

## Localisation in nervous system disorders: examining the treatise written by Dr Xercavins in the late 19th century

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### ABSTRACT

In 1889, Dr Francisco de Paula Xercavins Rius (Sabadell, 1855 - Barcelona, 1937) published *De la localización de las enfermedades del sistema nervioso*, a painstaking review of the functions and localisations of the nervous system according to physiological knowledge at the time. Here, he examined sensitivity, motor function, and coordination at the levels of the spinal cord and brainstem, referring to the latter as the 'spinal sub-apparatus'. The second part of the study, titled 'the cortical sub-apparatus', examined the function of the grey matter and its involvement in sensitivity, motor impulse, and intelligence.

Xercavins showcased an exquisite knowledge of anatomy, especially that of the sensory and motor tracts of the central nervous system. He also included his own hypotheses and speculations regarding the seat of the higher functions.

### KEYWORDS

Francisco de Paula Xercavins, history of neuroanatomy, nervous tracts, cerebral localisation, cerebral functions, 19th century

### Introduction

Dr Francisco de Paula Xercavins Rius was born on 18 March, 1855, in Sabadell (Figure 1). He attended medical school in Barcelona and graduated in 1878. He earned his doctorate in 1882 in Madrid, with a dissertation on the nature and pathogenesis of puerperal processes.

Xercavins worked in Hospital de la Santa Creu and in Casa de la Caridad, both in Barcelona. As a clinician, he treated both psychiatric and neurological entities, as was common in those days, and he showed interest in a variety of subjects, especially preventive medicine and the rehabilitation of the mentally ill. He founded an occupational therapy farm at the Institut Mental de la Santa Creu. Xercavins also published studies on preventing and treating the "social epidemics" affecting institutionalised mental patients and prisoners.

In addition to the interests listed above, he was deeply involved in clinical neurology and neurological research. He organised a neurology clinic in which he used electrotherapy for different nervous diseases, and was one of Spain's early proponents of ionisation and vibratory massage, both of which were typical treatments in those times.<sup>1</sup>

His most distinguished works include *La fisiología en los fenómenos psicológicos - Plan de distribución cerebral* (1881) and *La corea (mal de San Vito) en Barcelona y su provincia* (1908). This article examines *De la localización en las enfermedades del sistema nervioso. Sistemas medulares. Plan de distribución cerebral del autor - 1881*. This treatise on the localisations of nervous diseases was presented at the International Congress of Medical Sciences held in 1881 in Barcelona.<sup>2</sup>

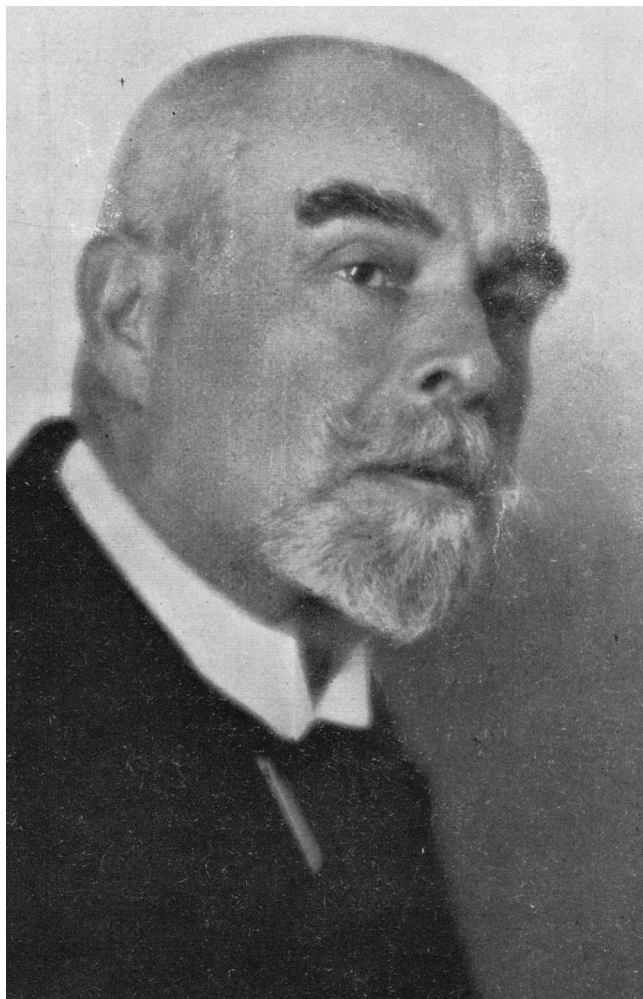


Figure 1. Francisco de P. Xercavins (1855-1937)

The relationship between Jean-Martin Charcot (1825-1893) and Xercavins is well documented; upon reading Xercavins' book, Charcot sent him a letter congratulating him on his excellent description of anatomico-physiological correlations and urging him to use his diagrams as a teaching tool.<sup>1</sup>

### Material and methods

This article examines Xercavins' *De la localización en las enfermedades del sistema nervioso*, published in 1889, as well as contemporary original works to compare authors' anatomical knowledge.

### Results

Xercavins presents his manuscript in two principal sections: the 'spinal sub-apparatus' and the 'cortical sub-apparatus'.

#### Spinal sub-apparatus

The first section presents the macroscopic anatomy of the spinal cord and brainstem in cross-sectional slices (Figure 2). The author states that slicing the spinal cord reveals the central grey matter with its anterior and posterior horns, and highlights the feature known as the column of Clarke at the base of the posterior horn.

