

ON THE VISUAL PATH AND CENTRE.¹

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BEFORE an audience like this, I certainly need not enlarge upon the great importance of the senses in the development of our intelligence, and indeed of our whole psychical life, of which doubtless the perceptions through our senses are the necessary conditions and basis. In order that modern psychology may possess a definite starting point and foundation, we must obtain an exact idea of the anatomical construction and physiological function of the paths and cortical areas of our senses, as well as their connections with other parts of the brain. In consequence of the law of evolution, there exists in man the highest development of the different centres, and of psychical life. For this reason we must principally study the paths and centres of the senses in *him*, whilst comparing the results obtained by experiments on animals.

For the deeper study of the senses, there is none so instructive as that of sight, which is, in certain respects, the principal one. Through the same we procure the greatest wealth of perceptions, which will continually serve as objects of our psychical activity. No sense can be so minutely examined in regard to its functions and pathological derangements, and a clinical examination will, in most cases, determine whether the lesion be of a peripheral or central nature. If we are ever to grasp the inner connection between the higher psychical activity and the construction and function of the senses, it must be principally through the deeper study of the visual path, its centre and activity. The more profound and penetrating the knowledge we obtain in this direction, the more certain will be the starting point of our

¹Paper read before the Congress of Experimental Physiology in London, 1892.

psychological researches, not only in this direction, but also in that of the other senses, for we may presume that there exists a certain analogy between them. It is for this reason I take the liberty of giving a short sketch of my opinions on the above, viz. :—the visual path and centre, based upon clinical facts gathered from others as well as myself. But I shall not enter into details, and the prescribed time will not allow me to bring forward the proof for many of my views, but for further particulars I refer you to my work, “*Beiträge zur Pathologie des Gehirns.*” The second volume has just now been published, a copy of which I now have the honour of laying before this congress.

In order to understand the nature of the cerebral representation of vision and its psychology, the localisation of the cortical centre for sight, is of more interest than that of the course of the visual path, which is principally an anatomical question. But the former proposition cannot be solved without a knowledge of the latter, and I shall, therefore, first discuss the question of the visual path. Moreover for a proper comprehension of the relation of the visual centre with those of other senses, it is necessary to have an acquaintance of the connection of the visual path with the central ganglia of the brain. I will, then, in considering these anatomical questions, express myself briefly, and mainly dwell upon some of the most important points, in which I differ from current doctrines.

Enquirers have tried in different ways to arrive at a solution of the question of the visual centre. Wilbrand, for example, has by using the purely clinico-ophthalmological method elaborated a theory, which may not be unknown to my auditors. Objections might be raised against his conclusions, in that the starting point of his statements is uncertain, in this respect, that only a few of his ophthalmological cases were examined after death. Nevertheless, I have, by using the combined clinico-anatomical method, arrived at much the same conclusions. Only by this latter method, the clinico-anatomical, can we secure a firm basis for the investigation of this field of study. Time after time, it has been adopted by celebrated observers, such as Ferrier, Luciani,

Tamburini, Wilbrand, Starr, Seguin, Nothnagel, Seppilli, &c., but the results at which they arrived have only partly coincided. Time will not suffice to give an historical sketch of their different opinions. I will only intimate that whilst some Frenchmen wish to extend the visual centre as far as the central convolutions, others, especially Englishmen, limit it to the occipito-angular region, and others, as Seguin and German authorities, confine it to the occipital lobe. Reinhardt would place the centre, in agreement with Munk's experiments, on the lateral surface of the occipital lobe, Nothnagel in the first occipital gyrus, Seguin on the mesial surface, and Hun places it immediately in the neighbourhood of the calcarine fissure. A new and rigorous analysis of the clinico-anatomical cases is of course necessary, and I have endeavoured to submit to it all accessible facts concerning the visual centre, and I am convinced that all these tend in the direction I propose indicating.

Besides these clinico-anatomical facts, there exists a number of other pathological ones of importance in the solution of the above problem. After extirpation of the bulbs, or a lesion of the frontal visual path, or of the external geniculate body, there arise centripetal degenerations; and after lesions of the visual cortex, arise degenerations of a centrifugal nature, which enlarge our knowledge of the centre itself. These changes have been principally studied by Monakow and myself.

Numerous investigators have devoted much time and patience in experiments upon animals, but I omit stating their conclusions here, in the belief that these renowned experiments are known by all present. Meanwhile, one should, with great circumspection only, be permitted to apply the results of experiments upon animals directly to man, especially as experimentors have not arrived at the same results.

