# Observations on Cerebral Localization.

By James Rollin Slonaker.

Ever since Hitzig[1] in 1870 sent a voltaic current through the brain of a wounded soldier and noticed a certain movement of the eyes, numerous investigators have been busy furthering our knowledge of cerebral localization.

Fritsch and Hitzig followed this discovery with many experiments on the cerebral hemispheres of the dog and noticed that stimulation of certain areas produced definite muscular movements on the opposite side of the body.

These experiments started many other investigators, among whom may be mentioned Ferrier,[2] Munk,[3] Horsley and Schafer,[4] Heidenhain,[5] and Beevor and Horsley.[6] The results of these and many later investigations have formed the basis of an exact cortical localization in the brain of man.

Numerous surgical operations and pathological observations have added to our fund of knowledge, so that now the cortical areas governing certain movements in man are quite definitely known. However, each new case will further prove and assist in making the localized areas in man more definite. With this in view I present the following data which I have gathered from the subject:

Mr. Ralph R. Laxton of Atlanta, Ga., met with an accident which fractured the skull near the median line in the Rolandic region. A portion of the bone was removed to relieve the pressure on the brain. As life was despaired of no metal plate was introduced, but the scalp simply closed over. The wound healed and the subject finally recovered. The external condition of the wound after recovery is that there is a more or less circular depression about one and a half inches across, due to the

[1] Hitzig, Reichert u. Du Bois-Reymond's Archiv., 1870.

[2] Ferrier, The Functions of the Brain, London, 1886.

[3] Munk, Die Functionen der Grosshirnrinde, Berlin, 1877-1880.

[4] Horsley and Schafer, On the Functions of the Marginal Convolution, Proceedings of the Royal Society, No. 231, March, 1884. Horsley, British Medical Journal, Vol. II, 1884.

[5] Heidenhain, Pflüger's Archiv f. Physiologie, 1881.

[6] Beevor and Horsley, A Record of the Results Obtained by Electrical Excitation of the so-called Motor Cortex and Internal Capsule in an Orang-Outang (Simia satyrus), Phil. Trans. Royal Soc., Vol. 181, B, 1890.

absence of bone. This depression lies as shown in Figures 1 and 2. These figures are shadowgraphs representing the side and back views respectively.

Fig. 1. Shadowgraph showing location of depression as seen from side.

Various muscular troubles arose, indicating a disturbance of the motor region of the brain. A line drawn outward, downward and forward at an angle of 71.5 degrees with the median line and starting from a point one-half inch, or about one centimeter, behind a point midway between the glabella and the inion, will approximately follow the central fissure[7], [8]. With such a line constructed one can quite accurately sketch in the outline of the brain and its principal fissures. Such a sketch is shown in Figure 3.

From this it is readily seen that the depression mostly affects the anterior central gyrus. Also by consulting Fig. 2 it is observed that the depression is situated almost wholly on the left side, passing over only about a quarter of an inch onto the right side.

The schemes representing the localized areas in man are based on the results of observations on the monkey, on human pathological data and on experiments on man.

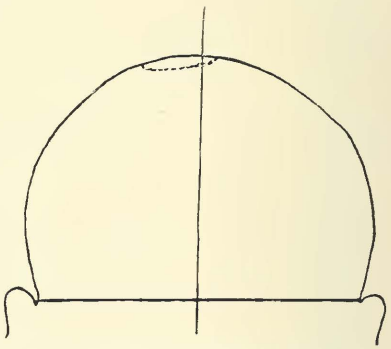

Fig. 2. Shadowgraph showing position of depression as seen from behind.

How Mr. Laxton's injury confirms our present knowledge of cerebral localization in man is shown in the following history of the case, a part of which I give in his own words:

"At the time of the injury, Nov. 25, 1892, I was 22½ years of age and weighed about 145 pounds. My height was about 5 feet 9 inches. At present I weigh 160 pounds and measure 5 feet 10 inches while standing on my left leg, and 5 feet 9 inches on my right.

[7] Deaver's Anatomy, Vol. II, p. 508.

[8] Reid, The Principal Fissures and Convolutions of the Cerebrum, Lancet, 1884.

