

B R A I N .

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Original Articles.

ON THE SENSORIAL LOCALISATIONS IN THE CORTEX CEREBRI.¹

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WHOEVER has made experiments on the sensorial centres knows how great and how many are the difficulties there are in proving the existence of disorders, total or partial, unilateral or bilateral, of the several senses. There is in this kind of research a constant danger of confusing objective facts with the individual appreciation of them. I therefore took pains to render more secure and rapid the diagnosis of sensorial alterations in animals whose brains have been operated upon, by making a comparative study of the value of the various methods employed, and finding new means better adapted to my object. I shall limit myself here to a sketch of the most general method of investigation applicable to the safe and

¹ This paper contains an abstract, or preventive communication, of the chief results obtained by the author in a recent series of long and laborious experimental researches on the sensorial localisations in the brain of the dog and the monkey. The full memoir is to be published shortly in Italy. The present abstract has been translated by myself from Prof. Luciani's original Italian manuscript.—The reader will find abstracts of Luciani and Tamburini's previous researches in 'BRAIN,' Vol. I. p. 529; Vol. II. pp. 284 and 580; a criticism of Munk by Ferrier, Vol. I. p. 229; a paper by Ferrier on Amblyopia, Vol. III. p. 457; and an abstract of Ferrier's recent researches on Localisation in the present volume, p. 139.—A. DE WATTEVILLE.

rapid discovery of the chief forms of tactile, visual, auditory, and olfactory disturbances which present themselves in consequence of the extirpation of various cortical areas. This diagnostic method which, when employed methodically, in every case makes the results obtained perfectly comparable among themselves, consists in the observation and the definition of the behaviour of the animal under the various stimuli which act upon its several senses, during the time it is taking its food, with its eyes open or with its eyes bandaged, or again with one eye open and the other closed. One prepares for the animal some favourite article of food; for instance, boiled meat divided into small pieces, and when the hour for the meal has arrived, when the appetite of the animal is keenest, its favourite food is shown it and given it to taste; then its eyes are well closed by means of sticking-plaster. Now, especially if it be the first time, the animal will make with its leg a few efforts to remove it, but if a piece of meat is immediately thrown out to it it leaves the plaster alone, and occupies itself in a search for the food, sniffing vigorously with its nose close to the ground, and moving about with great rapidity. This is the most opportune condition for testing the tactile, auditory and olfactory senses: it is enough to touch the various points of the skin, on the limbs, head or trunk with a straw or a pellet of cotton wool fixed to the end of a small rod, that the animal should under normal tactile conditions suddenly react, quickly turning the head towards the part touched, whilst it goes on seizing the food; it remains passive, or almost so, however, if the points touched are the seat of the diminution of the general sensibility. This mode of testing the sense of touch gives such clear results as to leave nothing to be desired.

By throwing pieces of meat at intervals upon the plate, sounds are produced more or less perceptible according to the size of the pieces and the force with which they are projected. The animal then has not only the sense of smell, but also that of hearing to divert its search. As soon as it has swallowed a piece of meat it stands motionless, pricking its ears in order to catch the direction of the sounds of other pieces falling, and if the hearing is perfect on both sides, it quickly turns either

to the left or to the right, according as the food is thrown nearer to one ear than the other; whereas if one of the two sides (or both) is deficient, the animal behaves in such a way as to show the side on which audition is imperfect (or manifests the bilaterality of the lesion). This is the best means of discovering even slight and unilateral alterations of hearing; whilst the test with the diapason (made to vibrate in the proximity of one or other ear), calls, loud and sudden noises are of use for investigating more profound auditory troubles.

This method of testing by the mode of alimentation with closed eyes is also of use to appreciate, though less accurately, alterations in the olfactory sense. For this purpose, it is enough to eliminate the intervention of the sense of hearing, by first disposing on the ground pieces of meat at a certain distance from one another, and noticing the rapidity with which the animal finds them by olfaction only. Then, after obstructing one or the other nostril with a plug of cotton wool, and holding the animal in the arms, one gradually brings its nose towards a piece of meat; one can thus judge comparatively of the acuteness of the sense in the two nostrils by measuring the distance at which the meat lies, when the animal begins to sniff and stretch its nose. The rapidity with which it reacts to more or less powerful odours (ammonia, acetic acid, chloroform, turpentine, cloves, &c.) may fulfil the same purpose.

