, as to assume that afferent impulses could be carried in a nervous system totally incapable of efferent or centrifugal neural action. Still less plausible, if possible, is the assumption of a brain receptive to all external impressions, yet devoid of the power to react to these according to its specific individuality. By this scheme Flechsig has not succeeded in superseding Meynert's analysis of the gradual development of conscious volition, through a series of acts at first unconscious, but successively recorded on the cortex of a correlatively developing brain.

To effect a record of acts performed or of impressions received, a record that subsequent acts are able to revive, so that many may be simultaneously present in consciousness, and that the continuity of the stream of consciousness may be preserved—this seems to be the one function of the non-sensory areas of the brain cortex. In this way this marvelous structure specializes and intensifies the general power of memory, which is the fundamental attribute of all organic tissue. Consistently with the conception of one simple and uniform function to all the non-sensory areas of the cortex, we find, it is said, in these a uniform and relatively simple structure. And this is the chief anatomical distinction between the areas of the brain which constitute central expansions of nerves, the sensory areas, and the remaining portions which are not sensory. The latter are the so-called psychic areas of Flechsig, identical with the regions which, several years ago, were called by Broadbent "the superadded convolutions." "There is not only one seat of the soul," exclaims Flechsig, "there are at least two—the great anterior, and great posterior asso-

ciation centres." "The attribute of a soul-making function to the centres in question rests primarily on an argument of exclusion. The mind," says Flechsig in substance, " is a product of the brain. Such and such parts of the brain do not produce mind, but only sensory impressions or motor impulses. But as mind is clearly produced, it *must* originate in the action of the parts of the cortex which remain after subtracting the sensory areas. Therefore, these must be psychic centres." They are called also associating centres, because the genesis of mind is explained precisely on Condillac's hypothesis, by the simple addition, association, or blending together of two sensations.

"Any one sensation is not mind," declares Flechsig, although he had previously interpreted all his observations on the medullization of nerve tracts, as proving that mind was constructed from a sensation. Two sensations are not mind; but if two different sensory impressions meet in the region of the brain which is intercalated between the two sensory centres where such impressions are generated, then something new is formed by their association, and this something is an idea, a thought, a mental tendency, there is a piece of mind. In each psychic centre we can deduce the mental faculties which are there developed, by observing what sensory centres border on each side of it. The insula lies between the auditory and the motor speech centre: it is therefore the psychic centre for the faculty of speech. The parieto-occipital lobe is intercalated between the visual centre and the touch-motor centre, the somæsthetic area of Barker, constituted by the Rolandic convolutions. Hence the posterior psychic centre is the seat of faculties which may be considered as composed of the sense of touch and the sense of sight—faculties which tend towards scientific observation or æsthetic talent, as the case may be. Following this line of thought, we should expect to find the frontal lobes, intercalated between the somæsthetic centre and the olfactory sphere, to be the seat of faculties which

could be traced to a combination of the sense of touch and the sense of smell. But here the synthesis breaks down, and Flechsig, who localizes in the frontal convolutions the sentiment of personality, the sense of the *ego*, is much put to it to explain what share the olfactory sphere should bear in the genesis of this part of the mind. Unable to do so, Flechsig at this point abandons the strict application of his own theory, and deduces the sentiment of the *ego*, not from a combination between two sensory centres, but exclusively from the adjacency of one—namely the somæsthetic sphere in the central convolutions. The sentiment of the *ego* and of personality is said to arise as a natural sequence from the impressions of touch, which put the individual into connection with the outside world; and the impulses to movement, which give him control over it.

The foregoing exposition sounds wonderfully clear, and convincingly ingenious, until we attempt to analyze exactly what it means, and then the apparent clearness becomes veiled by the densest obscurity. The theory involves the following postulates:

1st. That sensations are not psychic phenomena. Flechsig defines psychic phenomena as vital phenomena distinguished from all others because accompanied by consciousness. Now, a sensation, to be such, must be accompanied by consciousness, often of peculiar vividness. Consciousness is not essential to organic susceptibility or to afferent neural impulses, but an unconscious sensation is a contradiction in terms. The first postulate, therefore, is false.

2d. That a mental act proper always implies generalization from two or more sensations, or from the memory residues of sensations. This statement raises the cardinal problems in philosophy, which are far beyond the province of this paper to discuss. It may be, however, admitted that for a certain class of mental acts the proposition is approximately correct.