In the first place, in order to discover the visual path and centre, every clinical case supplemented with a *post-mortem* is serviceable, in which some defect of central origin is observable in the field of vision. These defects are almost always hemianopic. But nearly as important as the positive cases are the negative, with an absence of any defect in

the field of vision, but with a lesion in the neighbourhood of the visual path or centre. These latter control the conclusions drawn from the positive cases. A necessary condition, to obtain a sure result, is that the clinical and pathological examinations are conducted by competent persons, because hemianopsia is often latent and frequently impossible to detect in feeble and unintelligent patients. Since I commenced to make a systematic examination of my patients in this respect, I have found in my hospital in Upsala, nearly 40 hemianopic cases, supplemented in the *post-mortem* records; whilst Seguin, in 1886, could only discover about the same number in the whole of literature. The number of cases has considerably increased of late years, and there are now perhaps more than 160 on record. Lesions of the visual path, especially cortical ones, are also evidently very common, and we may hope that further clinical researches upon this matter will thoroughly elucidate the organisation of this sense. This, however, can only be the case, if clinical and pathological scientists work methodically. An analysis of the already published cases proves that the present manner of working does not satisfy the requirements of science, for many even of the most important cases are incomplete. My statements are chiefly based upon my own cases.

The Visual Path can be divided into the frontal, middle and occipital. I shall not dwell upon the anatomical construction of the frontal visual path, as it is only of minor importance in elucidating the problem before us. Nature has herself indicated its direction. In the optic nerves, chiasma and tracts, the fibre from different quadrants lie in separate bundles, and those from corresponding points are not immediately beside each other. Fibres from the upper retinal quadrant lie dorsally in the tracts.

The Middle Path.—The course of the optic fibres and their connection with the central ganglia has not yet been thoroughly investigated. It is very important to notice that it is necessary to distinguish between visual and optic fibres; a lesion of the former produces a defect in the visual field alone, whilst the latter are to be considered as reflex

fibres. There is no doubt that the three great central ganglia, the external geniculate body, the pulvinar and the corpora quadrigemina anterior, all receive fibres from the optic tracts; but the question is, do they all receive visual fibres? Thereupon depend their several functions. The above three main ganglia have evidently different duties to perform in different animals, but I only here intend referring to their importance in man. The solution of this problem should be effected by an analysis of the respective clinico-pathological cases. The central ganglia are often injured by lesions, which are succeeded by hemianopsia, but these are often microscopical, and extend simultaneously with larger lesions into the occipital or parietal lobe, and, of course, are then overlooked.

Literature specifies at least eight¹ cases of tumour in the central ganglia, six of hæmorrhage, and sixteen of softening, accompanied with hemianopsia. An analysis of these cases gives the following results. In the case of tumour the growth was so diffuse that no enlightenment could be obtained concerning the functions of the above three main ganglia. Of the cases of hæmorrhage there were only two, Dreschfield's and my own, in which the lesion was so circumscribed that a conclusion could be drawn of the function of the pulvinar, but from the freshness of the hæmorrhage and its pressure upon neighbouring ganglia the result could but be considered uncertain. Neither are the sixteen cases of softening of use in the solution of the problem, and this for reasons you will find discussed in my book. Thus the analysis of the clinical cases with hemianopsia does not decide this question, and here, therefore, the importance of the negative cases arises. Nothnagel has, by an analysis of lesions in the corpora quadrigemina, proved that such need not give rise to any form of visual disturbance, and further, some cases go to prove that the destruction of the pulvinar is not always accompanied with hemianopsia. By means of exclusion we shall also prove that there is no clinical proof that in man the pulvinar or corpora quadrigemina ought to contain visual fibres and thus be necessary to

¹See my work "Pathologie des Gehirns," Upsala, 1892, p. 266.

sight. Consequently, the external geniculate body is the main sight ganglia in man. Its destruction will always produce some form of hemianopsia.

The position of the fibres in this ganglia has only partially been ascertained. My own researches in a case of atrophy of one optic nerve have persuaded me that fibres from both eyes lie immediately together in this ganglia, and not in separate bundles, as in the frontal portion of the visual path. And, finally, Monakow has on account of his own enquiries expressed the opinion that the visual fibres do not lie in direct connection with the ganglia cells, but ramify in the ground substance. To the above I will only add that the clinical analysis does not render any support to the commonly accepted theory that a lesion in the posterior portion of the internal capsule gives rise to hemianopsia, and still less to the idea that a decussation in the middle line of the corpora quadrigemina takes place.

