

Cerebral Localization and Organization

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edited by

GEORGES SCHALTENBRAND

and

CLINTON N. WOOLSEY

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Foreword

The symposium recorded in this book grew out of a suggestion made by Drs. Schaltenbrand and Bay and plans for the meeting were developed by the three of us in the fall of 1959. It seemed desirable to consider the problem of cerebral localization in the light of recent neurophysiological, neurological, and neurosurgical experiences. Anatomy, it was felt, had contributed relatively little that was new. Neurophysiology, however, had developed certain apparent contradictions which could have led to a symposium devoted entirely to that field, but this we wished to avoid. Although the history of cerebral localization had been the subject of a meeting in London, shortly before the International Neurological Congress of 1957, it seemed necessary to review the speculative constructions of the classical theories of localization. Finally, recent results on hemispherectomy in man had provided new contributions to the problems of cerebral localization and of central neural organization.

Arrangements for the symposium were entrusted to the Centro de Estudos Egas Moniz and to the Hospital Escolar de Santa Maria of Lisbon, and the proposal was championed by the World Federation of Neurology. Two directors of the conference were chosen, Dr. Georges Schaltenbrand, Würzburg, and Dr. Pedro Manuel de Almeida Lima of Lisbon. In addition to those invited to present papers, the following discussants were also asked to participate: Dr. Henrique João de Barahona Fernandes, Lisbon; Dr. Edward A. V. Busch, Copenhagen; the late Dr. Klaus Conrad, Göttingen; Dr. Macdonald Critchley, London; and Drs. Richard Jung and Traugott Riechert, Freiburg im Breisgau. Unfortunately, Dr. Critchley's airplane was grounded in Paris and he was unable to reach Lisbon.

The meeting opened on Friday, October 21, 1960, under the chairmanship of Dr. Ludo van Bogaert, president of the World Federation of Neurology. It continued on Saturday, under the guidance of Dr. Pearce Bailey, Director, International Research Programs, NINDB, NIH, Bethesda, Md., and was concluded on Sunday morning, the 23rd, with Dr. Schaltenbrand in the chair.

Thanks to the generosity and kindness of our Portuguese friends, special luncheons were offered to the conference by Prof. Almeida Lima and Prof. Barahona Fernandes, and a banquet was provided by the Centro de Estudos Egas Moniz and the Calouste Gulbenkian Foundation.

After the conference, editing of the papers and discussions for publication was entrusted to Drs. Schaltenbrand and Woolsey. They wish to express their appreciation to Dr. Almeida Lima and his staff for the recording and transcription of the discussions and to Mrs. Ingeborg Betcke, of Würzburg, and to Mrs. Maree Giese and Mrs. Martha Erickson, of Madison, for their patient assistance in preparing the papers and discussions for the press. Mrs. Helen Digenis, of the French Department of the University of Wisconsin, assisted in the editing of the French sections.

Very special thanks are due to Dr. T. C. Erickson, of the University of Wisconsin, for his assistance in identifying and checking the references and for assuming the onerous task of preparing the index.

It would not have been possible to bring together scientists from such distant places in the world without the help and special support of the National Institute of Neurological Diseases and Blindness, NIH, Bethesda, Maryland. In the name of the World Federation of Neurology, the organizers of the symposium, in behalf of the participants, wish to express to that institution their sincere gratitude.

Ludo van Bogaert

April, 1964
Antwerp, Belgium

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Introduction

GEORGES SCHALTENBRAND

The principal problems of localization are of interest not only for the relations between body and mind, but they are also important for the diagnosis of disease and for the cure of our patients. We are less interested in lists of many different symptoms and syndromes; we are more interested in working theories applied to the problem of localization by different investigators in neurology and physiology.

Two groups of scientists have been invited to discuss these problems, clinicians and representatives of the basic sciences. Some of you may wonder to which of these groups you may belong. Two sets of questions have been sent out to stimulate the reports and the discussions. The first set is that of Dr. Critchley, assembled in his Queen Square Centennial Oration (2), dealing largely with problems of aphasia. You will see that these questions can be enlarged to include other performances and disturbances of the brain such as the gnostic functions, praxies, and intelligence. As a matter of fact, this has already been done by Critchley himself.

