Russia's contribution to neuroscience: excellence and obscurity

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ABSTRACT

Introduction. Recognition of Russia's contribution to neuroscience has been limited due to language, the country's isolation, and in the Spanish context the rejection of Russia following the Civil War. A considerable number of English-language articles by Russian writers are beginning to compensate for this shortcoming.

Development. A review was performed of works by Russian authors who are relatively well-known among specialists in Spain; their contributions are organised by subject area (neuroanatomy, neurophysiology, clinical neurology, etc) and relevant biographical details are discussed. The study of Lenin's brain and the repression of neuroscientists under the Soviet regime are also addressed.

Kozhevnikov is a key figure in Russia and states under its influence, establishing neurology as an independent specialty. In Europe, Kernig and Brudzinski may be the most popular eponyms, but the giant pyramidal cells named for Betz and the numerous structures named for von Monakow also stand out in the field of neuroanatomy. Pavlov and Luria are also recognised as influential figures in neuropsychology. The study of Lenin's brain represents an investigation into the structural basis of intelligence. Finally, Bekhterev's probable assassination exemplifies Soviet Russia's darkest era.

Conclusions. Russian neurosciences have been a victim of history. Favourable political changes and the publication of English-language texts by Russian authors have significantly increased the recognition of Russian neuroscience.

KEYWORDS

Bekhterev, Betz, Korsakov, Kozhevnikov, Luria, neuroscience, Pavlov, Russia

Introduction

Most neurologists are familiar with the names of numerous Russian authors (Bekhterev, Betz, Brudzinski, Darkshevich, Filimonov, Kernig, Korsakov, Kozhevnikov, Minor, Pavlov, Puusepp, and Rossolimo, among others). However, surprisingly little is known about the lives and circumstances hidden behind these eponyms, and these authors' important contributions to neuroscience, particularly in the second half of the 19th and first third of the 20th centuries.[1] One of the main reasons for this is the limited knowledge of the Russian language[a] in America and Europe, with the exception of countries under Russian influence. This was not a new phenomenon: Cajal also complained bitterly of the lack of recognition of his works published in Spanish.[2] Russia's isolation, particularly during the Soviet (USSR) period, was also an important factor.[3]

Fortunately, the dissemination of English-language books and articles by Russian authors over the last decade or more is a first step in compensating for this shortcoming. This review addresses the contributions of Russian scientists to various fields of neuroscience, the historical context in which these authors worked, and their influence in North America, Europe, and Spain.[4] As far as the author is aware, this is the first such review to be performed in Spain.

[a] One exception is Luis Simarro, whose library contains a Russian-language book by V.M. Bekhterev (Javier Campos, personal correspondence).

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Figure 1. Vladimir Alekseyevich Betz (1834-1894)

Development

The 2007 double issue of the *Journal of the History of the Neurosciences*[5] is an essential source. Producing this edition must have been no easy task: as one of the editors (Koehler) admits, it took years to find the correct person, somebody with contacts in Russia and command of the language, as well as expertise and enthusiasm. He found such a contributor in Dr Alla Vein, now working as a neurologist in Leiden, Netherlands; she qualified at Moscow Medical Academy and subsequently specialised at the Clinic for Nervous Disorders founded by Kozhevnikov, the father of Russian neurology. This monograph stands in contrast to the meagre representation of Russian authors in the 1953 edition of *Founders of Neurology*,[6] which included only five Russians among a total of 133 biographies. The representation of Russian neuroscience is no better in Finger's[7] *Origins of neuroscience* (five authors of a total of over 600). Remarkably, Russian authors are just as rare among the 55 eponyms collected by Koehler, Bruyn, and Pearce,[8] who mention only Korsakov, Kernig, and Brudzinski. However, we should highlight a 2009 article by Balcells Riba,[9] dedicated to neurology in Eastern European countries. In this review, the adjective "Russian" is used in reference to authors born in Russia or in territories or republics occupied during the Tsarist period (up until the Revolution of 1917) or by the USSR (until its collapse in 1991). Any investigation into neuroscience in Russia would be incomplete without at least a brief discussion of the political and cultural circumstances of the time.[3] Proper nouns are transliterated from the Cyrillic names. For authors with dual nationality, for instance in the case of von Monakow,[6] the nationality corresponding to the place of birth was selected arbitrarily. Rather than merely providing a biographical index, it was considered more valuable to review the most relevant clinical fields (neuroanatomy, neurophysiology, neuropsychiatry, etc), also noting the circumstances surrounding these authors' lives and the impact of their work beyond Russia, particularly in Spain. Relevant historical developments are also discussed, including the study of Lenin's brain and the harsh repression of many neuroscientists during the Soviet era.

