Korbinian Brodmann (1868-1918)

Laurence Garey

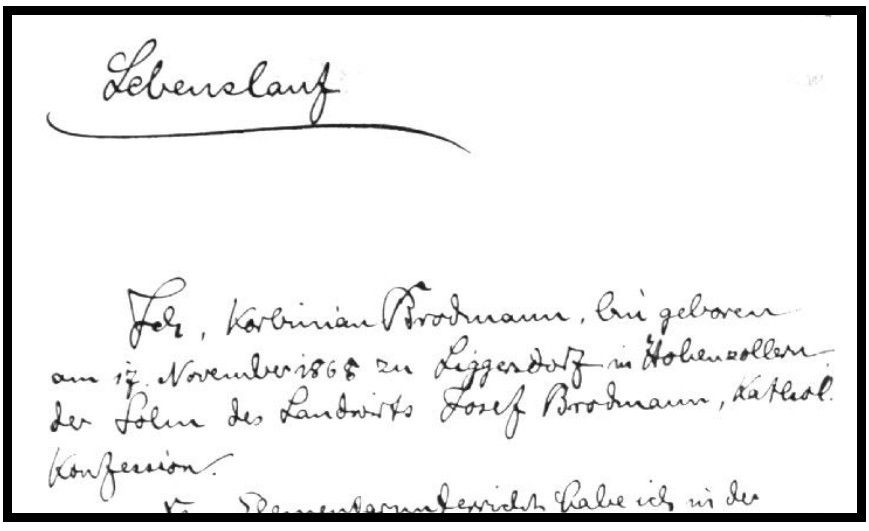
Figure 1: Korbinian Brodmann

This article began as the Introduction to my translation of Brodmann's Localisation in the Cerebral Cortex *(1994), and then appeared in shorter form in* IBRO News *(1995). I should like to thank Professor Karl Zilles for permitting me to use Figure 3 from the C. and O. Vogt Archive, at the Brain Research Institute, University of Düsseldorf, and for helping to identify the subjects. I also acknowledge some material from the excellent website of Marc Nagel http://www.korbinian-brodmann.de/ and the support of the Brodmann Museum in Liggersdorf.*

In 1909 the Johann Ambrosius Barth Verlag in Leipzig printed the first edition of Brodmann's famous book *Vergleichende Lokalisationslehre der Grosshirnrinde in ihren Prinzipien dargestellt auf Grund des Zellenbaues*, one of the major 'classics' of the neurological world. To this day it forms the basis for 'localisation' of function in the cerebral cortex, with Brodmann's 'areas' still widely used. Indeed, his famous 'maps' of the cerebral cortex of man, monkeys and other mammals must be among the most commonly reproduced figures in neurobiological publishing. In spite of this, few people have ever seen a copy of the book, and even fewer have actually read it!

So who was Brodmann (Figure 1)?

Korbinian Brodmann was born on 17 November 1868 in Liggersdorf, Hohenzollern, the son of a farmer (see below).


Lebenslauf

Ich, Korbinian Brodmann, bin geboren
am 17. November 1868 zu Liggersdorf in Hohenzollern
der Sohn des Landwirts Josef Brodmann, kathol.
Konfession.

Figure 2: First paragraph of a handwritten 'Lebenslauf', a sort of expanded curriculum vitae. We read: 'I, Korbinian Brodmann, was born on 17 November 1868 in Liggersdorf in Hohenzollern, son of the farmer Josef Brodmann, of the Catholic faith.'

He studied medicine in Munich, Würzburg, Berlin and Freiburg, where he received his 'Approbation' in 1895, which allowed him to practise medicine throughout Germany. After this Brodmann studied at the Medical School in Lausanne in Switzerland, and then worked in the University Clinic in Munich, working under Grashey in Psychiatry, among others. His intention was to establish himself as a practitioner in the Black Forest.

But he contracted diphtheria and 'convalesced' in 1896 by working as an Assistant in the Neurological Clinic in Alexanderbad then directed by Oskar Vogt. Under his influence, Brodmann decided to concentrate on neurology and psychiatry, and Vogt described him as having 'broad scientific interests, a good gift of observation and great diligence in widening his knowledge.' Vogt was preoccupied with the idea of founding an Institute for Brain Research, which finally materialised in Berlin in 1898.

In order to prepare for a scientific career, Brodmann took his Doctorate in Leipzig in 1898 with a thesis on chronic ependymal sclerosis. He worked with Binswanger in the Psychiatric Clinic in Jena, and then in the Municipal Mental Asylum in Frankfurt from 1900 to 1901, where meeting Alzheimer inspired an interest in the neuroanatomical problems that occupied his further scientific career.