It is a pity that we cannot test with the same ease alterations in the sense of taste, which we have no other means of appreciating than the readiness with which the animal reacts to bitter substances (colocynth, quinine, digitaline, &c.) applied to the two sides of the tongue.

The careful examination of the visual sense is of the greatest importance, in order to secure a diagnosis of its disturbances, whether partial or total, bilateral or unilateral, such as hemiopia, amblyopia, psychical blindness, complete and absolute blindness. The best method here is still the test by alimentation, whilst one of the eyes is closed or both are open. Thus, for instance, after the left eye has been closed, small pieces of meat are thrown to the animal (avoiding the production of any sound) first in a line with its nose, or a little to the left, so that

the images be thrown upon the external segment of the right retina; secondly, to the right, so that the images be thrown upon the internal half of the same retina. The animal turns at once to seize its prey if the section of the retina on which the image falls is normal, but shows that it does not perceive it, if that part of the retina be blind; or finally shows that it perceives, but directs itself towards the food with some hesitation, and not in the precise direction if the retina be amblyopic. It is, in general, difficult to distinguish between hemiopia and hemi-amblyopia; more difficult to distinguish between amblyopic phenomena and those of psychical blindness—an expression by which we intend to designate, with Munk, a peculiar condition in which the animal preserves the capacity of seeing, but has lost that of recognising objects. In order to succeed in this diagnosis it is necessary to place on the ground small pieces of meat along with pieces of sugar, or some other inodorous and non-alimentary substance of the same size. If the animal is simply amblyopic, it has only to approach the pieces of sugar in order to recognise them by mere sight without smelling or tasting them; but if it is psychically blind, if it has lost the memory of visual signs, it requires more than sight to recognise them, viz., smell and taste. This test gives sufficiently clear results in dogs, very evident ones in monkeys.

In certain cases, dogs operated on at certain points of the cortex show themselves completely blind to food placed in small pieces on the ground; in order to find them they employ smell and touch only. Still, we have not to do here with complete and absolute blindness (cortical, as Munk calls it), but perhaps with a psychical blindness of an extreme type with or without amblyopia. For if the animal be led into the open air in a garden where it has been accustomed to stay, one sees it proceed straight along the paths, successfully avoiding the contact of hedges, walls, and other fixed obstacles which it comes across; whilst on the other hand, it constantly strikes against any unusual obstacle, such as a board, placed across the path which the animal is following.

II. After this short description of the methods of investigation applicable to the organs of nerve, I shall now give an

account of the most important results obtained by me. I shall speak first of the cortical centre of the sense of vision, which has been the principal object of my researches, because it is the one which lends itself to the most searching physiological analysis.

The first question which presents itself with reference to the visual centre or sphere refers to the localisation of the same in the dog and the monkey. My new experiments point to the necessary conclusion, that appreciable visual disturbances follow not only extirpation of the *occipital*, but also the *parietal*, *temporal*, and *frontal* lobes. According to some results, the complete or partial destruction of the *cornu ammonis* also produces marked disorders of vision. Analogous results induced Goltz to admit, that in dogs the visual centre is so diffused in the cortex, that there cannot be said to exist any localisation of it. But if we consider more closely the effects of decortications of the various lobes, it is found, that lesions of the *frontal* and *temporal* lobes give rise to transitory visual troubles which gradually diminish, and finally disappear altogether (or at least become inappreciable), after a few days or weeks. Similar lesions of the *occipital* and *parietal* lobes produce permanent results; a certain improvement takes place during the first few days after the operation, but they then persist unaltered for months, or during the whole time of the observation.

We have observed another fact which does not agree with the doctrine of Goltz. When the lesions in the frontal and temporal regions are of small extent, that is to say, comprise but a single segment, sufficiently circumscribed, of these lobes, they may give rise to no appreciable disorder of vision, whereas equally limited lesions in the occipito-parietal province constantly produce evident visual disturbances.

We shall not be able to interpret these facts, considered in their whole and in their particular, without appealing to the theory that the visual sphere—though chiefly concentrated in the occipito-parietal zone of the hemisphere—is not clearly circumscribed therein, but enters into relation with other centres, as it were “par engrenage,” by means of direct anatomical prolongations.

