Archiv für Psychiatrie und Zeitschrift Neurologie, Bd. 185, S. 670—674 (1950).

From the Montreal Neurological Institute (Director: Prof. W. PENFIELD)
McGILL-University Montreal, Canada.

The supplementary motor area in the cerebral cortex of man*.

By
WILDER PENFIELD.

With 2 figures.

(Eingegangen am 6. April 1950.)

OSKAR and CÉCILE Vogt in their exhaustive studies of the cerebral cortex have striven always to discover the physiological meaning as well as the cytoarchitectonic structure of its cortical fields. They have combined cytological analysis with physiological testing of the same species in a brilliant series of studies that must compel the admiration of experimentalists everywhere.

Clinicians and physiologists who cannot study function and structure simultaneously must beware of the assumption that every functional unit of the cortex has its characteristic cytoarchitectural boundary until this has been proven for each unit. Consequently the following observations of functional localization are made objectively and with provisional cytoarchitectonic agnosticism.

Just anterior to the sensorimotor area which borders the central fissure of Rolando (precentral and postcentral gyri), there is an area of cortex from which responses (chiefly motor) are obtained by electrical stimulation. This area does not correspond very exactly with the cytoarchitectonic zones outlined by BRODMANN, or VON ECONOMO, or CAMPBELL. It does correspond more nearly with the area 6a beta of VOGT and VOGT (Fig. 1). But the responsive zone does not seem to extend so far onto the lateral surface of the hemisphere.

HORSLEY and SCHÄFER (1888) showed that in monkeys rotation of head, eyes and trunk to the opposite side could be produced by stimulation anterior to the motor cortex. SHERRINGTON and his pupils (LEYTON and SHERRINGTON, 1917) showed that within the longitudinal fissure of chimpanzees, stimulation, anterior to the motor strip, occasionally produced movements of shoulder and chest, or thumb and fingers. This is apparently the area to which this report refers.

---

* Prof. OSKAR und CÉCILE VOGT zum 80. und 75. Geburtstag gewidmet.

From the Department of Neurology and Neurosurgery, McGILL-University, and the Montreal Neurological Institute.

VOGT and VOGT (1919) reported[1] that just anterior to the representation of the lower extremity there was, within the longitudinal interhemispheral fissure, a small area where movements of arm and fingers were produced and, anterior to this, „adversion" or turning to the opposite side together with movements of the limbs associated with such turning.

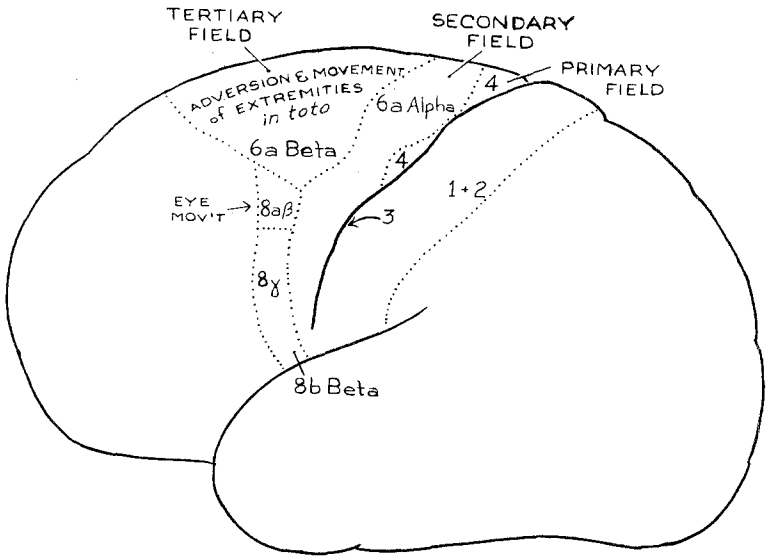

Figure 1. Motor fields of the human cortex redrawn after VOGT and VOGT (1926).

FOERSTER (1936) superimposed the map of his studies of the cortex of man upon the map of the VOGTS (1926), as indicated in Fig. 1, and concluded that there was a „frontal adversive field" in man which must be the area 6a beta. As the result of his experience of stimulation of the human cortex, he concluded that in this area there was represented turning of head, eyes and trunk to the opposite side and synergistic flexion or extension movements of the contralateral extremities.

During the past 22 years, that have followed my own period of study with O. FOERSTER[2], I have carried out a series of well over 500 craniotomies during which there was electrical stimulation of the human cortex under local anaesthesia. Analysis of these records, undertaken with my associate KEASLEY WELCH, has made it clear that the

[1] The experiments of the VOGTS on cercopithicus were carried out over the years 1907 to 1918 and are a model completeness. They are summarized in a monograph (1919) dedicated to August FOREL on his seventieth birthday.

[2] See FOERSTER and PENFIELD, 1930.

responses obtained from this region by stimulation are considerably more varied than those described by FOERSTER.