The second set of questions was formulated by myself. It tries to link anatomical, physiological, and electrophysiological research to clinical facts:

1. The results of many authors raise doubts about the old conception of point-to-point correspondence between receptor surfaces and cortical areas. Is there any evidence for a more diffuse propagation of nervous impulses than was formerly accepted?

2. Are there any experiments showing whether nervous impulses can be systematically shifted to other regions of the brain by additional stimuli, for instance, labyrinthine stimuli? Might the phenomena of occlusion, extinction, and reinforcement be interpreted in this way?

3. Is there any evidence that nervous impulses can carry the character of information, for example, that sensory messages are coded, as suggested by Amassian and Waller (1)?

4. Introspective observation suggests that perceptions, especially spoken language, may be repeated like an echo for some time. Is there any evidence that a series of neuron discharges induced by direct stimulation of the brain behaves similarly and is repeated by the nervous system?

5. What evidence is there for migration of integrated activity over certain regions of the cortex, which would correspond approximately to von Monakow's (3) chronogenic localization?

6. To what extent can symptomatology of the damaged nervous system be explained by reintegration of personality rudiments, which concur and interfere with each other?

7. To what extent can the contradictions between the opinions of the strict "localists" and the "function analysts" be explained by the idea that localization of function is an individual performance based on individual biography, which follows statistical but not absolute rules?

There is no hope, of course, that we shall be able to solve all the riddles of brain function and of localization in this symposium, but I hope that we may learn from each other, and that we may get fresh impulses for research, teaching, and clinical work.

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Localization in the Cerebral Cortex from the Anatomical Point of View

ADOLF HOPF

It is a fundamental fact of biology that structure, metabolism, energetic processes, and functions are closely linked. Changes in the structure of a macromolecule may be accompanied by a release or by a consumption of energy. The synaptic vesicles visible in the electron microscope contain chemical transmitter substances and correspond to the site of synaptic delay. In the dimensions of the electron microscope and of macromolecular chemistry, a convergence of the structural, metabolic, and energetic aspects of problems is developing. However, for low-power light microscopic and macroscopic dimensions, such a connection is mostly missing. This is especially true of the brain. Studies concerning the cerebral cortex often overlook the intimate connection between structure and function. If the anatomist discovers areas of different structure in the cortex, it is the physiologist's task to look for the special functions of those structures. Because a special function for an area has not been established, it does not follow that structural differences are without functional significance. Past experience in brain pathology has shown that there is no close relation between clinical defects and damage to precise parts of certain gyri. Vogt (26), Kleist (17), and Foerster (7) were the first to attempt to make use of the specific structure of the cortex (the so-called "architecture") for an explanation of their findings and for a more precise localization. More recently they have been followed by some neurophysiologists and neurosurgeons. Therefore, architectonic studies, formerly carried out only by a small circle of investigators, have been critically re-examined.

The well-known architectonic maps of Brodmann (2, 3), von Economo and Koskinas (4), and C. and O. Vogt (25) have been strongly criticized by Lashley and Clark (18) and by Bailey and von Bonin (1). The statement of these authors that a large speculative superstructure was erected on a relatively small empirical basis is correct. One can also agree with their objection to allotting to any areas the role of elementary organs (*Elementarorgane*) with fixed individual functions.

Bailey and von Bonin further contend that large regions of the cortex,

namely the granular frontal cortex and the entire parietal cortex, have a nearly uniform structure. A close examination of this statement is of great importance for the neurological sciences, since our conception of the cerebral cortex, i.e., of a part of the central nervous system which comprises 90 per cent of the gray substance and about sixteen billion nerve cells, depends on whether we accept it or not.

The views of the North American authors cited have been accepted by many, because of lack of personal experience with the subject, though reflection should have led to skepticism. During phylogenesis, the brain not only shows an increase in mass but also a higher differentiation. New cortical structures appear. This fact is uncontested from lower forms up to the chimpanzee. It is unlikely that this principle should not apply to the human brain. The supposed uniformity of the human cortex, which surprised Bailey and von Bonin, has other causes. These authors formerly studied brains of monkeys in which the situation is easier to survey. Into a narrow space are compressed several areas of very different structure. They are easy to survey at a glance. In man, on the other hand, some areas extend over several gyri. Therefore, one may have the impression of a certain homogeneity. Differences of the same order as those found in the macaque develop over a greater distance and, therefore, only appear less important.

