Die Grosshirnrinde des Menschen in ihren Massen und in ihrem Fasergehalt, by Prosektor Dr. Theodor Kaes / reviewed by Henry H. Donaldson.

DIE GROSSHIRNRINDE DES MENSCHEN IN IHREN MASSEN UND IN IHREM FASERGEHALT

BY

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"Die Grosshirnrinde des Menschen in ihren Massen und in ihrem Fasergehalt. Ein gehirnanatomischer Atlas, mit erlauterndem Text und schematischer Zeichnung, *16 Tabellen, 15 Kurven und 79 farbigen Tafeln* (*Folio*), von Prosektor Dr. Theodor Kaes, in Hamburg. Erster Teil: Kurven und Tafeln. Zweiter Teil: Text. —Jena, Verlag von Gustav Fischer, 1907.

This quarto by Dr. Theodor Kaes, of Hamburg, comprises the records of years of detailed work. The book is divided into two main parts. The first part contains the drawing of a transverse section through a gyrus, used to illustrate the nomenclature employed by the author, 15 charts (Curven) based on the measurements of the entire human cortex and its layers, and 79 colored plates showing variations in its fiber content.

These plates, the publication of which has been made possible by a grant from the Royal Society of Göttingen, are printed in pairs. They illustrate the arrangement of the fibers in 12 localities from each cerebral hemisphere of a given brain. Sections from 39 brains are thus given (Plates 1-78), each pair of plates being accompanied by the corresponding table of measurements. Plate 79 illustrates a few pathological appearances which were incidentally observed. The last sheet of this part gives the bibliography of the author from 1891 to date.

Part II contains Table 1, showing the weights of the 41 brains examined, and also 48 pages of text together with 15 tables of measurements. It will be seen from this outline, that the unique feature of the book is the series of colored plates; the text, tables, and curves being merely subsidiary to them. The book, therefore, should be considered as an atlas intended to support the interpretations made by the author, and also to furnish standards for comparison by other investigators, and it is from this point of view that our criticisms will be made.

To determine how far these conditions are fulfilled, let us begin with an analysis of the fundamental Table 1, containing the records for the 41 brains on which the measurements have been made.

In each case there is given either the fresh weight of the encephalon, or both the fresh weight and the weight after preservation in Müller's fluid. Then follow two columns, one headed "Hemispheres," and the

other "Cerebellum," but these terms are loosely used, since the combined weights of the parts thus designated are made to equal the total weight of the encephalon. In this table also the weight in Müller's fluid for the brain of "Spanier, 3¾ years," should be 1450 grams instead of 1350 grams, as printed, while in nine other cases, there are slight discrepancies between the weight of the encephalon and the sum of the weights of its parts. In some cases the discrepancies are due to misprints, while in others, they probably depend on the loss of fluid following division of the fresh encephalon.

According to my calculations from Kaes' data, the gain in weight due to the absorption of water by the brains while in Müller's fluid, is on the average 16 per cent of the fresh weight, but this in turn is largely lost by the subsequent shrinkage after alcohol, so that the cortex after being thus hardened probably has nearly its initial thickness.

On comparing the fresh weight of the normal brains in Kaes' series with those in the other standard series of brain weights, Kaes' records show nothing unusual in this character. It must be noted, however, that with the exception of two or three instances, these brains are from persons of very moderate intelligence.

How far the final histological procedure (Weigert-Wolters' stain) modifies the thickness of the cortex, is not known. There exists, therefore, a gap in our information concerning the relation of the thickness of the fresh cortex to the cortex as described and measured by Kaes.

Continuing the analysis of the 41 cases entered in the table, we find that there are 28 males and 13 females. In all the curves and discussions, Kaes treats the two sexes together. This is theoretically objectionable, but an examination of the curves shows that the modifications introduced by combining the records for the sexes are not significant, although detectable.

Far more important is the question of the number of records to be removed from this table in order that it shall represent only approximately normal individuals of the same race.

Kaes himself removes from among the males, one microcephalic, one negro and one criminal (decapitated), and from among the females, two microcephalics, but uses the remaining 36 cases as a basis for his study of growth and medullation.