3d. It is quite otherwise with the third postulate of

Flechsig's theory. According to this the generalization in question is affected by the propagation to an associative centre along associative fibres, of excitations originating in the sensory centres which lie on either side of it. Two specific excitations are said to combine with each other—thus a visual impression from the cuneus, with a tactile impression from the posterior central convolution—the combination taking place in the posterior psychic area of the parieto-occipital lobe.

But what possible meaning can there be attached to such a statement as this? What proof or precedent exists for the conception of a material combination of the excitations of two nerve centres, by means of their simultaneous excitation of a third? We know of the extension of afferent irritations from one nerve centre to another, and the consequent excitation of motor centres, and the overflow of this along centrifugal tracts. We know of the influence of the auditory word centre upon the Broca centre, as a special case of sensory-motor excitation. We know of the extension of irritations from one sensory centre to another, with consequent shifting of peripherically referred sensation; and we know of the inhibition of motor centres, visceral, vascular, or muscular, by the excitation of non-motor centres. I think this exhausts the known precedents for theories on the interaction of nerve centres. None of them in the least resembles the case imagined by Flechsig. It seems to me that his third postulate must be rejected on the ground that, for the mystery which enshrouds brain processes, it has substituted pure nonsense.

There is no such thing as a complex sight-touch impression. We are not, therefore, concerned to show how such an impression, of which we have no knowledge whatever, might possibly be formed. What plainly happens is that an object presented simultaneously or successively before the retina and an organ of touch, as the hand, excites visual and tactile impressions, and these unite *in*

consciousness to constitute a complex experience of the object. There is not the slightest indication that they unite anywhere else. Flechsig's elaborate argument would never have been constructed, but for the desire to demonstrate the working of cerebral mechanisms entirely irrespective of consciousness. The union of two impressions in consciousness is in itself a somewhat metaphorical way of saying that the mind is, at the same time, conscious of two aspects of the same object.

There has been no combination in space, and such a combination, which has never been proved, is impossible to definitely imagine. The combination has been affected between two events in time.

The gist of the entire question lies in this most simple and elementary case. It is not worth while, therefore, at this time to follow the same line of thought into consideration of the numerous mental acts which are remote from sense perceptions. From the elementary case we infer that the excitation of a sensory centre becomes the occasion for diffused excitation of all other parts of the cortex, except, possibly, other sensory centres. There is nothing to indicate that the secondary excitation is limited to any special locality; hence nothing to indicate that for mental purposes any more significance attaches to the adjacency of cortical centres than to the precise localization of the first or second violins in an orchestra, where also, separated masses of molecular movements so focus into unity as to produce musical sounds. The unifying focus is the auditory consciousness of the listener, without which, as has been said, a symphony by Beethoven would remain nothing but the scraping of horses tails over cats' bowels. Consciousness is the unifying focus for all such processes in the brain as cross its threshold. Subliminal processes are not unified, and thus are neither sensory nor psychic.

The discovery of the memory residues of specific sensory excitations in non-sensory regions adjacent to the sensory centres, would, were it possible, tend to exhibit

some such interaction between the two as Flechsig's theory postulates. But this discovery has not been made. Munk's experiments on so-called psychic blindness and deafness only show the effect of extirpating the entire cortical expansion of the optic or auditory nerves. The animal then, naturally, became unable to see or hear, but it was impossible to show that he, still less a higher animal, had, therefore, lost all previously acquired experiences of vision or hearing. Certainly this is not the case with adult human beings who have become cortically blind. Flechsig admits that the sensory residues of sensory impressions are not stored up in the sensory centres themselves.

If for Flechsig's obscure and clumsy theory we substitute in part Meynert's suggestion, that whenever any event occurs at any level of the cerebrospinal system, the nervous perturbation it occasions is propagated to the cortex of the brain, whose elements retain an organic memory of the excitations they have experienced—we remain within the limits of simple and unbiased observation. Guided by this suggestion, we may, indeed, occasionally detect an influence of adjacency, which otherwise would be inexplicable.

Thus, as I have mentioned, Flechsig is compelled to abandon his combination theory when called upon to explain by it the relations of the frontal lobes to the olfactory sphere. He tries to show that in regard to this, human development does not follow, but contrasts with the general order of phylogenetic evolution; because "in man the sense of smell has become relatively insignificant, and its encephalic organs relatively atrophied; and correspondingly medullization, that is function, begins with the important sense of touch, and not with the unimportant sense of smell."