In Autumn 1901 Brodmann joined Vogt and until 1910 worked with him in the Neurobiological Laboratory in Berlin where he undertook his famous studies on comparative cytoarchitectonics of mammalian cortex (Figures 3,4). Vogt suggested to Brodmann that he undertake a systematic study of the cells of the cerebral cortex, using sections stained with the new method of Nissl. He was also given the task of editing the *Journal für Psychologie und Neurologie*, which he did for the rest of his life (Figure 5).

Figure 3: Brodmann (left) at work in the Berlin Institute in about 1906 with some of his colleagues (from left to right: Cécile Vogt, Louise Bosse, Oskar Vogt, Max Lewandowski, Max Borchert).

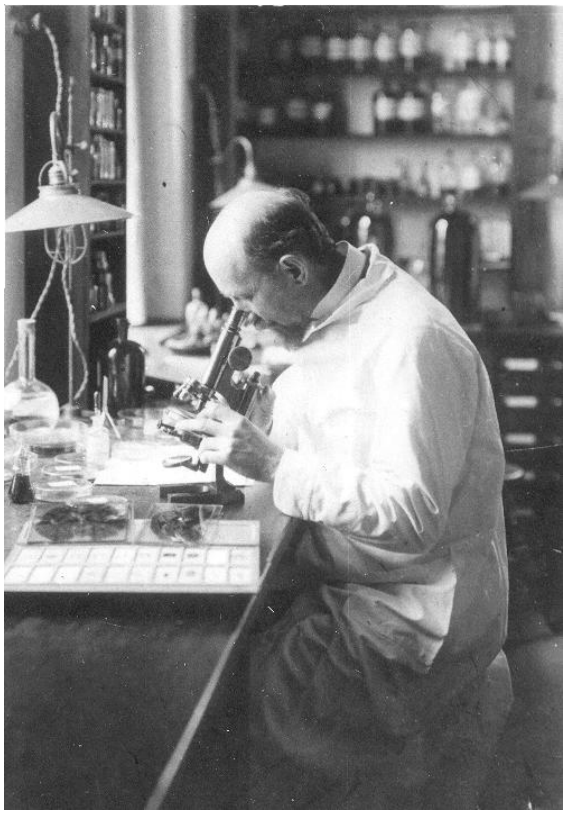


Figure 4: Brodmann with some human brain sections.

Figure 5: Frontispiece portrait of Brodmann published in the *Journal für Psychologie und Neurologie*

Cécile and Oskar Vogt were engaged on a parallel study of myeloarchitectonics and physiological cortical stimulation. In April 1903, Brodmann and the Vogts gave a beautifully coordinated presentation, each of their own architectonic results, to the annual meeting of the German Psychiatric Society in Jena. Brodmann described the totally different cytoarchitectonic structure of the pre- and postcentral gyri in man and the sharp border between them.

Brodmann's major results were published between 1903 and 1908 as a series of communications in the *Journal für Psychologie und Neurologie*. The best known is his sixth communication, of 1908, on histological localisation in the human cerebral cortex. The journal lived on as the *Journal für Hirnforschung* and in 1994 became the *Journal of Brain Research*. His communications served as a basis for his famous monograph, published in 1909, but he did not live to see its second edition in 1925.

Brodmann's career in Berlin was marred by the surprise rejection by the Medical Faculty of his 'Habilitation' thesis on the prosimian cortex (Figure 6).

Figure 6: Drawings by Brodmann of the lateral and medial views of the brain of a prosimian lemur, with his stippling to indicate the various cortical areas. The study was undertaken for his thesis, which was rejected by the Berlin Medical Faculty, but these figures became Figures 98 and 99 in his 1909 monograph.

So when, as Oskar Vogt admitted, the Neurobiological Laboratory did not seem to be developing as well as he had expected, in 1910 Brodmann went to work at the Psychiatric and Neurological Clinic in Tübingen. The attitude of the Berlin Faculty remains incomprehensible. In contrast, he was warmly welcomed to the Faculty of Medicine in Tübingen where he was appointed Professor. The Academy of Heidelberg also honoured his work with the award of a prize.

Figure 7: The Brain Research Institute in Tübingen in modern times

He was very active in Tübingen: not only did he have clinical duties, but he expanded his interests to more anthropological aspects of the brain, with some emphasis on the then very popular question of differences in the brains of different human races. He even built up a Brain Research Institute himself (Figure 7).