The Occipital Visual Path.—The determination of the situation and limits of the occipital visual path is of the greatest moment in deciding the debated question as to whether the parietal, and especially the angular gyrus, belongs to the sight area or not. It is very common for lesions in the parieto-angular region to be accompanied with hemianopsia, and this fact has given rise to the opinion that it belongs to the sight area. But a critical analysis of the cases tends towards another view, for in a considerable number of cases lesions in that region are not followed by hemianopsia. How, then, can we find a clue to this apparent contradiction? The explanation is as follows:—If the lesion implicates the visual path in the optic radiation of Gratiolet, it will induce hemianopsia, but not otherwise.

Where does the Visual Path lie?—This question will be solved by a clinico-pathological analysis. Literature mentions at least 13 cases of abscess or tumour in the parietal lobe. In eight of these hemianopsia was present; in five not. There are also four traumatic cases. In most of these the lesions (tumours or traumata) were so large and diffuse, or they pressed upon the optic radiation to such an extent, that their influence cannot be accurately determined. The negative

cases are, again, of decisive importance, for they prove that a lesion of the parieto-angular cortex need not induce a defect in the field of vision. It is just the same in cases of hæmorrhage. Six were followed by hemianopsia, but in one of mine—that of a professor of medicine—the hæmorrhage was not accompanied with hemianopsia. Finally, there exist at least 25 cases of softening in the parietal lobe, in 12 of which hemianopsia was present; in seven absent. An analysis of all these cases gives us this result: the visual path is situated in the ventral portion of the optic radiation, and there forms a bundle less than a centimètre thick, which lies at the level of the second temporal gyrus and second temporal sulcus. A lesion of the parietal or angular lobes induces hemianopsia, only if this bundle be pressed upon directly or indirectly, a lesion of the dorsal part of the optic radiation does not produce a defect in the field of vision. One of Dr. Anderson's, and another of Dr. Bruns' cases, show in what manner the fibres lie in the bundle forming the visual path. The fibres for the dorsal retinal quadrant lie dorsally, and one of my own cases shows that the fibres for the ventral retinal quadrant lies ventrally. It is probable that the macular fibres have a more median situation than the peripheral.

We now enter upon the consideration of the occipital lobe. A number of observations have been made in literature upon occipital lesions. Most of them were accompanied with hemianopsia, but only a few of them are of use in the accurate study of the localisation of the centre of vision. In 20 cases the lesion was diffuse in the medulla of the occipital lobe. None of them localise the visual centre to a circumscribed portion of the lobe, because the visual path was destroyed by the lesion, but many of them go to prove that it does not extend further than the occipital lobe. All cortical or sub-cortical circumscribed lesions, on the contrary, are of great importance in the localisation of the visual centre. The first question that arises is, Does the centre of vision lie on the lateral, mesial, or ventral surface? Eight cases with cortical lesions on both the lateral and mesial aspects of the cortex do not solve this question, but

the fact that in 11 cases of lesions situated in the lateral centre, there existed no defect, or only a transitory one, in the field of vision, proves that we need not seek the visual centre in that situation, more especially as, in some cases, the lesion was bilateral. On chart H in my book, I have collected a number of cases without hemianopsia, but with lesions on the lateral or ventral surface of the parietal or occipital lobes, and a look at it ought to convince us that we need not expect to find the visual centre in either of these regions. Just as convincing are the cases with lesions exclusively on the mesial surface (chart G), of which literature mentions at least 25 examples. A methodical analysis of them leads to the following results:—Firstly, a lesion on the mesial surface causes hemianopsia only if the cortex of the calcarine fissure, of the fibres derived from it, are affected. Secondly, a lesion limited to the calcarine cortex can induce a complete hemianopsia, and of this the most instructive case is, I believe, one now published in my book, which includes all guarantees for an exact conclusion. It was stationary, uncomplicated, and the clinical examination, as well as the *post-mortem*, was accurate. The lesion was limited to the cortex in the depth of the calcarine fissure, and the hemianopsia was complete and absolute. Besides, many other negative cases confirm this result, and, in particular, one of my own, with a bilateral destruction of the *margo falcata*, without defect in the field of vision, proves that the visual centre is not to be looked for there, as Nothnagel and others have affirmed. As to the still more accurate limitation of the visual centre in the cortex of the calcarine fissure, the cases, on the whole, are not sufficiently definite to decide, but there are not at present any absolute reasons for extending it further than the lips of the fissure. In some cases a complete hemianopsia resulted without a lesion in the frontal part of this cortex; in others without any affection of the most posterior part; but in all cases the middle part of the fissure was implicated.