White matter rings these structures. Its most anterior region contains a small bundle of fibres. This is the direct pyramidal tract, otherwise known as the bundle of Türck. Laterally, we observe the crossed pyramidal tract; the most posterior area contains the direct cerebellar tract, or tract of Flechsig. Behind that, between the posterior horns, the white matter is divided into left and right sides by a median sulcus. The more external white matter bundle is the tract of Burdach, and the more internal bundle is the tract of Goll. The slice is also used to illustrate the radicular zones, which are linked to the 24 pairs of roots emerging at the anterior horns of the spinal cord.

The slice at the level of the medulla oblongata reveals the pyramidal decussation, such grey matter structures as the olive, and nuclei of the lower cranial nerves. Different tracts, extensions of those in the spinal cord, can be observed in the white matter.

Grey matter in the pons corresponds to the nuclei of cranial nerves. The white matter contains the pyramidal tracts and transverse fibres emanating from the cerebellum.

The slice at the level of the cerebral peduncles reveals the nucleus of the third cranial nerve and a grey matter formation dividing the peduncle in two parts: the anterior pes pedunculi, and a superior portion, the head or tegmentum.

In this section, the author concludes that white matter above this level is the continuation of that found in the cerebral peduncles. He also highlights the presence of a series of central grey nuclei near the internal capsule, referring to the thalamus, lenticular nucleus, and caudate nucleus.

Next, we find the functions of the different bundles located in the spinal cord and brainstem. At brainstem level, the sensory pathways were recognised thanks to experimental sectioning and to neuropathological findings.

Xercavins states that unilateral destruction of the spinal cord, whether in an experimental model or caused by disease, decreases motility on the same side as the lesion, and affects sensation on the opposite side; this is a summary of hemi-section lesion to the spinal cord, described by Brown-Séquard in his 1846 dissertation.<sup>3</sup>

Conservation of the vibratory and arthrokinetic sensitivities was not mentioned. This was because Rumpf began his studies of vibratory sensitivity in 1889, after Xercavins had presented his lecture.<sup>4</sup>

Based on various studies, the author presented his conclusions: "Sensory pathways are established in the spinal cord, from the posterior grey column to the central grey matter of the opposite side".<sup>2(p14)</sup>

Since the tract of Goll degenerates in the ascending direction, it seems likely to have a sensory function. Nevertheless, clinical, histological, and experimental