On 1 May 1916 Brodmann took over the Prosectorship at the Nietleben Mental Asylum in Halle. For the first time he was assured of reasonable material security and here he met Margarete Francke (Figure 8), who became his wife on 3 April 1917. In 1918 their daughter Ilse was born.

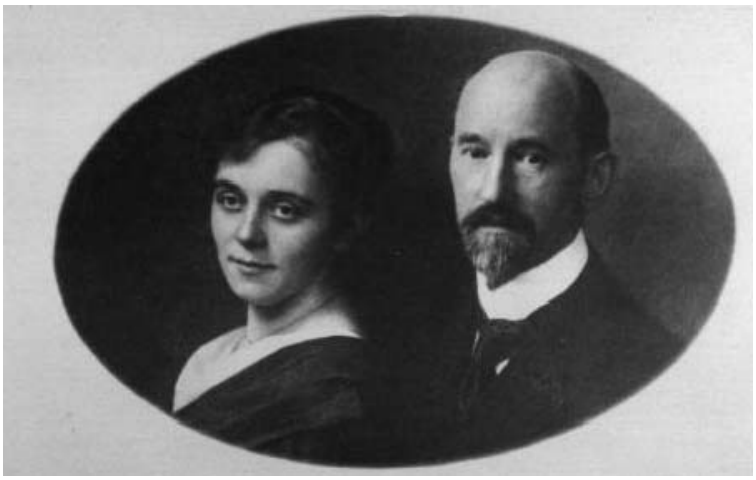


Figure 8: Korbinian Brodmann and his wife Margarete

During his time in Berlin Brodmann had lectured in postgraduate courses in Munich organised by Kraepelin who anticipated an important contribution to neuroanatomical research from architectonics and neurohistology. Brodmann received a prestigious appointment to Kraepelin's newly formed Psychiatric Research Institute in Munich in 1918 and took charge of the Department of Topographical Anatomy. Nissl also joined the Institute, and thus began a harmonious collaboration between the two great neuroanatomists, although Brodmann was only to live for less than a year.

On 17 August 1918, he developed what seemed to be a simple influenza, but after a few days signs of septicaemia appeared. It is thought that an old infection that he had contracted during an autopsy some time earlier had flared up. Brodmann was normally very strong and healthy, and even saw his illness as a way of catching up a backlog of work. He seemed not to suspect that this was not to be. One day he was seen to be making writing motions on his bed with his finger, before sinking back, dead.

In his biography of Brodmann, Vogt wrote in 1959: 'Just at the moment when he had begun to live a very happy family life and when, after years of interruption because of war work, he was able to take up his research activities again in independent and distinguished circumstances, just at the moment when his friends were looking forward to a new era of successful research from him, a devastating infection snatched him away after a short illness, on 22 August 1918.' Kraepelin declared at Brodmann's graveside that science had lost an inspired researcher (Figure 9).

Before Brodmann, the greatest confusion had reigned concerning the laminar structure of the cortex. In 1858, Meynert's pupil, Berlin, gave a first description of the six layers of the human isocortex as distinguished by variations in cell size and type. Brodmann refined and extended these observations, integrating ideas on phylogenetic and ontogenetic influences with his theories of adult cortical structure, function and even pathology. In 1905 Campbell's major work entitled *Histological studies on the localisation of cerebral function* appeared. However, in 1953 von Bonin commented that Campbell's division of the primate brain was not as 'fine as those of the German school', referring particularly to the work of Brodmann. Several authors had produced studies on individual human cortical areas. They include Bolton (1900) on the visual cortex and Cajal between 1900 and 1906 on several areas. In particular, Brodmann had little respect for Cajal's or Haller's 'erroneous' views on cortical lamination (see Favourite Sentence, number 1, below).

The basis of Brodmann's cortical localisation is its subdivision into 'areas' with similar cellular and laminar structure. He compared localisation in the human cortex with that in a number of other mammals, including primates, rodents and marsupials. In man, he distinguished 47 areas, each carrying an individual number, and some being further subdivided. The Vogts described some four times as many areas from their myeloarchitectonic work. Later work was to a great extent elaboration of Brodmann's observations. In the cytoarchitectonic atlas published by von Economo and Koskinas in 1925, Brodmann's numbers were replaced by letters. In 1962 Hassler commented that 'von Economo and Koskinas describe almost exclusively Brodmann's cortical areas ... there is therefore no justification for replacing Brodmann's numbers.' Bailey and von Bonin (1951) were among the few people to accept von Economo's parcellation; they criticised Brodmann and the Vogts, and only differentiated some 19 areas themselves. Others, including Kleist (1934) and Lashley and Clark (1946), were also against a too vigorous subdivision of the cortex. However, since then a number of atlases have appeared, essentially vindicating Brodmann's view, among which is that of Sarkissov and his colleagues in 1955.

