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The First Instrument for Cerebral Mapping: Zernov's Encephalometer and Its Modifications

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Introduction

As Audrey Davis wrote, "…the instrument has remained a neglected and peripheral source of historical evidence" (Davis A, 1978, p.107). This is particularly true in relation to surgical instruments. According to Felip Sid, "…in Surgical History we tend to forget that it has been only with the help of specific tools that certain operations have been successfully undertaken." (Sid, 1994, p.157). The recently published Instruments of Science: An Historical Encyclopedia has some entries for diagnostic techniques (such as endoscopy, ultrasound, CT, MRI, PET) but surgical instruments are not even mentioned (Bud & Warner, 1998). The latter are considered to be not scientific instruments but simple tools (Warner, personal communication). The aim of this paper is to view a history of one specific device named the encephalometer that is believed to be the prototype of modern stereotaxic instruments now widely used both for research and clinical practice. It also illustrates the use of metaphors (in this case geographical - the idea of cerebral mapping and drawing parallels between terrestrial and cerebral hemispheres) for inventing a new device.

In Parallel with Geographical Terminology

The first prototype of a stereotaxic instrument was conceived and designed in 1889 by Dmitrii Zernov (1843-1917) - a professor of anatomy at Moscow University. His invention was based upon the similarity of the shape of cranium and brain to the terrestrial globe. This resulted in a real geographical atlas of the human brain, where each cerebral structure was expressed in the degrees of longitude and latitude. Zernov wrote: "I built an instrument which enables to project the pattern of cranial sutures or cerebral sulci or deep-seated brain structures on the spherical surface and then transform it onto the plane similar to the projection of the terrestrial globe on the map. The localisation of a given point on the brain surface is determined by the degrees of latitude and longitude."

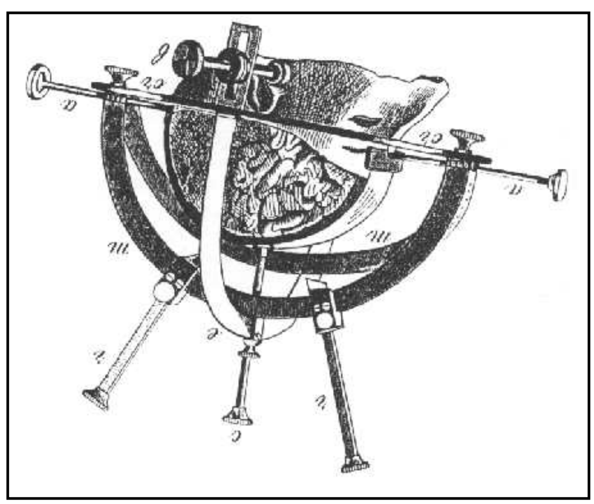

Figure 1. Zernov's encephalometer (reprinted from Zernov, 1889)

Editor's Column

We have just been through St. Patrick's Day always a festive occasion throughout America. It is even more so for me (or at least used to be) because it is my birthday. I do have more and more trouble acknowledging birthdays, although it is hard to ignore a birthday when it is on a holiday. However, I am trying. I can actually remember when I looked forward to a birthday (although even that is harder and harder to remember). While I am way over 50, David Kopf Instruments is now approaching its 50th birthday. Founded in 1958, the company has served the Neuroscience community for 47 years. Having just gone through the transition of the loss of its founder, the people of David Kopf Instruments, led by Carol Kopf, are showing the true spirit that has permeated the company during it existence. I encourage you to look at the list of new instruments that have been added to the product line recently (they are found under New Products on the Home page of the website; and isn't the site great!). It is truly a tribute to David and Carol, and to the wonderful Kopf employees that the company is not simply going on, but is truly innovating and expanding. There are some very exciting products in the works. Watch for them.

This article by Boleslav Lichterman, MD, is a historic look at the start of the stereotaxic instrument. The movement toward the use of instruments for localizing brain coordinates had its beginning in Russia during the late 1880s. Driven by the necessity for localizing brain regions, a crude human instrument was developed in 1889, as described by Lichterman.