I cannot find in literature any one well-described cases which stands in opposition to the opinion here expressed; but there are many appearing to lead to other conclusions, but which cannot stand a rigorous criticism. Monakow has

quite recently arrived at a contrary result. I will not in his absence criticise his theory on a variable localisation of the macula latea, but will only point out my own individual stand-point. I cannot find the clinical cases on which Monakow bases his opinion. He suggests that many spots in the parieto-occipital cortex can, under different circumstances, represent the field of vision. The way in which the fibres of the visual path, pass through the occipital lobe to reach the calcarine cortex, is not clear, but they probably lie in both the dorsal and ventral aspects of the optic radiation. Several facts go to show that, at least, the cortex for the macular field in the calcarine fissure is innervated in a double way.

Organization of the Centre of Vision.—The next question is: How is the centre of vision organised? At first there exists a projection in the calcarine fissure. I have mentioned above that my researches have led me to the conclusion that the fibres of the dorsal retinal quadrant lie dorsally both in the frontal and occipital visual path. The interesting case of Hun's, proves that there is the same arrangement in the calcarine cortex. Thus the upper lip represents the upper retinal quadrant, and other cases strengthen this opinion.

The question now arises: Where does the macular field lie in the calcarine cortex? In deciding this, there are no positive facts, but many cases indicate that the macular field may be more anterior, and the peripheral in the horizontal meridian, more posterior. Some time ago, I observed a case in which the whole of the right occipital lobe was destroyed, and the tip of the left damaged, but still the patient could read up to her death. This case is against the localisation of the macular field being at the tip of the occipital lobe.

Perhaps it is known that Wilbrand, by using purely clinico-ophthalmological facts has come to the conclusion that the macula lutea is innervated by both hemispheres in a variable manner. The clinical analysis of the cases seems to confirm this opinion, and such an arrangement is very favourable to those unfortunate enough to be afflicted with

hemianopsia, for they will still preserve the faculty of sight at the point of fixation. As above stated there seems to be another guarantee for the preservation of the macula lutea, and that is, double innervation, both from the dorsal and ventral portions of the optic radiation.

The third important question concerning the cortical retina, as I should like to call the cortex of the calcarine fissure, is whether both eyes or only one are represented in the lips of the fissure, and the crossed as well as the uncrossed fibres. This question is answered by the above case, where a lesion limited to the calcarine fissure had induced a complete hemianopsia of both sides, and others of my cases tend to confirm such a conviction, although it is in opposition to Munk's celebrated experiments.

Of as great interest is the question as to whether the same elements represent homologous points of the retina, or not, and how they are situated in relation to each other. I have myself observed some important facts bearing upon this question, and Wilbrand has elaborated a theory on the subject, supported by some clinical facts. After destruction of both eyes in a patient suffering from leprosy, there ensued a complete atrophy of the calcarine cortex, but in a case of destruction of one eye only, I found in that situation, a number of pigment-charged cells alongside of perfectly normal ones. These facts seem to prove that the elements of both retinal halves are represented in the calcarine cortex by different cells, which lie beside each other. As to the perception of colours, the commonly received opinion that it is situated on the ventral surface will not admit of criticism. Some of my own cases prove positively that colour perception is also situated in the calcarine cortex.

It is well known that this cortex is characterised by a special anatomical construction, and particularly by solitary cells and a layer of small cells, corresponding with the streak of Vicq d'Azyr.¹

The above expressed opinion in regard to the organisation and limitation of the visual centre to the calcarine fissure does not stand in opposition to the results obtained by the

¹See my work, p. 378.

investigation of centripetal and centrifugal degenerations. Monakow also has found by this method that the calcarine fissure stands in connection with certain groups of cells in the external geniculate body. I will not discuss here the complicated problem as to which cells receive the impression of light. It might be left an open question, as well as that of the functions of the different layers in the cortex. After the destruction of the bulbs, or of the external geniculate body, the large as well as the small pyramidal cells undergo essential changes. If the above theory resists criticism, then many of the main problems of the visual path are solved. But we must further exert ourselves to seek new observations, still more accurate and detailed than those hitherto discovered, before the above theory can be considered as finally settled.

The next fundamental problem will be to discover the functions of the remainder of the occipital cortex and angular gyrus. But there is no doubt that this cortex has a certain connection with the function of the eyes. Word-blindness, and some other facts in human pathology corroborate such an opinion. I will not comment upon this very complicated problem, which is not yet, in my opinion, ripe for solution.

All these problems are of the greatest importance to psychology, but they cannot be decided without having obtained a solution of the visual centre. Therefore, it seems to me that this study is the most serviceable to us in indicating the right way leading from physiology to psychology.