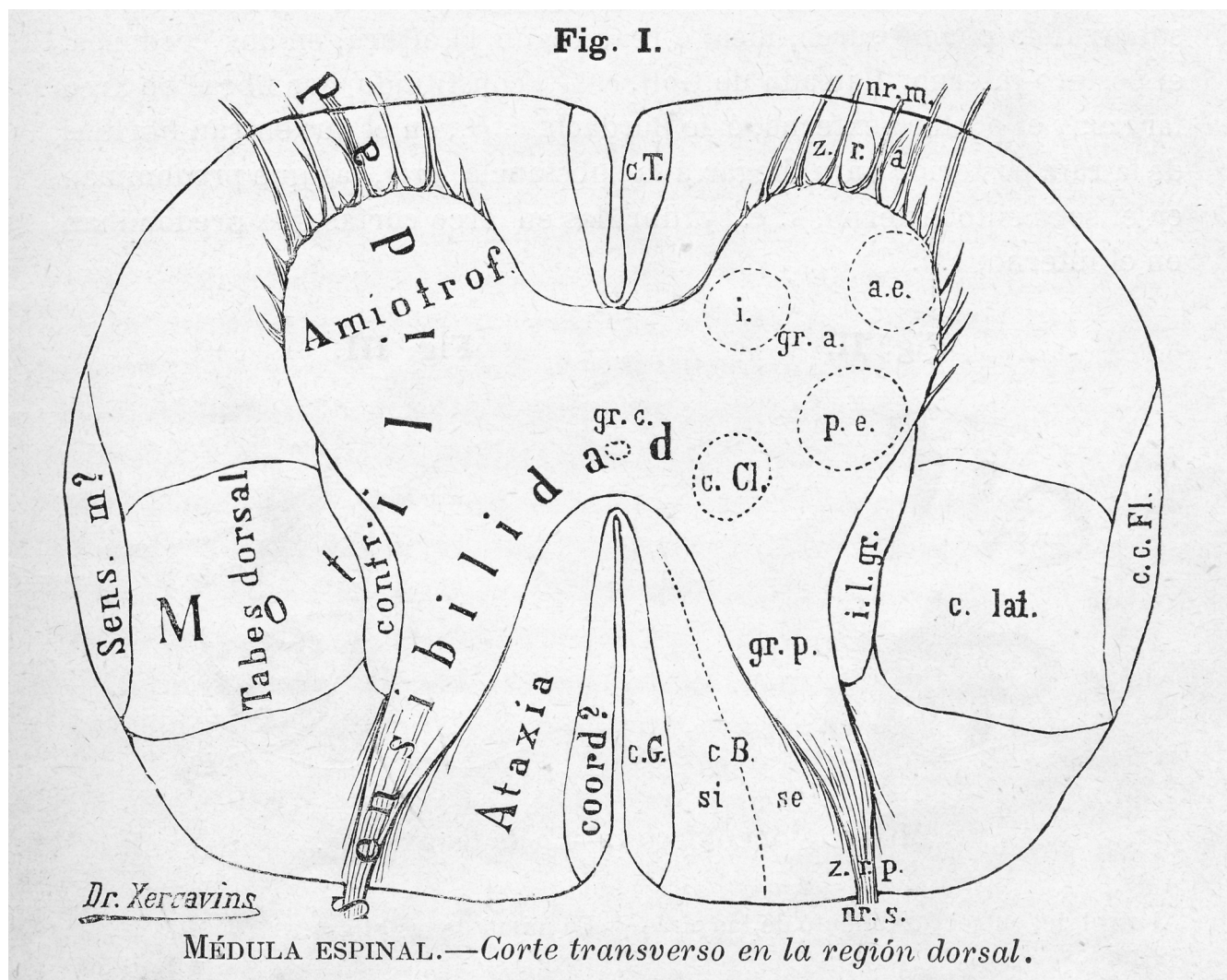


Figure 2. Spinal cord. Transverse section, thoracic region. Drawn by Dr Xercavins



evidence refute this theory. The author's conclusion was that "the tract of Goll is not responsible for transmitting sensory signals".<sup>2(p14)</sup>

Turning to the outwardmost of the posterior columns, or tract of Burdach, which is directly connected to the posterior roots, the posterior horn, and the central grey matter, Xercavins linked it to altered sensitivity. Other scholars disagreed; Dr Xercavins concluded the following:

The tract named for Burdach allows for sensation to be transmitted through its most external segment. It may link bundled grey matter cells with others higher up, but it does not constitute the main sensory pathway toward the brain.<sup>2(p15)</sup>

He analysed the studies by Erb that showed how sensory signals travel along the posterior segment of the lateral column at the lumbar level; there is no evidence that this function exists at the level of the spinal segments in the upper thoracic and cervical region. The author concedes that "radicles that penetrate the posterior segment of the lateral column enable sensory conduction, but they do not make this segment the principal conductor".<sup>2(p15)</sup>

On the other hand, studies by Vulpian state that histological findings are necessary to demonstrate that sensory stimuli are transmitted by the central grey matter of the spinal cord through the column of Clarke, which he regarded as the nucleus of the posterior roots of the spinal cord. From the column of Clarke, the sensory stimulus would pass through the central grey matter to the opposite side of the lateral spinal tract, and along the posterior part of that tract in an ascending direction.

Studies by such authors as Pierret, Vulpian, Brown-Séquard, Schiff, and others describe the transmission of pain sensation through the posterior nuclei of the spinal cord and the lateral spinal bundle, but they do not confirm that touch sensitivity follows the same path. Xercavins supported Wundt's hypothesis that pain and other types of sensation are transmitted along the same circuit.

Voroschilov's experiments in slices of the posterior grey matter led to the conclusion that "transmission of spinal cord sensory currents can be verified through the posterior column; they reach the opposite side through

the connective central grey matter, and subsequently ascend to the brain".<sup>2(p16)</sup>

Sensitivity at the level of the medulla oblongata is transmitted by the gracile fasciculus and the cuneate fasciculus, which act as the continuation of the posterior columns of the spinal cord. These fasciculi terminate in the restiform bodies, which lead to the cerebellum. Based on these macroscopic studies, the author deduces and affirms the following: "The direct passage of sensation from the spinal cord to the brain cannot be verified through the restiform bodies".<sup>2(p16)</sup>

In a later section, based on exclusion or on similar findings in spinal cord slices, the author states that "the sensory fibres pass through the medulla oblongata by means of the external ventral grey matter on the floor of the fourth ventricle".<sup>2(p17)</sup>

At the pontine level, the sensory conduction pathways are localised in posterior-exterior segments; the tracts become less compact as their fibres separate. According to the text, "sensory fibres in the pons must be localised in the posterior-exterior segments; somewhat separated at the point of entry, they then condense to form the bundle of fibres at the other end known as the external quarter of the cerebral peduncle".<sup>2(p17)</sup>

The author observes the fibres that degenerate and continue ascending at the level of the cerebral peduncles, and remarks that "the external or posterior quarter of the foot of the cerebral peduncle is responsible for sensory conduction ascending from the axis of the spinal cord".<sup>2(p17)</sup>

The study of the cerebral peduncles, and knowledge at that time, led the author to conclude that the tegmentum contained the nucleus marking the origin of the third cranial nerve. He also provides the location of the corpora quadrigemina and the optic nerve nuclei; this nerve and the olfactory nerve were both considered to feed into sensory pathways. Considering anatomical knowledge at that time, the author was probably unaware of the relationship between the second cranial nerve and the optic radiations, and of the intimal course of the olfactory nerve.

The link between sensory pathways and 'central nuclei' was clarified by the histological studies undertaken by Meynert and Flechsig, and by neuropathological studies performed by Vulpian and Charcot.