The experimental results obtained on monkeys are in accordance with this mode of interpreting the facts which relate to the visual sphere of the dog. My new experiments confirm on the one hand the capital importance of the occipital lobes as centres of vision, as already demonstrated by Munk, whilst on the other they confirm the view, that these centres spread by irradiation into the parietal lobes, especially into the angular gyri, and their fold towards the parieto-occipital fissure, as was shown by Tamburini and myself, and by Ferrier and Yeo. My new researches prove in addition, that the isolated destruction of the angular gyri produce slight, and rather transitory, visual disturbances; and that the effects of destruction of the occipital lobes are aggravated then considerably, but not rendered permanent by a posterior decortication of the angular gyri.

In order that the analogy between the visual sphere of the dog and that of the monkey should be complete, one would have to demonstrate, that extensive decortication in the neighbourhood of the temporal lobe of the monkey gives rise to transitory but appreciable visual troubles. The facts we have elicited bear out the statement, that in the monkey also the visual centres present such connections with other centres, as are considered by us as the organic condition of the great psychological principle of the association of sensations and ideas.

The second question relative to the visual centres consists in the determination of the relations existing between the retinal field of each eye, and both their relative cortical centres. My recent experiments confirm the view that the fibres of the optic nerve of the dog undergo in the chiasma an incomplete decussation, as was seen by Tamburini and myself, and that the extirpation of one of the occipital lobes produces a bilateral homonymous hemiopia, as Munk was the first to prove clearly, though more extensive in the eye of the opposite side. From this fact, now recognised as constant, it is logically concluded, that each of the visual spheres has a direct relation with the more extensive internal segment of the retina on the opposite side (including about two-thirds of the retinal field), and with the less extensive external segment of the retina on

the same side (including about one-third of the retinal field). But it does not follow from the fact that the direct and crossed fibres of the optic nerves correspond to two distinct segments of the retinal area, that they be distributed to distinct sections of the visual sphere, nor that each definite point of the retina have a fixed and constant relation with definite points of that sphere. I have obtained three different series of results which do not allow me to accept this conclusion.

1. Bilateral homonymous hemiopia results not only from complete extirpation of one occipital lobe, but also from extensive decortications of one parietal, and also of one temporal lobe.

2. Partial bilateral extirpations in the province of the occipital lobe (visual sphere of Munk), never produce distinct phenomena of partial blindness, but visual troubles, more or less accentuated, equally or almost equally diffused over the several segments of the two retinæ.

3. The hemiopic effects consecutive to extensive unilateral extirpations in the occipito-temporal and parietal region of the vortex, and the visual troubles diffused throughout the whole retinal field which occur after circumscribed bilateral extirpations in the same region, are not permanent but transitory phenomena.

These three groups of facts are, on the one hand, destructive of the well-known theory of Munk of the projection of the several segments of the retina upon definite segments of the visual sphere; on the other, they prove that though the crossed optic fibres arrive from the internal, the direct from the external retinal segments, they do not preserve their relative position throughout their long course, and in both cases enter promiscuously into relation with the ganglion elements of their respective segments of the visual sphere. Fig. A represents schematically our cortical visual centre or sphere: the dark points, which greatly predominate in the great occipito-parietal area of the left hemisphere, indicate the relations which the optic fibres coming from the internal segment of the right retina bear to the cortical centre of vision; the light points, which are more thinly scattered over the same region, indicate the relations which the optic fibres

coming from the external segment of the left retina, bear to the same centre. It is easy to understand how, on this hypothesis, the three groups of facts first mentioned find a natural and adequate explanation.

The same theory applies to the visual centre of the monkey. The only well-demonstrated fact of Munk's (and which is confirmed by my recent researches) is the bilateral homonymous hemiopia which immediately follows the extirpation of an entire occipital lobe. But according to the doctrine of Munk this phenomena should be permanent, whilst my results show it to be temporary, and reproducible by repeated partial extirpations of the same lobe. This confirms the fact that the visual sphere of the monkey extends beyond the limits of the occipital lobe, and proves that each segment of the visual centre is related with the fibres of the crossed tract as much as with that of the direct fasciculus of the optic nerve—just as what we have shown to obtain in the dog.

The third problem to solve is that concerning the functional nature of the visual cortical centres. Are the visual *perceptions* only, or are also the simple visual *sensations*, localised therein? (taking these expressions in the definite sense assigned to them by the followers of Flourens). Or in other words, the hemiopic effects consequent on extirpation of the whole visual centre on one side, and the absolute blindness following their complete bilateral extirpation, are they definitive and permanent phenomena as Munk believes; or do they (as happens after incomplete uni- or bilateral extirpations) tend to become gradually attenuated, until they become reducible to simple psychical blindness?