This led to refinements over the next several years and may have influenced the development of the animal stereotaxic devices that were chronicled by Louise Marshall, Ph.D. and Horace W. Magoun, Ph.D. in 1990-91 in issues 27 and 28 of the Carrier (you can get a copy of these issues simply by going to the past issues section of the Carrier section of the home page and downloading them!). Thus, the development of human stereotaxic instruments actually predated the development of animal instruments. It is amazing to me how little attention is paid to the instruments of our science. Sometimes, it seems that those entering the various fields of scientific endeavor seem to take the tools of their trade for granted, without realizing what goes into the development of such instruments and how much we owe to both the devices and to their inventors. Science truly moves ahead on the skills of its instrument makers. I hope you enjoy this article for the information and insights it brings.

The world stage is continually changing. With the new government forming in Iraq, the tragedy of tsunami in Southeast Asia and the ongoing (at this time) drama of Terri Schiavo, we have enough to keep our attention on themes of human life, death and society. However, it is also another season (that will be over by the time this goes to press) that promises both hope and comfort. Easter is a time that brings the world an enduring vision of sacrifice producing great benefit. Whatever one's belief system, the underlying message of this time has to be that we are all worthwhile. We must redouble our efforts to behave toward each other with this as the underlying assumption. I wish each of you, our readers, this; that you take a minute to reflect on how you can reach out to make another person's life a bit better.

If you would like to write an article for the Carrier or have a question about the use of a Kopf product, please contact me.

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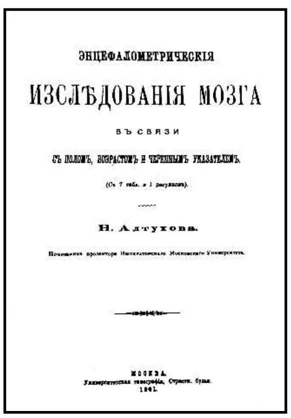
The device (Figure 1) was called an encephalometer and consisted of a metal ring fixed to the head in the horizontal plane with two orientation marks: the frontal point of Broca just above the glabella and the occipital eminence. The third orientation point was the external acoustic meatus on each side. The role of the equator was played by a perpendicular graduated arch fixed to the parietal region. The mobile sagittal arch was also graduated and served as a meridian. In order localize any brain target on the surface of the head it was necessary to fix the meridian above it and pull down the radial probe. The sagittal suture was analogous to the first terrestrial meridian: "In parallel with geographical terminology I replaced North and South hemispheres by frontal and occipital, and East and West - by right and left hemispheres." - Zernov (1889, p.77) noted. He concluded that his method might be used in patients, for example for proper trepanation in case of brain abscess.



ЭНЦЕФАЛОМЕТРИЧЕСКІЯ

ИЗСЛѢДОВАНІЯ МОЗГА

ВЪ СВЯЗИ

СЪ ПОЛОМЪ, ВОЗРАСТОМЪ И ЧЕРЕПНЫМЪ УКАЗАТЕЛЕМЪ.

Н. Алтухова.

МОСКВА.

Figure 2. The title page of Altukhov's thesis (1891)

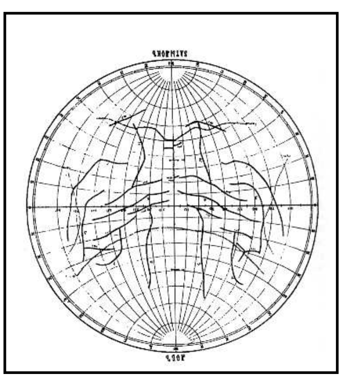


Figure 3. A simplified map of average scalp projections of cerebral gyri and sulci in males according to Altukhov (reprinted from Rossolimo, 1907)

Zernov's pupil Nikolai Altukhov compiled detailed projection maps based on 40 post-mortem investigations on heads of various shapes, age and sex (Altukhov, 1891) [Figures 2 and 3]. Projections of anterior and posterior parts of the corpus callosum, insula and some basal ganglia (thalamus, nucleus lenticularis and caput nuclei caudati) were localized on the surface of the head. He also noted similarity in female and paediatric brains and concluded that the former are underdeveloped. Three cases were treated using the encephalometer. It was used twice for exact localization of brain abscesses and once in a case of Jacksonian seizures. The latter case was a 13-year old girl with a cranial vault defect. The encephalometer was used for determining what part of the brain surface corresponded to the cranial defect and whether the motor region was involved. Altukhov predicted that "…in the nearest future the encephalometer will become one of the important tools for a neurologist and one of the necessary tools for a surgeon." (Altukhov, 1891, p.52).