Xercavins concludes, “the posterior sixth of the internal capsule, or lenticulo-optic segment, is a conduit for all the sensations from the opposite half of the body”.<sup>2(p18)</sup>

After examining studies by Meynert and Gratiolet describing connections between the thalamus and the cerebral cortex, the author states,

Histologically speaking, the optical thalamus and the direct posterior fasciculus should be considered the conduits for signals ascending from the spinal apparatus to the cortical apparatus.<sup>2(p19)</sup>

With additional mentions of authors including Cohn, Meynert, and Nothnagel, he concludes that “the optical thalamus, according to clinical and experimental findings, does not form part of the motility system; this is the central grey matter nucleus acting as an intermediary between the spinal sensory apparatus and the cerebral grey layers”.<sup>2(p19)</sup> Xercavins concludes that he does not know the function of sensory conduction in the tract of Goll. He does not specify the type of sensation transmitted by the tract of Burdach, and erroneously states that the tract ascending from the lateral column (spinothalamic tract) is not the main sensory path.

### Motility system

Based on neuropathology studies providing evidence of the destruction of the brain’s central nuclei —the basal ganglia— and the decussation of the pyramidal tracts in the medulla, which carry motor impulses, Xercavins states that the motor pathway can be located by mapping degeneration caused by lesions at the above sites in a descending direction.

He summarises findings by Charcot, Carville, and Duret as follows:

Common hemiplegia [the most frequent type] may arise from total or partial lesion to the caudate or lenticular nucleus, or both at once; it may also result from those located in the centrum ovale, or in the three anterior sixths of the internal capsule and the internal fourth of the pes pedunculi, always on the opposite side.<sup>2(p21-22)</sup>

Based on experiments and vivisections performed by such authors as Huguenin, Duret, Carville, and Hitzig, he deduced the presence of “a tract, known as the pyramidal

tract, which leaves the deep regions of the Hitzig zones, passes through the centrum ovale, and constitutes the 4th and 5th sixths of the internal capsule and the two middle fourths of the pes pedunculi; passing through the pons and anterior pyramidal tracts of the medulla oblongata, it continues to become the lateral column of the spinal cord on the opposite side”.<sup>2(p23)</sup>

The author distinguishes between severe hemiplegia, causing extreme disability, exalted reflexes and delayed rigidity due to pyramidal tract lesion, and reversible hemiplegia without rigidity owing to a lesion in the striate bodies.

At the spinal cord level, motor impulses are issued by the opposite side of the brainstem because of the medullary decussation. In addition, we read that the motor impulse of the pyramidal tract is transmitted to the anterior radicular zones.

The anterior internal column, known as the bundle of Türck, degenerates as the result of lesion to the pyramidal tract before the level of the pyramidal decussation; for this reason, Xercavins believed that the direct pyramidal tract, a separate entity from the crossed pyramidal tract, had to contribute to the pyramid’s motor function.

The pyramidal tract is differentiated from the nerve root zones by the lack of continuity between these structures; sectioning the pyramidal tract does not lead to degeneration of the root zones. As Xercavins concluded, referring to the pyramidal tract, “it does not transmit cerebral and spinal currents, but rather currents from peripheral spinal nerves, to the peripheral nerve”.<sup>2(p25)</sup>

Examining the lateral column, located in the antero-lateral area of the spinal cord, shows that it becomes progressively thinner until reaching the lumbar region; as such, its fibres terminate on the level of the roots emerging from the anterior part of the spinal cord. Motor pathways therefore include cell bundles in the anterior horns of the spinal cord, from which the motor roots originate.

The section on motility concludes with the statement that “motility functions seem to be located in the antero-lateral segments of the spinal cord along its full length”.<sup>2(p27)</sup> Here, the author fails to mention the anterior horn, where the second motor neuron is located.

The section on amyotrophy presents two postulates. Firstly, lesions to the cortex, centrum ovale, basal ganglia, and pyramidal tract result in paralysis, not amyotrophy. Secondly, studies of progressive bulbar palsy showed that paralysis was accompanied by amyotrophy due to lesion of the grey nuclei of motor nerves located in the medulla oblongata.

Experiments by Hallopeau, Vulpian, Pitres, Hayem, and Charcot demonstrated that a spinal lesion accompanied by muscle atrophy will always be located in the anterior horns of the spinal cord, on one of the anterior grey columns.

This section ends with the summary statement that “every nerve involved in voluntary motility has its grey matter nucleus providing for the function and nutrition of the muscles to which it is distributed”.<sup>2(p26)</sup>

A lesion in the motor cortex, Hitzig zones, pyramidal bundle, and lateral column will give rise to muscle contracture in addition to paralysis, foot-clonus, or spinal epilepsy. Contracture is simply an exaggerated form of physiological muscle tone.

The author cites the opinion of Vulpian and Charcot, who believed—but were not certain—that contracture (spasticity) originated in cells in the posterior spinal roots rather than in the pyramidal tract.

Since trismus and tetanus are caused by irritation of sensory nerves, Xercavins states that “contracture is the exaggeration of physiological muscle tone resulting from a state of irritation that occurs in the sensory portion of the diastaltic arches and affects the motor portions with which it joins, thus exciting the motor neurons of the spinal cord”.<sup>2(p26)</sup>

‘Diastaltic’ is a term coined by Cannon<sup>5</sup> to describe the wave of intestinal contractions that is preceded by a wave of inhibition.

A modulatory apparatus functions between the psychic impulse and the muscle contraction: this is the cerebellum, which communicates with the thalamus, striate, and motor centres of the medulla oblongata.