Modern experimental methods have supported cortical localisation, both anatomical and functional. One need only consider the exquisite correspondence found in the visual and somatosensory systems between individual cortical areas and subtle variations in physiological function (Powell and Mountcastle, 1959; Hubel and Wiesel, 1962, 1977). For an anatomist, it is gratifying to read Brodmann's uncompromising views on the importance of structure in structural-functional relationships (see Favourite Sentence, number 2, below). In many cases Brodmann's areas have been further subdivided, but no major objections to his pioneering work have been upheld for long. On reading his *Localisation*, one is struck by the many forward-looking references to concepts and techniques that emerged only much later, such as multiple representations of functional areas, the chemical anatomy of the brain, and ultrastructure (see Favourite Sentence, number 3, below).

What might Brodmann have discovered if he had lived beyond the age of 49?

Figure 9: Brodmann was able to relax a little and reflect on the importance of his concepts towards the end of his all-too-short life

Laurence Garey
Professor of Anatomy
Faculty of Medicine
UAE University
PO Box 17666
Al Ain, United Arab Emirates

Tel: +9713 703 9497
Fax: +9713 767 2033
e-mail: l.garey@uaeu.ac.ae
http://www.fmhs.uaeu.ac.ae/anatomy/garey/garey.htm
http://www.fmhs.uaeu.ac.ae/anatomy/dept/anatomy.htm