I have called this by the noncommital term — *supplementary motor area*. Its position is indicated by the dotted region in Fig. 2. The conclusions are drawn largely from the use of electrical currents of threshold strength (usually a little higher than that required to produce

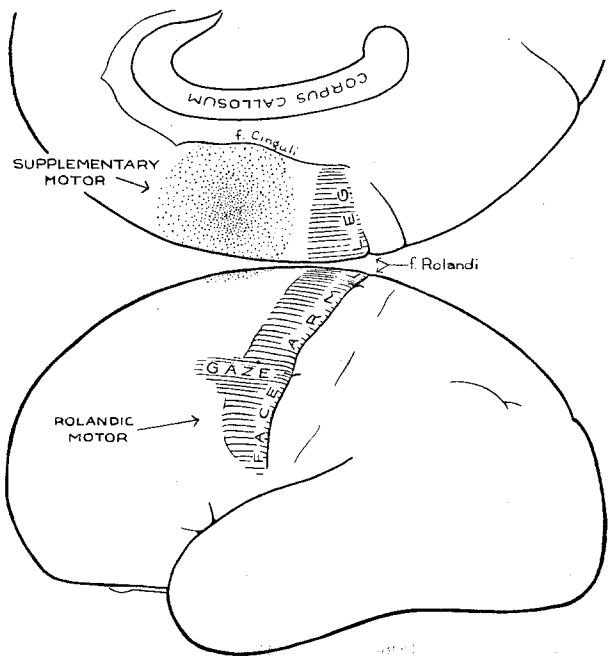

Figure 2.
Supplementary motor area and Rolandic motor area of man as outlined by cortical stimulation.

Rolandic motor or sensory response) and not from currents which produce after-discharge and epileptic spread.

Within the supplementary motor area, as shown in Fig. 2, stimulation produces the following responses:

1. *Vocalization*: a vowel cry which may be sustained or rhythmically interrupted.

2. *General movements.*

a) These may constitute the assumption of a posture, in which the musculature of both sides of the body is employed. Most often the contralateral hand is raised and the head and eyes turn as though regarding it.

b) There may be a slowly developing manoeuvre or rhythmic performance, such as a pawing or stepping rhythm.

c) Occasionally there may be a rapid incoordinate movement of one part.

3. *Inhibition.* That is arrest or slowing of voluntary action. This inhibition seems to apply to specific movements, not to all movement. Speech may be arrested while voluntary movement of the hands is possible, or movement of the hand may be prevented while speech is still possible.

4. *Autonomic change.* Occasionally accleration of the heart rate has been produced and more often pupillary dilatation.

5. *Sensation.* Patients have described sensations such as a general bodily sensation sometimes called flushing, or a feeling in the epigastrium or head.

In the dominant hemisphere there is a narrow zone between the supplementary motor area and the motor representation of the foot, the stimulation of which produces *aphasia.* When stimulation is thus employed, it serves to inactivate, for voluntary use, the cortex adjacent to the electrode. While the electrode is kept in place, the patient is typically aphasic just as he is during stimulation of Broca's area. He can speak, but after the manner of aphasics.

The supplementary motor area continues to give its typical electrical responses, when directly stimulated, even after ablation of the Rolandic motor and sensory gyri. Thus it moves the opposite limbs which are paralyzed on voluntary effort. Excision of the supplementary motor area alone, on one side, produces no detectable deficit in patients after the first postoperative weeks have passed.

Deutsche Zusammenfassung.

Das zusätzliche motorische Feld in der Hirnrinde des Menschen.

Auf Grund von Reizversuchen bei Operationen wird ein zusätzliches motorisches Rindenfeld in der medialen Hemisphäre vor der Beinregion der Zentralwindung unterschieden.

Elektrische Reizung dieser Region ergibt die folgenden Reaktionen:

1. Spracheffekte mit vokalartigem Schrei, der über längere Zeit angehalten oder rhythmisch unterbrochen sein kann.

2. Allgemeine Bewegungen:

a) Haltungsänderungen mit Beteiligung beider Körperseiten. Häufig Hebung der kontralateralen Hand- und Blickwendung von Kopf und Augen auf diese.

b) Langsame oder rhythmische Bewegungen mit einem Stepperrhythmus.

c) Seltene rasche unkoordinierte Bewegungen.

3. Hemmung willkürlicher Motorik für einzelne spezifische Bewegungen, aber nicht für alle. So kann Sprechunfähigkeit bestehen, während willkürliche Extremitätenbewegungen erhalten sind oder umgekehrt.

4. Vegetative Veränderungen: Pupillendilatation oder seltener Herzbeschleunigung.

5. Eigenartige Empfindungen, die als allgemeine Wärme- oder im Leib und Kopf lokalisierte Empfindungen beschrieben werden.

In der dominanten Hemisphäre erhält man in einer schmalen Zone zwischen dem zusätzlichen motorischen Feld und der Beinregion bei Reizung eine Aphasie, ähnlich wie nach Reizung der BROCAschen Region.

Die zusätzliche motorische Region gibt noch ihre typischen Reizeffekte auch nach Entfernung der motorischen und sensiblen Zentralwindungen und bewegt in diesem Falle auch die für Willkürbewegungen gelähmten kontralateralen Glieder.

Excision des zusätzlichen motorischen Feldes macht nach Ablauf der ersten postoperativen Wochen keinen erkennbaren Defekt.

Literatur.

FOERSTER, O.: BUMKE u. FOERSTERS Handb. Neurol. **6**, 1 (1936). — FOERSTER, O., and W. PENFIELD: Z. Neur. **125**, 475 (1930). — HORSLEY, V., and E. A. SCHÄFER: Philos. Trans. **179** B, 1 (1888). — LEYTON, A. S. F., and C. S. SHERRINGTON: Quart. J. exper. Physiol. **11**, 135 (1917). — VOGT, C., and O. VOGT: J. Psychol. u. Neurol. **25**, 277 (1919). — Naturwissenschaften **14** (**50**), 1191 (1926).

Prof. W. PENFIELD, Montreal (Canada), 3801 University street.