Based on anatomoclinical findings by Hitzig, Meynert, Pierret, and others, our author concludes, “the cerebellar apparatus is responsible for overall coordination of motility...lesions, especially those affecting its peduncles, result in abnormal movements, whether of the eyes or

the entire body; and ataxic pronunciation [scanning speech] in the absence of paralysis”.<sup>2(p34)</sup>

We read that when this modulatory system sustains injury, manifestations may affect the entire body, or else isolated parts, and the author distinguishes between cerebellar and spinal ataxia; ataxias of the latter type were described by Charcot and Vulpian. In the author’s (translated) words, “the postero-exterior column, or column of Burdach, is responsible for coordinating the movements of muscles innervated by the spinal cord; lesions to the internal segment in particular will result in ataxia of the limbs”.<sup>2(p34-35)</sup> In the same paragraph, the author links the tract of Goll to arthrokinetic sensitivity, although this function was denied in earlier paragraphs.

Pierret, Charcot, and Vulpian expressed doubt as to whether the tract of Goll forms part of the cerebellum. As for the tract of Flechsig, both Xercavins and Vulpian believed it to originate in the column of Clarke. Experimental studies revealed that the tract of Flechsig degenerates in the ascending direction and terminates in the cerebellum. Its function is to contribute to coordinating movement by transmitting information from the muscles to the cerebellum.

Although his doubts remained, Xercavins accepted the opinions of the authors named above and stated that the cerebellum, with all of its connections, “should be regarded as the organ of motor coordination, and lesions to its components result in the numerous types of ataxia”.<sup>2(p36)</sup>

With respect to localising the laterality of each function, the author explains the decussation of the sensory pathways at the level of the medulla oblongata, pons, cerebral peduncles, and internal capsule; this configuration explains why a spinal lesion at any level will result in anaesthesia on the opposite side.

As for longitudinal localisation, the author describes cases that match what are now known as alternate syndromes; at the level of the cerebral peduncle, the lesion gives rise to third nerve palsy on the side of the lesion and hemiplegia on the opposite side, as Weber observed.

#### Cortical sub-apparatus

Xercavins establishes the anatomical boundaries of the cortex by describing the grey basal ganglia as the



intermediate region between the spinal cord and the higher cerebral functions (Figures 3 and 4).

Whereas spinal grey matter appears in nuclei and bundles, cerebral grey matter is arranged in layers. The function of the grey matter in the cerebral cortex is to organise and generate motor impulses, receive sensory stimuli, and establish their type or modality, and lastly, be responsible for intellectual activity.

Motor impulses pass through the bundle of Charcot (the pyramidal tract), and through the basal ganglia. Sensory

stimuli pass from the spinal cord to the thalamus, and from that location to the cortex.

The classic, rigid view of functional localisation holds that intelligence is located in the frontal lobe, sensitivity in the occipital lobe, and motility in the parietal lobe. In contrast with the above, new clinical findings and pathology studies show that the different lobes of the brain each have multiple functions. Xercavins believed that the different lobes and gyri contributed, to a greater or lesser extent, to all of the brain's functions.