Flechsig admits, however, that medullated fibres are formed in the olfactory sphere at about nine months, that is, at the same moment that the pyramidal tract and also

many sensory tracts are ripening. Further, the greater importance of the sense of touch in later life does not contravene the earlier importance of the sense of smell at birth, by which even the human young seem to be chiefly guided in fumbling for the breast. Lower down in the animal scale, and among the earliest vertebrates, the sense of smell probably remains throughout adult life the chief guide in the search after food, thus of prime vital importance. In this fact may perhaps lie the reason for the subsequent development of the brain mantle around the originally enormous olfactory organs of the vertebrates. The primal instinctive activities are guided by these organs. When these activities begin to be recorded, so as to construct a continuous experience, a brain cortex begins to be formed and continues to develop in proportion to the increasing complexity of the record. As the sense of personality is undoubtedly associated with the development of continuous experience, and of the record by which the continuity is maintained, it would be approximately and historically correct to say that the sentiment of conscious personality had originated in acts of smelling. This, however, is quite different from saying that the sentiment of the *ego* had been mechanically generated by excitations of the organs of smell. The one plausible basis for Flechsig's speculations is the indisputable fact that masses of gray matter are, in the human brain, intercalated between the cortical areas which constitute the central expansions of nerve tracts directly exposed to external impressions. Further, that within the human species, the range of mental existence seems to be approximately correlated with the amount of gray matter which is so intercalated. Direct examination of the structure of these superadded convolutions, discovers in them mechanisms which would seem to provide for the infinitely multiplied propagation of neural impulses or excitations, and also for the impact of these upon ganglionic cells in a manner to secure something for which the electro-chemical science of the day

supplies the metaphor of storage. As a working hypothesis, and as a substitute for the earlier metaphor of the daguerreotype sensitive plate, we imagine a series of chemical changes, of molecular movements effected in the protoplasm of the ganglionic cells, or of their prolongations, which movements, having once occurred, may be revived by a recurrence of the original excitations, or of secondary excitations which traverse the same lines as the first.

According to Meynert, the brain cortex records all the events, of whatever nature, which transpire within the sphere of existence of the individual. The record is voluminous in proportion to the complexity of the experience acquired. The brain cortex of the new-born infant represents inherited ancestral experience, both phylogenetic and personal. The existence of the record at this time shows that such experience is separable from the brain, because transmissible by the infinitesimal speck of matter which constitutes the germ cell. The more voluminous the inherited mass of cortex, the greater the facilities afforded for recording the events of the new life which are about to transpire. Among the millions of cortical cells we are almost compelled to imagine infinitely complex series of secondary excitations duplicating, reduplicating, endlessly refining upon the original excitation. So that, even when this has arisen in a sensory centre, the sensory impression drops out of consciousness, and only its remote memory, shadow, symbol remains, based upon the series of mental events it was suggested or started. As the complication of the secondary excitations depends upon the number of nerve elements which can be excited, and this number is an inheritance from antecedent circumstance we may say in a general and metaphorical sense, that the new experience of the individual blends with the recorded experience of his family and race, to constitute the total experience of consciousness at any given moment. No space or material combination can be imagined, but a blending in time of an in-

finite series of events. The facts of specific quantitative inheritance show that during the process of making new records, that is during the individual life of the brain, its organic memories, its inherited habits are revived, and these modify the manner of the new recording. The records are not uniform to the same excitation, but assume specific forms which vary in each individual case. There is no moment in which external impression is not followed by specific reaction.

In all this there is no evidence to be found for the localization of psychic functions or faculties, but rather for the totality of brain action at any given moment to any given excitation.

I think the flimsiness of Flechsig's argumentation depends on the futility of his attempt to demonstrate that the brain is the mirror of mind rather than the expression of mind. The attempt has often been made before, but it is interesting to note how each in succession fails. And to this last and brilliant effort in the same direction it has seemed to me eminently worthy to invite the thoughtful criticism of this society.

Note.— Criticisms upon Flechsig's conclusions, and their cases, have not been lacking from other points of view than those developed in the preceding considerations.

Dejerine (Soc. de Biol., Feb. 20, 1897) protests vehemently against Flechsig's view that "only a third of the cerebral cortex is provided with projection fibres, the other two-thirds serving only to associate together the sensorial spheres, and the sensory-motor sphere." "This view rests upon the study of the brains of new-born children, or of those younger than five months: it is in absolute contradiction with the teachings of normal anatomy and the study of secondary degeneration." "All the cerebral cortex contains projection fibres, including, probably, the insula." "It is very possible that the infantile brains studied by Flechsig were deprived of projection

fibres. But it is inadmissible to say that *therefore* these did not later exist." "It is not astonishing that the sensory and sensori-motor centres develop earlier than other regions of the cortex, for they belong to an earlier order of phylogenesis."

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