This is too uncritical a treatment of the material, for it still leaves among the males the brains of one epileptic, four criminals and two non-Europeans, as well as two brains (Witt and Fries) with excessively thick cortices—these being omitted from the Plates—and among the brains of

the females, one criminal (decapitated) and three mental defectives—all of which are material quite unsuitable for the study of normal growth. Kaes' table, as he uses it, therefore, is only very inadequately purged of its abnormal and suspicious specimens, and it must be remembered that the 13 cases above indicated, which we believe should be classed with the five cases that he himself excludes, appear in all the curves and tables of averages that he gives.

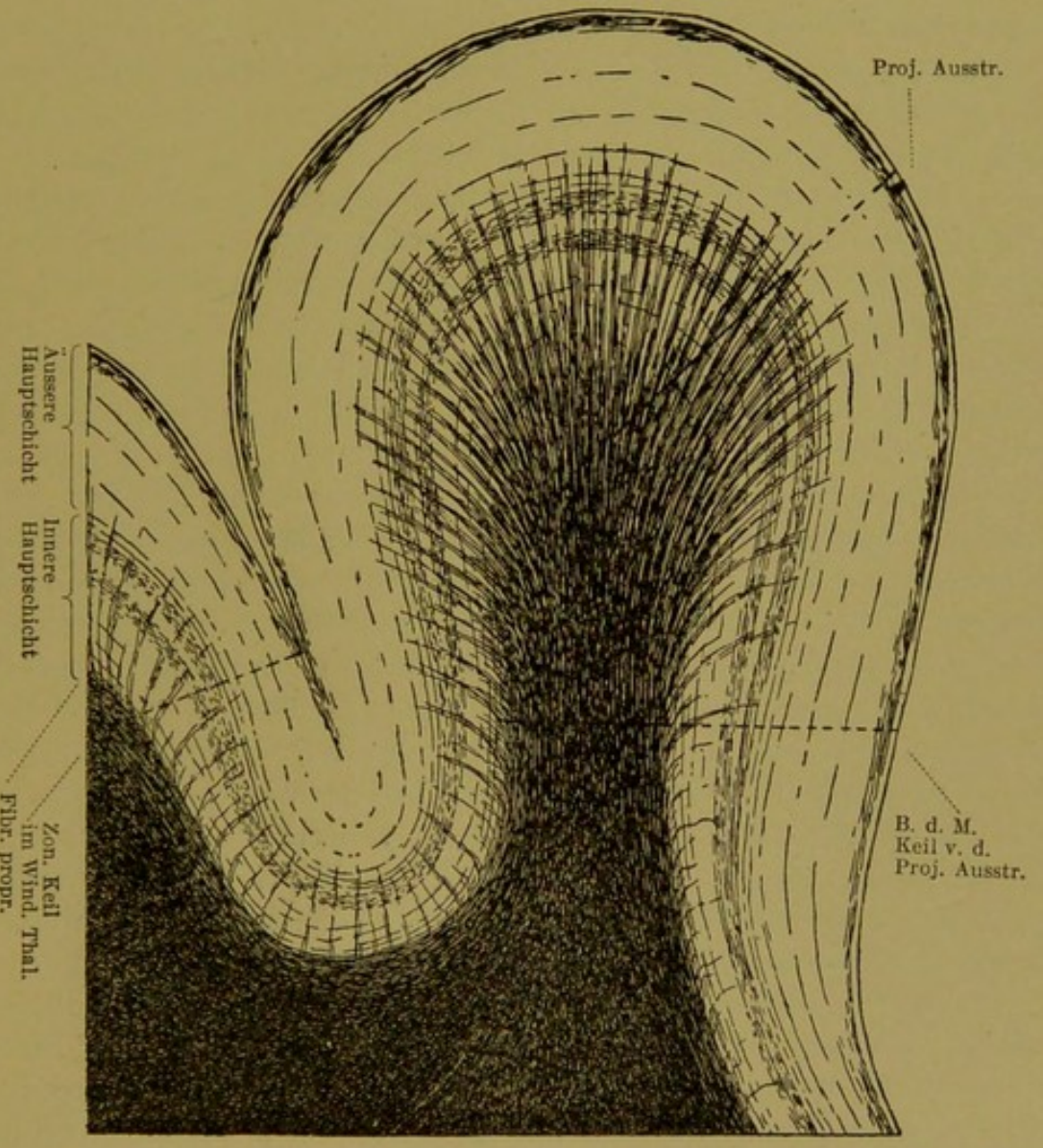
I took the time to redraw the curves for the thickness of the entire cortex, omitting the measurements made on the 18 brains above designated as objectionable, and as a consequence found the curves to be almost entirely relieved of the wide fluctuations which appear in Kaes' presentation.