Bibliography

1. Bailey, P. and von Bonin, G. (1951) *The Isocortex of Man*, Urbana: University of Illinois Press.
2. Berlin, R. (1858) *Beitrag zur Structurlehre der Grosshirnwindungen,* inaugural dissertation, Erlangen: Junge.
3. Bolton, J. S. (1900) The exact histological localisation of the visual area of the human cerebral cortex, *Philosophical Transactions of the Royal Society of London*, Series B, 193: 165-222.
4. Brodmann, K. (1903a) Beiträge zur histologischen Lokalisation der Grosshirnrinde. Erste Mitteilung: Die Regio Rolandica, *Journal für Psychologie und Neurologie*, 2: 79-107.
5. Brodmann, K. (1903b) Beiträge zur histologischen Lokalisation der Grosshirnrinde. Zweite Mitteilung: Der Calcarinatypus, *Journal für Psychologie und Neurologie*, 2: 133-159.
6. Brodmann, K. (1905a) Beiträge zur histologischen Lokalisation der Grosshirnrinde. Dritte Mitteilung: Die Rindenfelder der niederen Affen, *Journal für Psychologie und Neurologie*, 4: 177-226.
7. Brodmann, K. (1905b) Beiträge zur histologischen Lokalisation der Grosshirnrinde. Vierte Mitteilung: Die Riesenpyramidentypus und sein Verhalten zu den Furchen bei den Karnivoren., *Journal für Psychologie und Neurologie*, 6: 108-120.
8. Brodmann, K. (1906) Beiträge zur histologischen Lokalisation der Grosshirnrinde. Fünfte Mitteilung: über den allgemeinen Bauplan des Cortex pallii bei den Mammalieren und zwei homologe Rindenfelder im besonderen. Zugleich ein Beitrag zur Furchenlehre, *Journal für Psychologie und Neurologie*, 6: 275-400.
9. Brodmann, K. (1908a) Beiträge zur histologischen Lokalisation der Grosshirnrinde. VI. Mitteilung: Die Cortexgliederung des Menschen. Journal für Psychologie und Neurologie 10 231-246
10. Brodmann K (1908b) Beiträge zur histologischen Lokalisation der Grosshirnrinde. VII. Mitteilung: Die cytoarchitektonische Cortexgliederung der Halbaffen (Lemuriden), *Journal für Psychologie und Neurologie*, 10: 287-334.
11. Brodmann, K. (1909) *Vergleichende Lokalisationslehre der Grosshirnrinde in ihren Prinzipien dargestellt auf Grund des Zellenbaues*, Leipzig: J. A. Barth. Translated by Laurence Garey as *Localisation in the Cerebral Cortex* (1994), London: Smith-Gordon, new edition 1999, London: Imperial College Press.
12. Cajal, S. Ramón y (1900-1906) *Studien über die Hirnrinde des Menschen*, Leipzig: J. A. Barth. Translated by J. Bresler.
13. *Volume 1. Die Sehrinde*, 1900.
14. *Volume 2. Die Bewegungsrinde*, 1900.
15. *Volume 3. Die Hörrinde*, 1902.
16. *Volume 4. Die Riechrinde beim Menschen und Säugetier*, 1903.
17. *Volume 5. Vergleichende Strukturbeschreibung und Histogenesis der Hirnrinde*, 1906.
18. Campbell, A. W. (1905) *Histological Studies on the Localisation of Cerebral Function*, Cambridge: Cambridge University Press.
19. Garey, L. J. (1995) Brodmann's *Localisation in the Cerebral Cortex*, *IBRO News*, 23: 10-11.
20. Haller, B. (1908) Die phyletische Entfaltung der Grosshirnrinde. *Archiv für mikroskopische Anatomie und Entwicklungsgeschichte*, 71: 350-466.
21. Hassler, R. (1962) Die Entwicklung der Architektonik seit Brodmann und ihre Bedeutung für die moderne Hirnforschung, *Deutsche Medizinische Wochenschrift*, 87: 1180-1185.
22. Hubel, D H. and Wiesel, T. N. (1962) Receptive fields, binocular interaction and functional architecture in the cat's visual cortex, *Journal of Physiology*, 160: 106-154.
23. Hubel, D. H. and Wiesel, T. N. (1977) Functional architecture of macaque monkey visual cortex, *Proceedings of the Royal Society of London*, Series B, 198: 1-59.
24. Kleist, K. (1934) Gehirnpathologie vornehmlich auf Grund der Kriegserfahrungen, in O. von Schjerning, *Handbuch der aerztlichen Erfahrungen im Weltkriege 1914-18*, Vol. 4, Leipzig, J. A. Barth, p. 343.
25. Lashley, K. S. and Clark, G. (1946) The cytoarchitecture of the cerebral cortex of ateles: a critical examination of architectonic studies, *Journal of Comparative Neurology*, 85: 223-305.
26. Powell, T. P. S. and Mountcastle, V. B, (1959) Some aspects of the functional organization of the cortex of the postcentral gyrus of the monkey: a correlation of findings obtained in a single unit analysis with cytoarchitecture, *Bulletin of the Johns Hopkins Hospital*, 105: 133-162.
27. Sarkissov, S. A., Filimonoff, I. N., Kononowa, F. P., Preobraschenskaja, I. S. and Kukuew, L. A. (1955) *Atlas of the Cytoarchitectonics of the Human Cerebral Cortex*, Moscow, Medgiz.
28. Vogt, O. (1959) Korbinian Brodmann, Lebenslauf, in *Grosse Nervenärzte*, Vol. 2, pp. 40-44.
29. von Bonin, G. (1953) Alfred Walter Campbell, in W Haymaker (ed.), *The Founders of Neurology*, Springfield: Thomas, pp. 16-18.
30. von Economo, C. and Koskinas, G. N. (1925) *Die Cytoarchitektonik der Hirnrinde des erwachsenen Menschen*, Vienna/Berlin, Springer.

Favourite Sentences from Localisation in the Cerebral Cortex

1. 'Cajal's thesis that rodents and other lissencephalic mammals possess an anatomically simple cortical structure characterised by a reduction in the number of layers, thus cannot be accepted as correct. Equally, Haller's assumption of a primitive three-layered cytoarchitecture should be rejected as erroneous.'

2. 'One thing must be stressed quite firmly: henceforth functional localisation of the cerebral cortex without the lead of anatomy is utterly impossible in man as in animals. In all domains, physiology has its firmest foundations in anatomy. Anyone wishing to undertake physiological localisational studies will thus have to base his research on the results of histological localisation. And today with greater reason than ever, one must recall the words of the past master of brain research, Bernhard Gudden, spoken three decades ago in the face of a dangerous tendency to specialise in extirpation experiments: "Faced with an anatomical fact proven beyond doubt, any physiological result that stands in contradiction to it loses all its meaning ... So, first anatomy and then physiology; but if first physiology, then not without anatomy".'

3. 'It is possible that later it will be feasible to further differentiate histologically many grossly morphologically similar cell types according to their fine structure. For this, the main necessity is new histological, and particularly staining, techniques that have a specific affinity for functionally related cells or, what amounts to the same, histochemically related cells, and will reveal them selectively.'