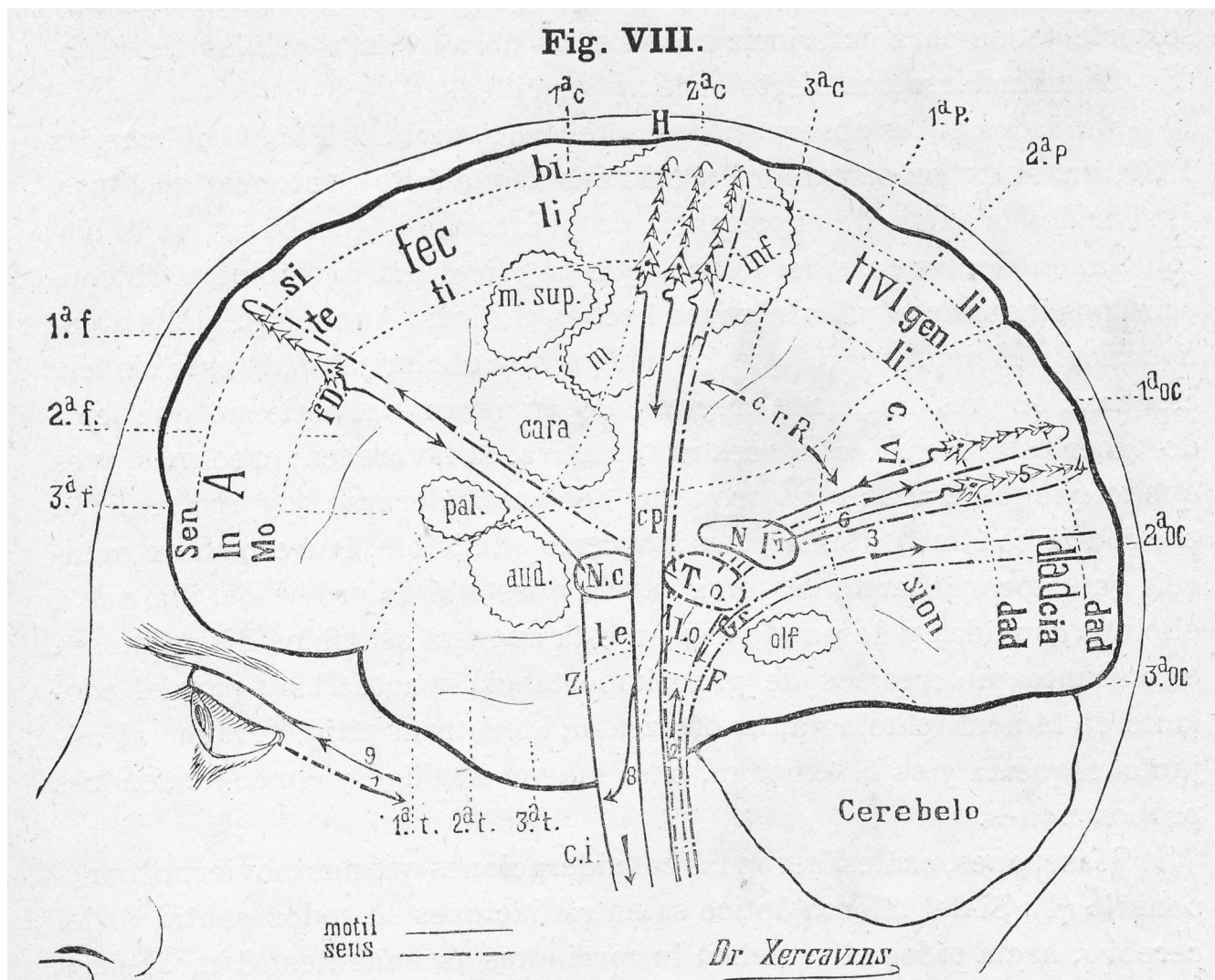


Figure 3. Antero-posterior view of the brain with its central nuclei and internal capsule

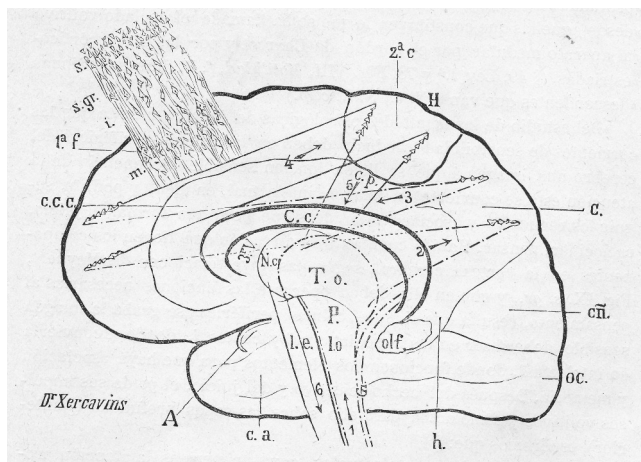


Figure 4. Brain, internal surface

The teachings of his time established an analogy between the columns of the spinal cord and the layers of the brain, stating that the more peripheral layers acted as the continuation of posterior columns of the spinal cord. The anterior columns of the spinal cord extend to become the deep layers of the brain.

As a newly qualified doctor in 1881, Xercavins summarised the medical knowledge of his time in his “map of the distribution of cerebral functions” and supported it with the latest clinical and experimental findings. His references are a testament to his curiosity and commitment to continuing education. In his later work, he modified that plan and presented his new ideas in two sections:

- The peripheral grey matter layers of the cerebral cortex constitute the seat of sensitivity. They are also home to “common sense”. The deep layers of the cerebral cortex generate motility impulses, which are transmitted to the spinal cord through the bundle of Charcot (pyramidal tract) and the corticostriatal fibres. Intellectual activity takes place across the length and breadth of the intermediate layers of the cortex.
- Both the peripheral layers, which receive sensory information, and the deep layers which give rise to motility are regarded as consisting of cell groups or territories. The intermediate layers that are the seat of

intellectual functions are also laid out in small segments or ‘brainlets’.

My conclusions, based on the above, are as follows:

1. Elements of sensitivity, intelligence, and motility are to be found in all lobes of the brain.
2. Elements of sensitivity, intelligence, and motility must be located in the different layers that make up the cerebral cortex, from the most peripheral to the deepest.
3. The brain contains lobes and gyri, and its many layers have been shown to be associated with findings of sensitivity, intelligence, and motor impulses corresponding to a specific organ or region of the body. These regions are represented within the cerebral cortex.<sup>2(p54)</sup>

Histological studies show that the posterior column of the spine reaches the internal capsule and continues through the direct posterior bundle of Gratiolet, which terminates in the occipital lobe. The author believed, although not without many doubts, that this bundle transmitted visual stimuli, which is why other authors referred to the same structure as the optical bundle.

Based on studies by Betz and Tarchinoff, he concludes:

Throughout the cortical grey matter, one finds sensory cells occupying the peripheral layers, but especially the middle layers; these cells are also dominant in the post-Rolandic area, that is, the posterior lobes above the anterior ones [here, the author refers mainly to the parietal lobe].<sup>2(p56)</sup>

Questions remained as to whether fibres from the pyramidal tract project to the striatum; Charcot had shown that degeneration of the pyramidal tract reached the spinal cord with no alterations in the striate nucleus, but German authors, including Gudden, were doubtful. Dr Xercavins was more inclined to agree with Charcot’s version.

Nevertheless, Flechsig’s studies were able to demonstrate that cortical fibres from all cerebral lobes reach the basal ganglia, and that the latter transmit motor impulses to the spinal cord, although they did not specify how they might be related to the pyramidal tract.

At a later date, studies by Betz and Meinart showed that motor cells were found in all deep layers throughout the cerebral cortex, and especially in the ascending, frontal, parietal, and paracentral convolutions, otherwise known as the Hitzig psychomotor centres. These cells are less abundant in the deep post-Rolandic layers.