When we examine the curves in Chart I as thus redrawn, it appears that the thickness of the entire cortex diminishes rather rapidly from the first entry (three months) to the entry for the seventh year, after which the thickness remains nearly the same up to the entry for the 65th year, which is as far as Kaes' material should be used. Of course variations occur after the entry for the seventh year, but so far as these are not due to the technique, they represent merely individual deviations, and are no more to be interpreted as growth changes than are the deviations in the absolute weight of the brains to which the sections belonged. Yet in the face of this apparently self-evident fact, Kaes (Part II, page 11) describes the variations in the thickness of the cortex shown in the curves drawn by him as representing growth processes, and speaks of a decrease in cortical thickness up to the 23d year, followed by an increase up to the 45th year, where it is to be noted the thickness attained is even *greater* than that at birth.

After this phenomenal increase in cortical thickness at 45 years, he speaks of a subsequent thinning, going on to old age, though apparently quite undisturbed by the fact that the next entry, at 45½ years, shows a cortex which has suddenly decreased about one millimeter in thickness. It is perhaps worth repeating that the two 45-year brains (Witt and Fries), the cortices of which mark Kaes' maximum at maturity, are not represented in the series of plates illustrating the fiber systems of the cortex, although no reason is given for omitting them. These interpretations by Kaes of his curve after the seventh year are quite unwarranted by the material, and lead to confusion only.

On the same page of the text where this description is given, Kaes repeats a conclusion which he has previously published, namely, that the more developed and rich in fibers a cortical locality is, the narrower the

cortex. This very interesting conclusion is in general correct when applied to the growth changes in a given locality. The narrowing comes about in this way. Kaes measures the thickness of the cortex from the ectal border of the fiber-free layer to the ectal border of the fibrae propriae (portion included by both brackets in the accompanying Schema). From



Schematic representation of a section through the cortex showing the layers of medullated fibers. Weigert-Wolters' fiber stain. (After Kaes. Only a portion of the designations for the layers are given.)

Äussere Hauptschicht = Outer main layer.

Innere Hauptschicht = Inner main layer.

Fibr. propr. = Fibrae propriae.

Zon. Keil im Wind. Thal. = Zonal wedge at bottom of sulcus.

Proj. Ausstr. = Radiating projection-fiber bundles.

B. d. M. Keil v. d. Proj. Ausstr. = Width of column formed by radiating bundles of projection-fibers.

the age of three months to the seventh year, the layer formed by the fibrae propriae thickens rapidly, its ectal border being built out towards the surface of the cortex. With the advance of this border, which always forms the ental limit of a measurement, the total thickness of the cortex naturally diminishes. Kaes' schema of a cross section through a gyrus with a portion of his nomenclature, is here repeated to facilitate the description of his results.

After the seventh year it is hard to tell from the revised curve whether the process of thinning still goes on, but more complete records might show it to continue through the remaining years. This same idea is of course applicable to brains in which through arrest of growth, the formation of fibers in the cortex has been hindered or stopped. Kaes, however, is not content with applying this idea to the growing cortex alone, but since at maturity the cortex is thinnest at the bottom of the sulci, intermediate at the sides, and thickest at the summit of the gyri, he extends this notion by stating that the cortex is therefore least developed in the last locality, and most developed in the first.

In order to test his view, we may examine the data contained in his Table 2, which gives the averages for the thickness of the cortex on the convex surface of each hemisphere. During the interval between the entry at three months (his youngest record) and that at seven years, when the greater part of the thinning of the cortex has been accomplished, the loss in thickness, presumptively due to growth, is .57 mm. at the bottom of the sulci, .80 mm. at the sides and .81 mm. at the summit of the gyri. This means that the fibrae propriae have increased in thickness most at the summit and sides. As the amount of this change is a measure of development, it follows that the cortex in the latter localities has undergone more development than at the bottom of the sulci. The measurements, therefore, are exactly opposed to Kaes' statement.

Kaes has also given attention to the changes which occur in the thickness of the two main layers ("Äussere Hauptschicht" and "Innere Hauptschicht") into which he divides the cortex, but as this presentation is open to exactly the same criticisms as are here offered in connection with his study on the growth in the thickness of the entire cortex, nothing will be gained by examining his descriptions in detail.