My own researches, though still incomplete with reference to the determination of the definitive effects of total extirpation of our visual centres, are however more than sufficient to be opposed to the theory of cortical blindness, as much as to that of the absolute and permanent blindness which Munk believes to have observed in consequence of the complete bilateral extirpation of his visual sphere (circumscribed, as we know, to the two occipital lobes). The fact is that after the most extensive extirpation of the occipito-temporal area, which is far more extensive than the visual sphere of Munk,

absolute blindness does not persist beyond a few days, and may even fail to supervene at all, if the extirpation is made by successive operations. The place of absolute blindness (when it occurs) is taken by a complete psychical blindness, through which the animal seems blind to any food placed on the ground before it, but seems still capable of avoiding fixed obstacles met on the way, and to follow the path in a straight line. Later on, the psychical blindness becomes incomplete, but yet permanent; the animal begins again to make use of sight in the search for its food, but is not able to distinguish meat from sugar by its visual impressions only, and remains in that state without any ulterior improvement.

These and many other new results which will be consigned and discussed in my forthcoming monograph, demonstrate that the cortical visual centre is not the seat of sensations of perceptions only; its function is to elaborate psychically the visual sensations which take place in the mesencephalic ganglia, and more especially in the corpora quadrigemina, which must rank high in this respect according to well-established scientific facts.

Experiments on the monkeys confirm and throw fresh light upon this theory. The definitive visual symptoms presented by my monkeys after extirpation of the occipital lobes only, or of these and the angular gyri together, characterise clearly the psychical blindness in its opposition to absolute blindness and to simple amblyopia, and leave nothing to be desired from this point of view. When some time has elapsed after the extirpation, their visual sensations become perfect again; they are able to see minute objects, what they want is the discernment of things and a right judgment concerning their properties and their nature; they are deficient, in a word, of visual perception. For instance, if small pieces of fig, mixed with pieces of sugar, are offered to them, they are incapable of choosing by sight only, but require to take the sugar in their hand and put it in their mouth in order to assure themselves that it is not an alimentary substance. These are phenomena of psychical incomplete blindness, because the mutilation of the centres of visual perception has been incomplete. If the theory of Munk has been correct, that

not only perceptions but also sensations take place in the visual sphere, our monkeys should have shown a deficiency not only in the former but also in the latter.

III. What we have said concerning the centre of vision greatly facilitates the comprehension of all which relates to the other sensorial centres; for one may expect *à priori*, and with much probability, that the latter are constructed on the same general plan as we have just seen obtain for the former.

With reference to the *auditory centre*, our experiments teach that no evident disorder of hearing follows extirpations of the frontal and occipital lobes in the dog. If, however, we remove the zone intervening between the temporal and occipital lobes, undoubted evidence of auditory disturbance is obtained, leading one to suspect that the limit of the cortical auditory centre merges superiorly into the portion of the visual sphere, which corresponds to the external segment of Munk. The effects of extirpations in the province of the parietal lobe confirm what was recognised by Ferrier, and afterwards by Tamburini and myself, that the bend of the third external convolution certainly makes part of the auditory sphere in the dog, but demonstrate also that this sphere irradiates into the parietal zone above this convolution, into the region corresponding to the zone F of Munk.¹ The fronto-parietal tract also, which extends in front, above and below the fissure of Sylvius, and comprises portions of the 4th, 3rd, and 2nd external convolutions, and the lower and anterior portion of the gyrus hippocampi, certainly contain an important portion of the auditory centre; and their destruction, we find, produces marked disturbances of hearing. Our results tend to show that not only the whole cortical area of the temporal lobe, as admitted by Munk, but probably also the cornu ammonis (which anatomists consider as an introflexion of the cortex) forms an integral portion of the auditory sphere. Thus we may conclude that the auditory area irradiates from its central point in the temporal lobe, upwards towards the parietal region, forward towards the frontal, backwards toward the hippocampal, inward towards the cornu ammonis.

¹ See illustration representing Munk's Localisations, 'BRAIN,' Vol. II. p. 236; and Ross, 'Diseases of the Nervous System,' 2nd ed. vol. ii. p. 356.