"In perhaps sixty seconds from the time of the blow I was conscious again, but I do not remember any sensation in my right leg at the time, except that it was very cold. I did, however, observe the progress of paralysis in the right arm. This began in the fingers and extended gradually up the arm. For some time after I was operated upon I was unable to find the way to my mouth with a glass of water. This paralysis was, I think, due to extravasation of blood, which was gradually absorbed later, as I have for more than twelve years been doing a good deal of work with the pen and some with the telegraph key. I think I may safely say that I have entirely recovered the use of the arm. At times, however, I feel the characteristic dull sensation in the muscles of the right side of the body up to the shoulder, and even in the upper arm itself. Then, again, the sensation is hardly apparent above the waist line, all of which tends to show that the area of depression is not sharply defined."

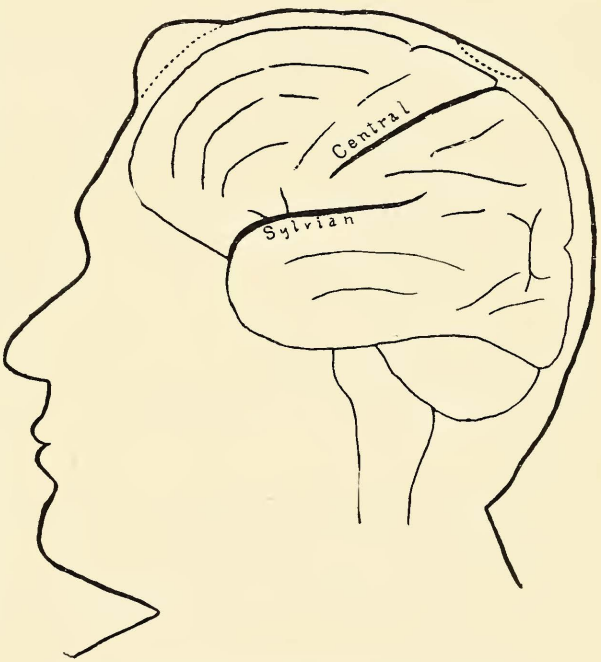


Fig. 3. Showing depression in relation to fissures of the brain.

The left arm was broken by the accident so he was unable to use it, but he states that it was not affected by the paralysis.

It would be interesting in this connection to know if the change in barometric pressure has any influence on the location of this dull sensation. Accurate observations in this respect are lacking. The only information Mr. Laxton can give on this point is as follows: "As regards baro-

metric effects, I have not been able to form any definite idea, though I have lived for ten months of the past year in southern Mississippi, where my office was just seven feet above the level of the Gulf of Mexico. I believe, however, that if the humidity of the atmosphere and the general condition of my system were exactly the same in both localities, I would find a difference between the sea level and a point three or four thousand feet above it. I have not had an opportunity to make observations in higher altitudes, but know that I am capable of more physical exertion in the mountains of western North Carolina than in the low country. I was on Lookout Mountain a few weeks ago, making the trip up the incline railway, but was not able to notice any change in feeling due to the rapid rise, of something like one thousand feet, from the city of Chattanooga to the top of the mountain. Just prior to a sudden change from dry to wet weather, I am apt to suffer from pains in the right leg, which I suppose are akin to rheumatism. As soon as precipitation begins the pains cease. This pain is most marked in the right hip joint."

In regard to stature, as has already been stated, he stands one inch higher on the left foot than on the right. The right leg also measures one inch less in circumference than the left, both in the thigh and the calf region. The muscles of the right leg, especially in the region of the calf, are less firm than those of the left. These conditions did not prevail before the accident. There is also a difference in the development of the two sides of the chest, which condition existed to a certain extent before the accident.

Concerning the resulting disturbances, Mr. Laxton says:

"There is a certain deficiency of sensation in the right leg and abnormal reflex action occurs. There is also an apparent deficiency of synovial fluid. There is almost an entire lack of control of the toes of the right foot, particularly the big toe (see Figs. 4 and 5). There is consequently a lack of balance in walking somewhat related to that observed in people who have lost one leg and use an artificial one. There are times when I feel for a few minutes as if the paralysis were entirely gone, but I have to be extremely careful not to feel too sure of myself and to follow the plan of not attempting a full length step with the right foot. The sensory paralysis extends very slightly to the bottom of the left foot." (Fig. 4.)