Yet before leaving this part of the book, it is desirable to make some additional statements which have a general application to the remaining tables and curves. In the tables of measurements (Table 2-Table 16) there is in each a column designated "II u. III Schicht." The measurements given under this heading are those for the entire outer main layer,

although the part designated by the heading is but a fraction of that layer. Similarly, under "Äussere Meynert-Associationschicht" are given the measurements for the entire inner layer, although again the part designated is only a fraction of that layer (See Schema). No mention of this arrangement in the tables appears in the text.

By inspection, and not by anything found in either the text or the tables, we learn that the measurement of the main layers applies to the cortex at the summit of the gyri only.

As the schema shows, the sum of the thicknesses of the two layers in question should equal the thickness of the entire cortex. When the tables are tested on this point, the result is very unsatisfactory. Out of the 41 records in Table 2, only three occur in which the sum of the two layers is equal to the entire thickness of the cortex at the summit. Of the remaining 38 cases, 19 show a plus or minus deviation up to one per cent, and the remaining 19 show a plus or minus deviation which averages over 4 per cent. The most extreme instance (Noelzel, 30 years) gives a sum of the layers 14 per cent less than the thickness of the entire cortex. On the cause of these discrepancies, the text is silent. It should be stated, however, that such discrepancies are less marked in the special tables which accompany the plates.

In connection with both the tables and the charts, it is of the greatest importance to determine how Kaes deals with the five cases which he considers pathological. For this Tables 2-16, inclusive, are to be examined. In Tables 3-15, inclusive, the measurements on the pathological specimens are indicated by heavy type, so that here they may be picked out easily. They should be indicated in the same way also in Table 2, but this has not been done. Table 16 gives the grand averages for the thickness of the cortex in the entire series of localities examined, and it is important to note that according to the text, the measurements on the abnormal brains are here included. Hence the averages in Table 16, which might have had a sort of value if based upon the normal brains alone, are not only worthless, but what is more important, quite misleading.

The treatment of the pathological records in the curves (I-V) is also very unsatisfactory. In each curve, the 41 cases of the original table are entered. Where the measurements on the pathological specimens are markedly different from those on either side of it, the value is sometimes indicated by a vertical, starting from the curve itself. This would be satisfactory if it were pursued as a uniform plan, but such is not the case. There is not one of the charts on which all of the records from the pathological brains are so distinguished. When the measurements from the

pathological brains do not, in the judgment of Kaes, seriously disturb the record, he incorporates them in the curve without special designation. Thus in Charts I and II, the indications for the measurements from these pathological brains are incomplete, and in Charts III-V they do not occur at all. At the same time, it is exactly these entries which most disturb the form of the curves.

Moreover, the drawing of the curves has been done with but slight feeling for accuracy. Neglecting trifling displacements, which are numerous, this statement is justified by the fact that out of the 1066 entries in the five charts (I-V) 43, or 4 per cent, are one square or *more* out of place. In one instance, the displacement amounts to seven squares. The squares measure about three millimeters on the side. In some cases this quite alters the appearance of the curve, but the chief importance of it lies in the fact that it gives rise to a feeling of distrust, which makes it necessary to verify every record.

We turn next to the plates. Here we have in color the depiction of the medullated fiber content of the cortex at 12 localities in each hemisphere of 39 out of the 41 brains. The brains of Witt and Fries, each 45 years old, and both of which according to the tables gave a very thick cortex, are omitted from the plates without comment.

At first glance, one is struck by the clearness of the illustrations. They suggest excellent preparations; but the further one studies these illustrations, the less satisfactory they appear.

The thickness of the sections is not stated, and so far as Kaes has given technical details, they are mainly to be found in his papers of 1891, 1893, and 1896. In these accounts he speaks of marking the localities from which specimens were taken, on a schema of the brain surface, but in the present instance, he is content to use such general designations as anterior frontal (Vordere Stirne), visual cortex (Sehrinde) etc., omitting the schema entirely. It is evident that the portions of the cortex to which these terms apply are always extensive and sometimes ill-defined, so that the value of the illustrations as standards, is much lessened by the impossibility of locating the sections with any degree of exactness.