The more the shape of the head differed from spherical, the greater a mistake of calculations was. But according to Zernov, from a practical point of view it could be neglected. However there were other opinions. For example, Vladimir Bekhterev (1857-1927) a leading Russian neuropsychiatrist wrote that the encephalometer "…rarely helps to find the exact localization of the relevant cerebral structure. When we tried to find the center of the leg we found the center of the face instead; in order to determine the location of the center of the leg we had to perform an extensive craniotomy." (Bekhterev, 1897, pp.2 and 14).

Further Innovations

The encephalometer was later modified by Grigorii Rossolimo a Moscow-based neurologist who strongly advocated a minimally invasive approach for intra cranial lesions: "Despite successes in surgical technique permitting to perform hemicraniotomy for removing a small intracranial lesion, one can not but admit, both a priori and from clinical experience, the necessity to minimize surgical injury and approve all methods of precise localization of the cerebral lesion." (Rossolimo, 1907, p.640).

Rossolimo revealed two defects of Zernov's device: (1) one should first find the cerebral structure on the map and then transport all co-ordinates onto the skull surface - this procedure was time-consuming; (2) the device could not be used without the map.

In order to cope with the above-mentioned problems, Rossolimo modified the instrument and called it "the brain topographer". He combined the device with the map of cerebral hemispheres again using the idea of terrestrial globe: "For this purpose we soldered to the basic horizontal ring with internal diameter of 260 mm a hollow aluminum hemisphere of the same diameter with engraved parallels and meridians at every 10 degrees engraved on its surface as if it were a terrestrial globe. The map of all gyri and sulci, location of the basal ganglia and cranial sutures according to Zernov and Altukhov were also engraved against these." (Rossolimo, 1907, pp.642-643).

In order to project any point of the above-mentioned map on the skull surface a number of 1.5 mm holes were made so that an aluminium joint-pin with an ink pencil on its end could easily reach the cranial surface. In a way this perforated metal hemisphere resembles the modern gamma-knife [Figure 4].

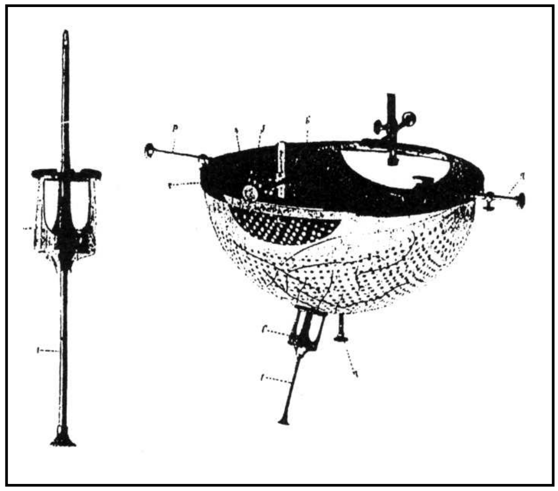


Figure 4. Rossolimo's brain topographer (Reprinted from Rossolimo, 1907).

The Rossolimo device was produced commercially in Moscow and advertised in the leading Russian periodical for neurology and psychiatry (The Korsakoff Journal) in the beginning of the 20th century.

Because of technical constraints, such as the absence of a human brain atlas, and for psychological reasons, these works turned to be "ideas before their time". Almost 50 years elapsed before stereotaxtic instruments became routinely used in neurosciences (Kandel & Schavinsky, 1972; Picard et al., 1983; Redfern, 1989; Davis R, 1992). Then it was time to recognize that "these pioneering Russian scientists predicted the eventual blossoming of human stereotaxtic surgery" (Redfern, 1989, p.274)

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