"I am just now experiencing considerable local irritation, the scalp even becoming, at times, sore on the outside. There are times when the

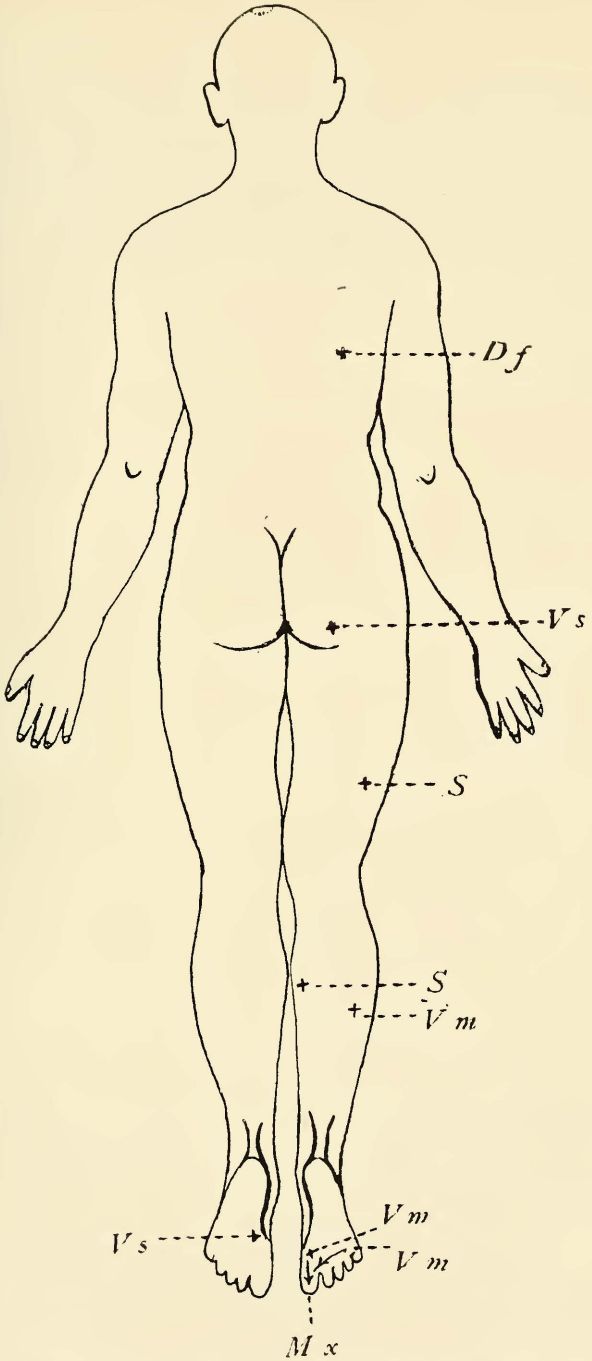


Fig. 4. Chart illustrating the positions of affected areas. Df, dull feeling; Vs very slight; S, slight; Vm, very marked; Mx, maximum.

under side of the scalp, the point of adhesion, has a feeling very similar to that of a vaccination scar just before the scab is ready to come off. Sometimes when I run my hand through my hair, I feel a slight tremor in the nerves of the calf of the right leg. The most sensitive part which gives rise to the tremor is the anterior edge of the depression."