With reference to the question as to the relation of the two cortical centres to the peripheral organ of hearing, my new experiments confirm more fully what Tamburini and myself had already recognised; each ear having connections with both auditory spheres, but chiefly with that of the opposite side. In fact, every unilateral extirpation of sufficient extent in the province of the auditory sphere causes a bilateral disorder of hearing, more marked on the opposite side; and every extirpation in the same province made on the opposite side, after the effects of the first operation have ceased to be apparent, does not only set up disturbances in the other ear, but reproduces also those which had disappeared from the ear on the same side.

These phenomena are not explainable otherwise than by admitting that the same conditions obtain in the case of the acoustic, as do in that of the optic nerve. In both we must distinguish a crossed and a direct fasciculus; the former consisted of a much larger number of fibres than the latter. Neither of these fasciculi possess any uniform relation with distinct segments of their respective cortical spheres, but their fibres irradiate themselves throughout the area of those centres. The schematic figure B represents the extension assumed by the auditory centres on the external aspect of the hemispheres; and the relationship of the crossed and direct fasciculi of the acoustic nerve to the cortex is indicated by the dark and light dots respectively. A comparison between the figures A and B shows how, from the superposition of the visual and auditory spheres, there results an intimate connection and union between the two, embodied in an intermediary zone in which the "engrenage," or working into one another of the two centres, takes place.

There now remains the question of the functional nature of the auditory sphere; we must determine whether this centre be destined, like that of vision, to *perceptive* action only, or whether it be one of acoustic *sensation* also, as Munk affirms. The effects of more or less extensive unilateral extirpations within the limits of the auditory sphere last, according to our recent results, for a longer or shorter time according to amount of cortical matter removed, but always disappear after some

time, or at least cannot be discovered by the means at our disposal. The symptoms consist in a more or less profound blunting of the acuity of hearing, but which never reaches complete deafness, and gradually fades off. An incomplete psychical deafness only subsists, by which the animal seems not to appreciate the meaning of sounds, noises, or calls, though it appears to hear them. The effects of a bilateral extirpation are always more serious: at first the auditory troubles may amount to absolute deafness, but soon pass into a condition of obtuseness of hearing; this also becomes attenuated and leaves behind it only more or less evident signs (according to the extent of the injuries) of psychical deafness. It seems therefore that Munk, in admitting a cortical deafness as a consequence of the bilateral extirpation of his spheres, is fallen into the same error which we alluded to with reference to the visual sphere, of attributing not only perceptive but also sensitive functions to the cortical centres.

IV. My new experiments on the *olfactory* centre or sphere are much less complete; but still, by collating those in which disturbances of the sense of smell were observed, we may gather some notion concerning the position and extent of the corresponding cortical area.

Extirpation of the occipital lobe never gives rise to disorders of olfaction; destruction of the temporal lobe, or rather of the zone F of Munk, on the contrary, is followed by such. This fact shows that this region contains considerable prolongations of the olfactory centre. No evident deficiency of smell follows the extirpation of the temporal lobe; but if the lesion extends to the neighbouring convolution above the fissure of Sylvius one observes a notable diminution of that sense. Finally, a number of experiments show that a more or less extensive decortication of the gyrus hippocampi, as well as a partial ablation of the cornu ammonis produce olfactory disorders, at first an almost complete loss of smell—a fact which seems to indicate to us that this portion of the brain is the central point of the olfactory sphere. Some of my experiments show, in addition, that the more or less extensive destruction of the gyrus hippocampi, as well as the partial ablation of the cornu ammonis, produces evident troubles, and

chiefly an almost absolute loss of olfaction, a fact which seems to show us that we have here the true centre, or fundamental nucleus, of the olfactory sphere.

These experiments, besides proving the great importance of the cornu ammonis in this respect, seem to point to a partial inter-hemispheric decussation of the olfactory fibres, analogous to what we said of the acoustic nerve—with this difference, however, that an opposite condition would prevail here, the direct appearing to be larger than the crossed fasciculus. Fig. C gives a schematic representation of the olfactory sphere, according to these views; but it shows only the part of it which emerges from the base of the hemisphere (hippocampal region) towards its external aspect. The region extends from below the Sylvian fissure upwards and forwards, and spreads out as far as the parietal lobe of the hemisphere, and to a less degree towards the frontal lobe. The dark dots, which are more numerous, indicate the relations of the direct fibres with the cortex; the light dots, present in smaller number, those of the crossed fibres.