On the subject of whether or not there may be cells specifically responsible for intellectual function, the author subscribes to Meynert's hypothesis: the cerebral cortex is made up of five layers, and intellectual functions reside in the intermediate layers.

Xercavins concludes the following:

Histology tends to assign the localisation of intellectual operations to the intermediate layers of the brain's entire surface; however, since the intermediate layers are predominant in the frontal lobe, those operations may be more centred in that lobe.<sup>2(p58)</sup>

Citing experimental studies by Kussmaul, Nothnagel, and Goltz, who employed fine cuts to lesion specific parts of the cortex, the author deduces that "there are no purely motor gyri; the convolutions that are mainly involved in motor function, or Hitzig centres, are also involved in sensory processing". Goltz had concluded that "the alterations that follow destruction of a specific site depend not on its location, but rather the degree or depth of the lesion".<sup>2(p59)</sup>

His reading of experimental studies by different researchers led the author to conclude that there was no such thing as a pure motor or pure sensory convolution: "the patient will present motor or sensory deficit according to whether the lesion is deep or shallow".

The psychic impulse that initiates movement, and in which both sensory and motor centres participate, logically begins in cells in the intermediate layers; in other words, "cells linked to intelligence must be between those for sensitivity and those for voluntary impulse".

#### Clinical cases

The author's review of clinical studies of cerebrovascular disease allowed him to conclude that cortical lesions were rare compared to lesions in the central nuclei [basal ganglia].

His conclusion reads as follows: "clinical studies confirm that since pathological processes of different types affect the cortical or deep tissue of the lobes of the brain, they are also accompanied by alterations in sensitivity and motility".<sup>2(p60)</sup>

Studies of cerebral vascularisation had shown that the cortex is irrigated by short vessels, whereas the centrum ovale and basal ganglia are irrigated by long vessels. This explains why cortical haemorrhages are unusual, whereas cerebral softening due to thrombosis or embolism is common; these cortical lesions appear as small wedges in the area irrigated by capillaries.

Haemodynamic factors account for the low incidence of diseases affecting the anterior and posterior cerebral arteries; the middle cerebral artery is directly impacted by the systolic component, which results in a higher incidence of vascular accidents.

He also mentions the poor circulation in the distal segments of the three cerebral arteries; in these outlying areas, this means that cerebral softening manifests under conditions of atony of the circulatory system.

The section ends as follows:

Lesions in the striate bodies and corresponding portion of the internal capsule result in the common type of apoplexy, or cerebral hemiplegia. Those affecting the cortex are characterised by paralyses that are sometimes partial but can become generalised as series of attacks occur; these coincide with spasms in the paralytic regions and cerebral epilepsy, followed later by delayed rigidity. However, intelligence is often spared, and rapid recoveries are sometimes seen.<sup>2(p62-3)</sup>

#### Histological, experimental, and clinical data

Using histology, experiments, and clinical practice as his basis, Xercavins puts forth the possibility of motor and intellectual functions coinciding in the same area of the brain. After presenting this functional topography, he describes the brain as a confederation of smaller brain centres from which sensory, intellectual, and motor functions originate.

Results from experimental studies by authors including Hitzig and Ferrier, and from the autopsy studies carried out by Wernher and Charcot, suggest that the psychomotor centres are located in the ascending frontal and parietal gyri, and in the paracentral lobe. The conclusion put forth is that "the centres of Hitzig should in a general sense be regarded as the cerebral psychomotor localisations of the upper and lower limbs on the opposite side of the body".<sup>2(p65)</sup>

Experiments undertaken by Ferrier had shown that psychomotor functions could also exist in a more limited form. One example cited by Xercavins focuses on the changes in eye movements due to occipital lobe lesions. With this in mind, he concedes that “the Hitzig convolutions are psychomotor centres corresponding not to the body as a whole, but rather to specific regions. There must therefore be other brain centres controlling the remaining peripheral muscle groups”.<sup>2(p65)</sup>

Another confirmed localisation was Broca’s area for speech, in the brain’s left hemisphere. Xercavins mentions that aphasia may affect left-handed individuals, with exceptions:

The centre of speech is firmly located in the operculum, that is, the foot of the third frontal gyrus. If the left hemisphere is the most functional, the centre will reside on the left side...nevertheless, in the left-handed or those with a dominant right hemisphere, speech function will be located in the right hemisphere.<sup>2(p68)</sup>

Broca’s area is specific only to speech and not other modes of language; Trousseau, Laborde, and others believe that there are distinct areas for written language and sign language. This indicates that intelligence would be present at other localisations. “Therefore, in agraphia, alexia, and amimia, the pathological localisation is not that found in the centre of true aphasia; rather, it is in the centres that innervate the arm, and nerves involved in vision and sign language”.<sup>2(p68)</sup> Here, the author is critical of the strict view of localisation of cerebral functions, and even of the idea of the dominant hemisphere.