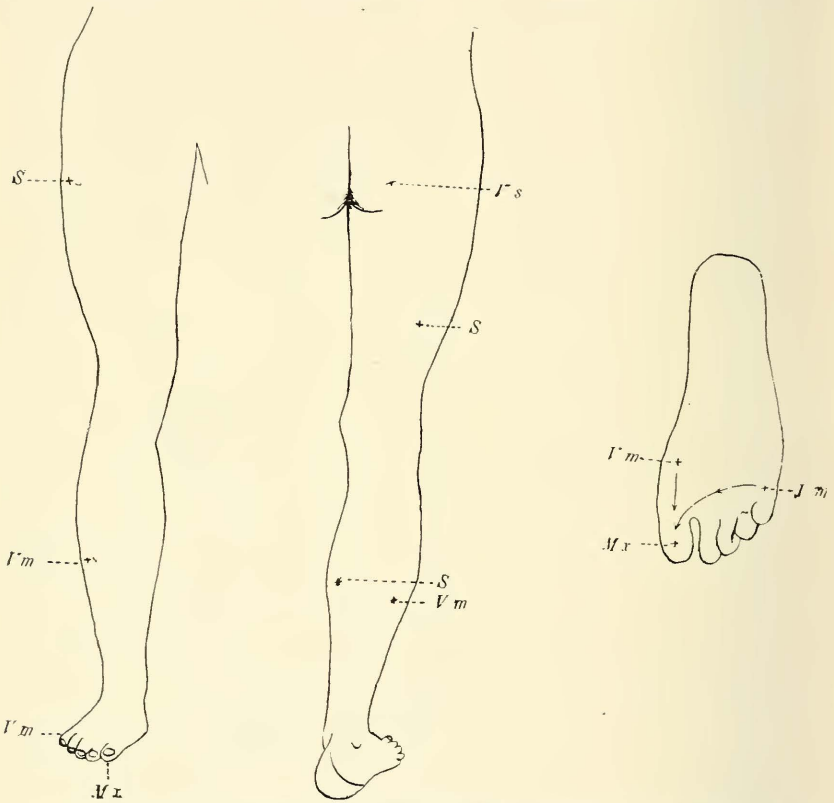


Fig. 5. Chart showing the position of affected areas in the right leg and foot Vs, very slight; S, slight; Vm, very marked; Mx, maximum. The arrows on the bottom of the foot indicate a continued but increasing disturbance.

In regard to the mental effect, Mr. Laxton says:

"There is no doubt that such an injury, so long as mechanical pressure continues, has at least a reflex bearing upon the mind itself, so that one suffering from it does not always feel like applying what he knows directly to the work in hand. If you will wear a brick fastened to your head con-

tinually for a term of years, or undertake a journey of indefinite length on foot through a tunnel not quite high enough to stand upright in, you will get an idea of the feeling."

In Figs. 4 and 5 I have indicated the location of the areas affected as described to me by Mr. Laxton. These areas range from a "dull sensation" to "very marked" and "maximum." It is interesting to note that the disturbance becomes more and more marked toward the feet. That while there is a great disturbance in all the toes of the right foot, this disturbance increases from the little toe and the center of the bottom of the foot to the hallux, where it is maximum.

One observes, also, that with the exception of a small area on the bottom of the left foot, which is very slightly affected, the disturbed areas lie wholly on the right side of the body. This we would naturally expect, as the greater part of the depression is on the left side of the median line of the skull. Since the depression extends slightly across to the right of the median line, we would expect some disturbance on the left side of the body. The slight disturbance on the bottom of the left foot would indicate that the portion of the brain close to the median line controls the center of the foot. We would expect a greater disturbance in the corresponding part of the right foot, because the corresponding area of the brain lies more nearly under the center of the depression.

We may, I think, reasonably infer that the region of greatest disturbance is controlled by that part of the brain lying under the center of the depression. Therefore the motor area controlling the movements of the great toe would lie about the center of the depression, and that of the small toes and the center of the bottom of the foot, in close proximity. As we have already concluded that the cortical area controlling the center of the bottom of the foot lies adjacent to the median longitudinal fissure, that for the small toes would be farther removed from this region than the center for the great toe. I think we may also conclude that the parts less and less affected are controlled by portions of the brain lying nearer and nearer the margin of the depression. The movement of the hair near the anterior margin producing a tremor in the calf of the right leg, would indicate that the motor center for this region is at this point.

Since all the muscles of a given region, i. e., thigh or calf of leg, are not equally affected, one may infer that different muscles of the same region may have somewhat widely separated centers of control in the cortex.

or that some of these centers may be more deeply seated than others, and for this reason less affected.

From the foregoing, I think the following conclusions can be drawn:

1. If we have made no mistake in locating the central fissure with reference to the area of depression, this area lies mainly over the anterior central gyrus of the left side and extends very slightly across the median longitudinal fissure to the corresponding gyrus of the right side.

2. The area controlling the center of the sole of each foot lies in the anterior central gyrus at the margin of the median longitudinal fissure.

3. The area controlling the hallux lies a little more lateral, perhaps one-half inch, from the margin of the median longitudinal fissure.

4. The area controlling the other toes is in close proximity to that of the great toe. It may be anterior, posterior or more lateral from that of the great toe. Since the region controlling the muscles of the calf lies anterior, it is very probable that it is more laterally situated. This accords with the results of Beever and Horsley.

5. The areas controlling the muscles of the calf on the outside and on the inside of the leg, the thigh, rump and scapular regions are located in the order named at greater and greater distances from the center of depression. I have no doubt that the scapular region (possibly some others, also) is only indirectly affected.

6. Though the data are not quite sufficient to indicate accurately the position of the motor centers involved, it is very probable that they are arranged laterally along the anterior central gyrus from the median longitudinal fissure in the following order: a. Center of sole of foot. b. Center for great toe. c. Small toes. d. Calf muscles on lateral surface of leg. e. Calf muscles on mesial side of leg. f. Thigh muscles. g. Rump muscles. h. Scapular muscles. With the exception of the first-named area this arrangement agrees with the results of other investigations.

Leland Stanford Junior University,
California.