In the illustrations the sections from all the different brains are pictured in nearly the same size, about 100 mm. by 33 mm. This obscures the fact that abnormal often differ from normal brains in the thickness of their cortex and also that in normal brains this character not only changes with age, but varies according to locality. Kaes' first plate (Tafel 1) serves to illustrate this last point. The six illustrations which

form the top row in this plate, represent as many different localities. They are from sections which, according to the table of measurements accompanying this plate, range from 4.80 mm. to 5.95 mm., yet the six illustrations are to all intents and purposes the same size. It is, therefore, evident that by this method of presentation important differences are obscured. To obtain illustrations of the same size, the larger sections must have been reduced, or the smaller ones enlarged, and if this were done by any mechanical process, it would follow that the relations of the main layers would not be modified by this treatment.

When the illustrations are tested with this point in mind, some astonishing results are obtained. For example, and it is merely an example, if we run our eye along the top row of illustrations in Plate 60, it appears that in the six illustrations the ectal edge of the outer stripe of Baillarger stands at very nearly the same level. This edge marks the boundary between the two main layers of the cortex. (See the junction point of the two brackets in the Schema.) As the total length of the illustration is nearly the same in all these instances, it follows that if they had been proportionately reduced, the relative thickness of the two main layers as measured should be similar in all of them. Let us compare this conclusion with the measurements in the table.

The following extract from the accompanying table, shows that the measurements for the thickness of the entire cortex, as well as for the main layers, differ rather widely.

From Kaes' Table for Plate 60; Right Hemisphere; Hindu, 40 Years.

Locality.	Thickness of cortex in mm.		
	Summit of gyrus.	Outer main layer.	Inner main layer.
1. Anterior frontal	5.7	2.5	3.3
2. Posterior "	5.16	2.1	2.9
3. Anterior central	4.9	2.2	2.8
4. Posterior "	3.9	1.4	2.5
5. Operculum	5.3	2.0	3.3
6. Insula	5.7	3.1	2.6

This table shows variations in the total thickness of the cortex from 3.9-5.7 mm. and a relation between the inner main layers which is indicated by 2.0 to 3.3 mm. in the operculum, and 3.1 to 2.6 mm. in the insula, while the stripe of Baillarger, as depicted in the illustrations, stands at almost the same level in both. It follows from this that the several sections have not been proportionally reduced, and that these illustrations have not been made in a way really to represent the sections.

Probably, therefore, they are based on drawings which are skillful after a manner, but not at all accurate. This conclusion is supported by two other observations. In his tables Kaes gives the number of bundles of radiating fibers found in strips of cortex 1 mm. wide. With the enlargement used, the illustrations correspond to original strips approximately 1.5 to 2.2 mm. wide. There should then always be shown in the illustrations more radiating bundles than were found in 1 mm., which is the standard width used in the table. The fact is quite the reverse. In 72 cases examined, the number of bundles shown in the illustrations is never more than that given in the tables, and for the most part is from $\frac{4}{5}$ to $\frac{2}{3}$ that number. Moreover, the numbers shown in successive illustrations do not bear any regular relation to the numbers given in the tables.

In many of the illustrations, very thick fibers are represented. When these are reduced to the size which they would have in the cortex before enlargement, it appears that they must represent fibers 25μ-50μ in diameter, quite an impossible caliber. Finally, no sections of blood-vessels appear. All these facts taken together justify us in stating that the illustrations in the plates do not in any proper sense represent the appearances or relations of the medullated fibers in the human cortex. At best and in a general way, they give a notion of the local abundance of these fibers, and show whether they are coarse or fine, so that to present and discuss Kaes' ideas of the changes in medullation with age, would hardly be satisfactory in view of the condition of his data.

To many of the observations recorded in this book we have made no allusion, but it is not necessary to go further, for the plates which we expected to find the important and fundamental feature, turn out to be nearly worthless either as evidence for the author's views or as standards for comparison.

We began the examination of this book with high hopes; we leave it depressed. At every point where it could be tested, it has failed to stand the test, and it is fair to assume that the tables, which we cannot test, are no better than the rest of it.

These things are unpleasant to write and disagreeable to read, but it was necessary to warn and caution those who might be over-impressed by this array of tables, charts, and plates against an uncritical use of them, for such use can bring confusion only as a consequence.

Yet, by his studies, Kaes has emphasized a very important method for the investigation of the cortex, and recognizing this, it is with genuine

regret that we give this reception to a book on which a colleague has spent so much time and labor, and which he must perforce, cherish as his magnum opus.