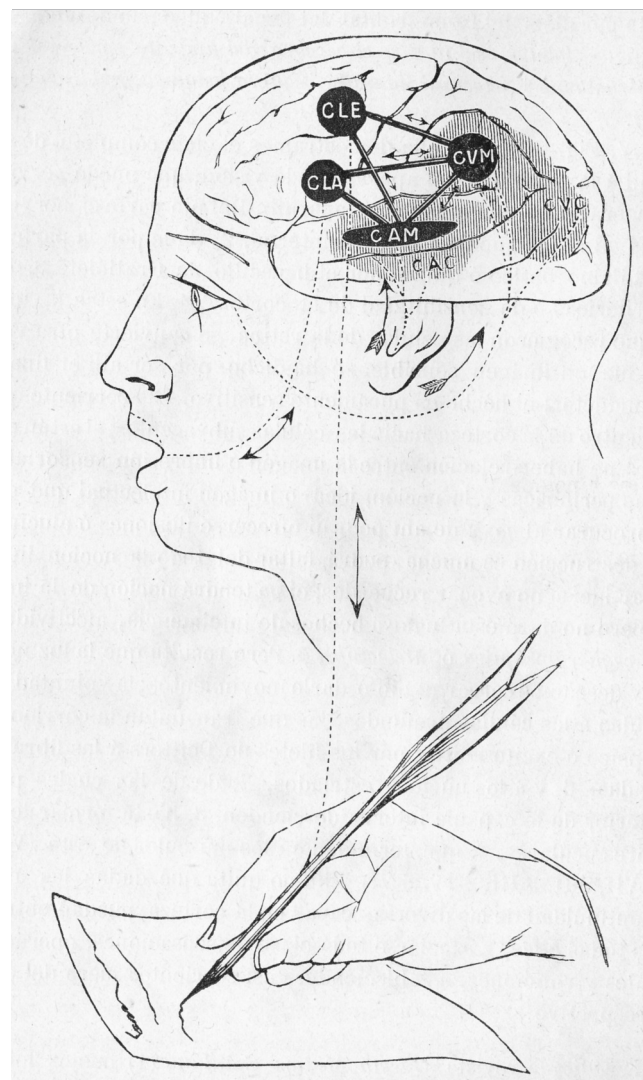
At the same time, other modes of language resist the idea of strict functional partitioning within the brain; both alexia and amimia require a far more complex level of intellectual and motor organisation.

The evolution of the brain is cited to account for the role of hearing in language acquisition; the circuit passing through the auditory centre is linked to the speech centre, and the two centres are linked by intelligence that modulates and attaches meaning to spoken language.

Since the auditory centre is located in the first temporal gyrus, “the superior temporal gyrus is recognised as the seat of hearing, and the third frontal gyrus, with speech; the insula is associated with disposition in that it

modifies processes in its neighbouring areas. Together, these three components make up the brain centre for hearing and spoken language”.<sup>2(p69)</sup> Xercavins, drawing on his own experience and literature reviews, elaborated a novel hypothesis about the origin of language, reading, and writing.

Using clinical studies by Obernier and Charcot and experiments by Gudden to support his argument, he states that “the occipital lobe is the part of the brain underlying the visual sensory apparatus, that is, the



**Figure 5.** Schema of the action mechanisms of visual function and speech

intellectual disorder known as psychic blindness and its effects on related muscles”.<sup>2(p71)</sup>

The last paragraph of the study describes the complete cycle of brain activity from a sensory stimulus to simple motor responses such as those involved in muscle reflexes, or even to higher activities such as interpreting vision or writing.

Using vision as an example, he presents an incomplete view of the visual pathways beginning with the stimulus to the retina and reaching the cortex of the occipital lobe after passing through the optical nerve, peduncles, internal capsule, posterior segment of the thalamus, bundle of Gratiolet, and occipital cortex.

The author does not mention the optic chiasm, visual pathway, corpora quadrigemina, or external geniculate body. From this reading, it can be interpreted that the pathway crosses or connects to the peduncles and the internal capsule.

Dr Xercavins once again presents his hypothesis on speech and visual function, which was based on Pierre Marie’s article reviewing aphasia and agrafia according to the Charcot hypothesis.<sup>6</sup> He includes a line drawing of the action mechanism behind these functions (Figure 5).

We posit that there is a common visual space that depends on a higher visual centre for words. An injury to the first centre gives rise to word blindness (when reading). An injury to the higher centre (interpretive) results in psychic blindness. The same concept can be applied to auditory function: there is a common auditory centre which is subordinate to a higher centre that processes words. Lesions at these locations produce word deafness and psychic deafness respectively; the latter term refers to Wernicke or sensory aphasia.

The localisation for a lesion producing verbal ataxia, referring to Broca’s aphasia, is at the level of the insula. An interrupted connection between the psychic auditory area and the insula would produce transitional or relational aphasia.

Alexia and agrafia are the product of a disconnection in the higher intellectual centres. The visuospatial

centre is affected in alexia, whereas psychomotor coordination is impaired in agrafia, although other hand functions are preserved. The conclusion reads, “the occipito-temporal lobes display not only sensory functions, but also intelligence, and the Hitzig centres display functions of intelligence and volition in addition to motility”.<sup>2(p73)</sup>

The study concludes that the cerebral localisation of multiple functions remains unknown; likewise, there are many gyri not known to have specific functions.

## Discussion

This treatise by Dr. Xercavins reveals his in-depth knowledge of anatomy, particularly of the sensory and motor pathways of the central nervous system; the long list of authors he cites is proof of his thorough and up-to-date knowledge of the literature published in his time. The author presents his own hypotheses and conjectures regarding the seat of the higher functions, especially language, reading, and writing.

## Conflicts of interest

The author has no conflicts of interest to declare.

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