Plate 2.1 shows that the first and second temporal gyri are not as uniform in structure as has been claimed. The two photos are taken from the same section. The cytoarchitectural picture of T_2 shows a preponderance of inner layers V and VI. They are dense and consist of many coarse cells. In T_1 this is not so. Furthermore, the second, third, and fourth layers are less dense compared with those of the first temporal gyrus.* In the myelin-stained sections (Plate 2.2) it is obvious that the first temporal has many more myelinated fibers than the second temporal gyrus. The constancy of the differences described was documented by photographs of fifty-four sections taken from thirty-four different hemispheres in a paper published in 1954 (12).

Unfortunately some investigators are unfamiliar with myeloarchitecture, otherwise they would not have overlooked these differences. If one is well versed in myeloarchitecture, one can easily assess structural differences and distinguish them readily from artifacts. The impression of a homogeneous human cortex cannot arise from study of myeloarchitecture. It may arise if the cytoarchitectonic method is used, because then one is limited

* At Lisbon similar sections of some other brains were demonstrated in order to prove the constancy of the finding.

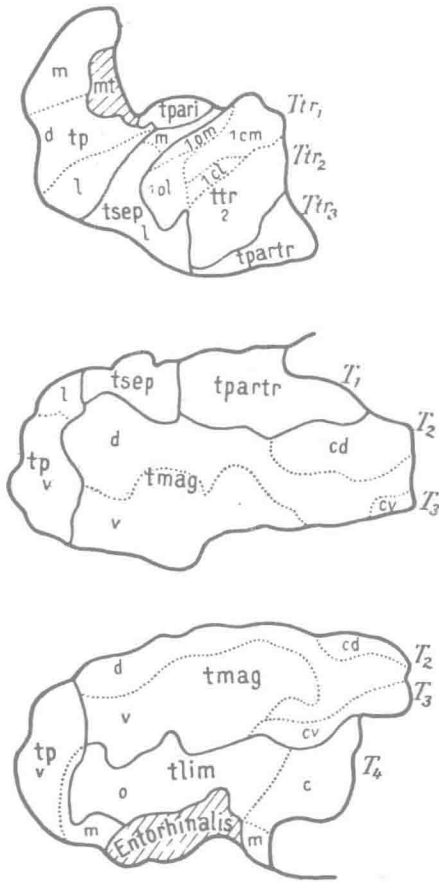


Fig. 2.1.—Myeloarchitectonic regions and subregions of human isocortex temporalis; *upper figure*, dorsal (supratemporal) plane; *middle*, lateral surface; *lower*, inferior (basal) surface; mt, formatio mesocorticalis temporalis; T_1 , T_2 , T_3 and T_4 , first, second, third and fourth temporal gyri; tlim, regio temporalis limitans (c, subregio caudalis; m, subregio medialis; o, subregio oralis); tmag, regio temporalis magna (cd, subregio caudodorsalis; cv, subregio caudoventralis; d, subregio dorsalis; v, subregio ventralis); tp, regio temporopolaris (d, subregio dorsalis; l, subregio lateralis; m, subregio medialis; v, subregio ventralis); tpari, regio temporalis parainsularis; tpartr, regio temporalis paratransversa; tsep, regio temporalis separans (l, subregio lateralis; m, subregio medialis); ttr, regio temporalis transversa (1 cl, subregio prima caudolateralis; 1 cm, subregio prima caudomedialis; 1 ol, subregio prima orolateralis; 1 om, subregio prima oromedialis; 2, subregio secunda); Ttr₁, Ttr₂ and Ttr₃, first, second, and third transverse temporal gyri (from Hopf, 10).

to microscopic observation and can only survey small parts of the cortex at a time.

With the aid of myeloarchitecture one can divide the human temporal isocortex into seven main regions (Fig. 2.1), which are mostly recognizable by simple macroscopic observation. Regio temporopolaris (tp) is separated by regio temporalis separans (tsep) from regio temporalis transversa (ttr), the latter covering the gyri temporaes transversi. There is a small regio temporalis parainsularis (tpari). In the neighborhood of regio transversa one finds regio temporalis paratransversa (tpartr) occupying the caudal part of T_1 . Regio temporalis magna (tmag) covers the second and third temporal gyri. Regio temporalis limitans (lim) borders on regio entorhinalis.