We cannot state much concerning the localisation of the question for the sense of taste. The insufficiency of the means of testing it in animals, and possibly the hidden position they occupy on the cortex, may explain this want of success. Among our numerous researches we only once succeeded in proving a disordered condition of taste. After a unilateral extirpation of the fourth external convolution, and of a portion of the gyrus hippocampi, we discovered a diminished sensibility to the taste of bitters (powder of digitaline) on the half of the tongue corresponding to the lesion, as compared with the opposite half. From this fact we can only draw the presumption, that the gustatory is to be found in close relationship with the olfactory centre. And in fact, in the same dog, we were able to note the deepest alteration of the sense of smell.

V. My studies concerning the localisation of the *tactile* sense, or in other words concerning the *general sensorial sphere*, though still unpublished, were made in greater part in conjunction with Dr. G. Seppili, now physician-in-chief of the Asylum at Imola. Our results may easily be resumed as follows: consequently to the total or partial extirpation of the

motor zone in the dog and the monkey, one constantly observes effects not only of motor paralysis, but also of cutaneous and muscular anæsthesia. When the lesion is not very extensive, one may, within a few days, obtain an almost perfect compensation of the paralysis of motion and sense; but when it involves the whole motor zone, or even if it is deep enough to reach the opto-striate tract, the phenomena are persistent, and one may have clear evidence of them (though less marked than at first) several months after the operation. After decortication of any one region which responds to electrical excitation with reactions circumscribed to a single part of the body, the sensori-motor paralytical effects are not limited to that part, but are diffused more or less to other parts of the body on the same side. Thus after extirpation of the motor zone of the posterior limb, there is a diffusion of the paralytical effects into the anterior limb, and *vice versa*; after extirpation of the excitable zone of the anterior limb and face, or of the face only, or of the neck and trunk, there is diffusion throughout the same half of the body. We have already asserted, that these effects are more intense in that portion of the body of which the cortical area has been chiefly or solely removed. Thus, to quote but one instance, after decortication of the excitable area of the anterior limb only, the paralytical phenomena, though they extend into the posterior limb, are mainly localised in the anterior.

From these results we must necessarily conclude, that a localisation or precise delimitation of single centres in the sensory-motor zone, based upon not their reactions to electrical excitation of various points of the area, as Hitzig and Ferrier were the first to do, but upon the effects of partial extirpations, as Munk pretends,—that such a localisation is not practicable. We are led to believe that this is due to the fact, that the single centres in the sensory-motor zone are so completely bound up with, and, so to speak, let into, one another, that it is not possible to divide them with a clear and definite line, such as is the case when the cortex is incised and removed; so that in destroying a centre one necessarily eliminates a portion of the neighbouring centres.

The almost perfect compensation of paralytical effects con-

secutive to the extirpation of a single excitable area, and which takes place after a few days, even in the part of the body corresponding to it, is a fact which argues in favour of the partial overlapping of the special centres contained in the general sensorial sphere. We must not forget the fact, demonstrated by myself in previous papers, that the centres of the limbs in the dog are not limited to the external cortex of the sigmoid gyrus, but extend over the whole still wider surface of the sulcus cruciatus, and it renders very difficult the complete extirpation of a single one of these centres. Considering the general sensory sphere as a whole, there remains the question whether it is limited to the frontal lobe, or whether it spreads out more or less into the other cerebral lobes. My recent researches exclude the occipital and temporo-sphenoidal lobes, but show that it does extend into the parietal lobe, extirpations of which constantly give rise to more or less extensive and durable tactile paralyses or pareses.

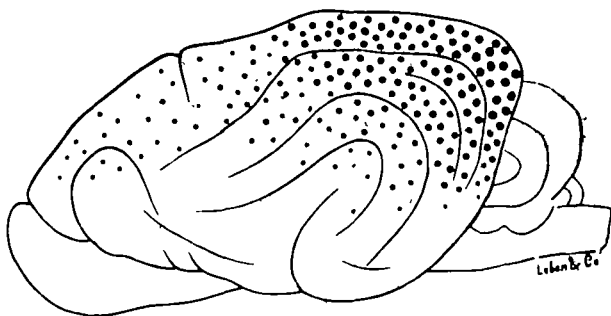
Let us remark finally, that in all experiments upon the tactile sphere there was a manifest and constant crossing of the relations between the peripheral sensory fibres and their respective cortical centres. Fig. D represents schematically the probable extension of the general sensorial sphere on the external aspect of the brain of the dog, comprising the several sensory-motor centres for the various parts of the body. One sees that what one calls "motor zone" is the central focus of the large portion of the sensorial sphere visible on the external aspect of the hemisphere—focus from which the latter is irradiated forwards towards the tip of the frontal lobe, backwards towards the parietal lobe, entering thus into intimate connection by "engrenage" with the visual, auditory, and olfactory spheres.

VI. If we compare together the four figures which indicate the localisation of these centres in the cerebral cortex, and ideally superpose them upon one another, we discover a remarkable fact, which I consider as one of the newest and most important results of my new inquiry. The four sensorial spheres, besides possessing each a territory of their own in the cortical substance, have, in addition, a common territory which is represented by the area of the parietal lobe, or more

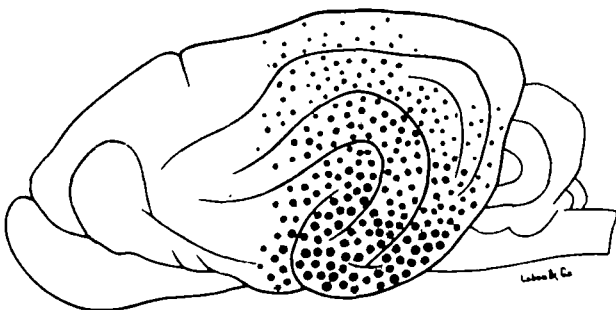
precisely by the zone F of Munk, which the latter calls the region of the eyes, attributing to it the humble functions of providing for the tactile sensibility of the eyeballs and conjunctiva.

In this region the mutual overlapping, or "engrenage," and consequently the partial fusion takes place of the single sensorial centres (excepting the gustatory centre, of which we know but little). Every one will thus see how this region is the most important in the hemisphere of the dog, where it represents, so to speak, the centre of centres. And indeed extirpation of this region, whilst it affects more particularly the visual perceptions, injures at the same time the auditory, olfactory, and tactile perceptions. There is no other portion of the brain of the dog lesions of which are capable of giving rise to effects so complicated, and so liable to set up profound psychical disturbances in the animal.

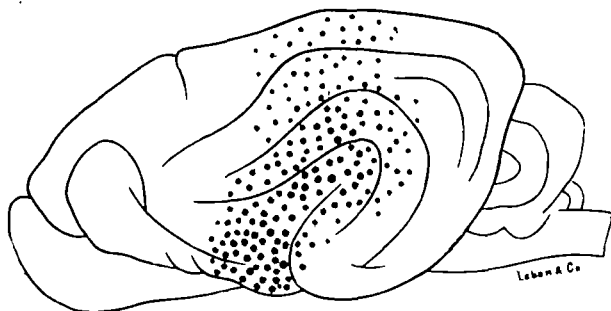
And in fact, after extirpation of the parietal lobes, Goltz—this diligent and able observer, but who starts from a point of view totally opposed to ours—has noted a notable alteration in the character of the animal; good-tempered and affectionate before the operation, they become peevish, quarrelsome, and refractory. He gives no explanation for this fact (which I have confirmed in a dog), and could not possibly give it on the grounds of his well-known theory. To me, on the other hand, this deep alteration in the psychical characteristics, appears to be referable to the loss of this important cortical area, in which the several sensory spheres meet and coalesce, and the removal of which necessarily produces the loss of the normal association of the psychical perceptions and images.



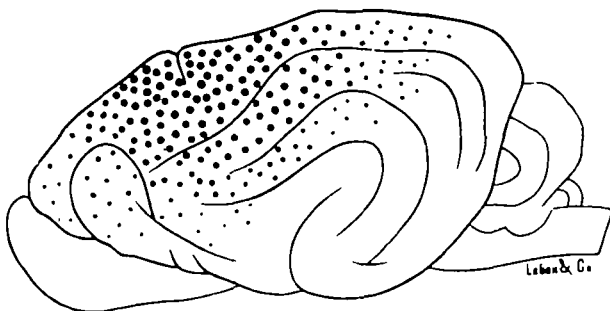
A.—VISUAL SPHERE



B.—AUDITORY SPHERE.



C.—OLFACTORY SPHERE.



D.—TACTILE SPHERE.