Neuroanatomy

Research into human anatomy was an area of particular interest in several Russian universities, particularly after Lenin's brain was studied by Cécile and Oskar Vogt in 1924. The Moscow Brain Research Institute was founded in 1928, later becoming the Pantheon of Brains,[10] which collected the brains of elite figures, including such eminent neuroscientists as Bekhterev, Rossolimo, and Pavlov. In fact, the idea had already been adopted by scientists and lecturers at other European universities and by writers, artists, and politicians.[11]

1. The fundamental contribution of Vladimir Betz

The six-layered structure of the cerebral cortex, as we know it today, was proposed in the mid-19th century by the physician Jules Baillarger (1809-1890) of Hôpital Pitie-Salpêtrière. In Vienna in 1872, the anatomist Theodor Hermann Meynert (1833-1890), known as the "father of cytoarchitectonics," observed differences in thickness between different areas of the human cerebral cortex, and variations in the distribution of different types of nerve cells.[13] However, the fundamental step was made by Vladimir Alekseyvich Betz (1834-1894; Figure 1), a dedicated anatomist and histologist at Saint Vladimir University in Kiev. In 1874, he developed the novel idea of the Rolandic fissure as the barrier between the anterior part of the cortex, the seat of the "giant" pyramidal cells (as Betz denominated them) in layer V, and the posterior part (including the temporal lobe), which predominantly consists of "nuclear layers."

Inspired by the experiments of Fritsch and Hitzig, Betz suggested that the cortical area anterior to the Rolandic fissure had motor functions, while the area posterior to the fissure was involved in sensory function.[14] Although he did observe apical and basal processes in Betz cells, it should be noted that the carmine stain gave far poorer definition than the reduced silver stain developed by the Spanish school of histology.

2. Von Monakow and the functional phenomenon of diaschisis

Although he was born in Russia (just north of Moscow),[15] Constantin von Monakow (1853-1930) and his family were exiled to the tranquillity of his adopted home of Zurich, Switzerland, during the Franco-Prussian War.[6] At a young age he learned to use von Gudden's microtome, practising on rabbit brains; this experience later proved valuable, when he contributed such neuroanatomical structures as the bundle of Monakow (rubrospinal fasciculus) and the Monakow nucleus (accessory cuneate nucleus); he was also the first to describe the arcuate fasciculus.[15] At his private clinic, between 1900 and 1914, he described what became known as Monakow's syndrome (infarctions in the territory of the anterior choroidal artery) and a reflex comparable to the Babinski sign, triggered by stimulation of the lateral part of the foot.[6] For a long time, Monakow was concerned by atrophy of the thenar eminence of one of his hands and the association with a possible spinal cord lesion. After autopsy, the spinal cord was lost and no explanation was found for the atrophy.

Surprised by the recovery observed in some patients following stroke, von Monakow hypothesised that these patients presented functional impairment in areas distant to the lesion, proposing the term diaschisis, from the Greek μισό ("half") and διαιρέστε ("to split"). The concept remained controversial for 50 years, and is today used to refer to metabolic changes triggered by distant subcortical focal lesions (connectional diaschisis) or by changes to diffuse neural circuits in the "connectome."[16]

3. Dogiel, the reticularist histologist

Lithuanian-born Alexander Stanislavovich Dogiel (1852-1922), professor of histology at Kazan University, was one of the most reticent opponents of Cajal's theory of neurons, despite having demonstrated his respect for the Spaniard. His commitment to reticularism was based on the existence of suspected neurofibrillary networks in the retina, observed with methylene blue staining.[6,17]

4. Lenin: the prized brain of a supposed genius

Since the time of his first stroke at the age of 51, Vladimir Ilich Ulyanov (Lenin) was surrounded by neurologists: led by Otfried Foerster (1873-1941), Oswald Bumke (1877-1950), Adolf von Strümpell (1853-1925), and Max Nonne (1860-1959) all served as his physicians. The decision to select Foerster to head the team was a good one: his scientific output was impressive both in the field of neurology and in neurosurgery: "a rare combination [...], he was outstanding in both fields."[18] Consideration may also have been given to his therapeutic instruction at the Neurological Institute in Breslau, Germany (now Wrocław, Poland).[19] Lenin was not only a radical activist; he was also the most intellectual of the Soviet leaders, having written important works on philosophy and imperialist economics.

Another logical decision was the decision to appoint the German neurologist Oskar Vogt (1870-1959) and his French wife Cécile Mugnier (1875-1962) (Figure 2) to study Lenin's supposed genius according to the cytoarchitecture of his brain. The Vogts fell in love working at Déjérine's laboratory in Paris, and made a lifelong commitment to research, sometimes obsessively, the cerebral basis of the human mind, despite earning only a modest income from their private clinic. In 1923, they travelled to Moscow for the First All-Russian Congress of Psychoneurology, where they presented 25 years' work on the cytoarchitecture of the cerebral cortex at the Institute for Brain Research in Berlin; at the congress they were offered the opportunity to study Lenin's brain. The aim of the research was to apply neuroanatomical understanding to "the brains of the elite," leading to the possibility of "nurturing superior brains." Vein and Maat-Shieman[20] interpret this as a historic attempt to

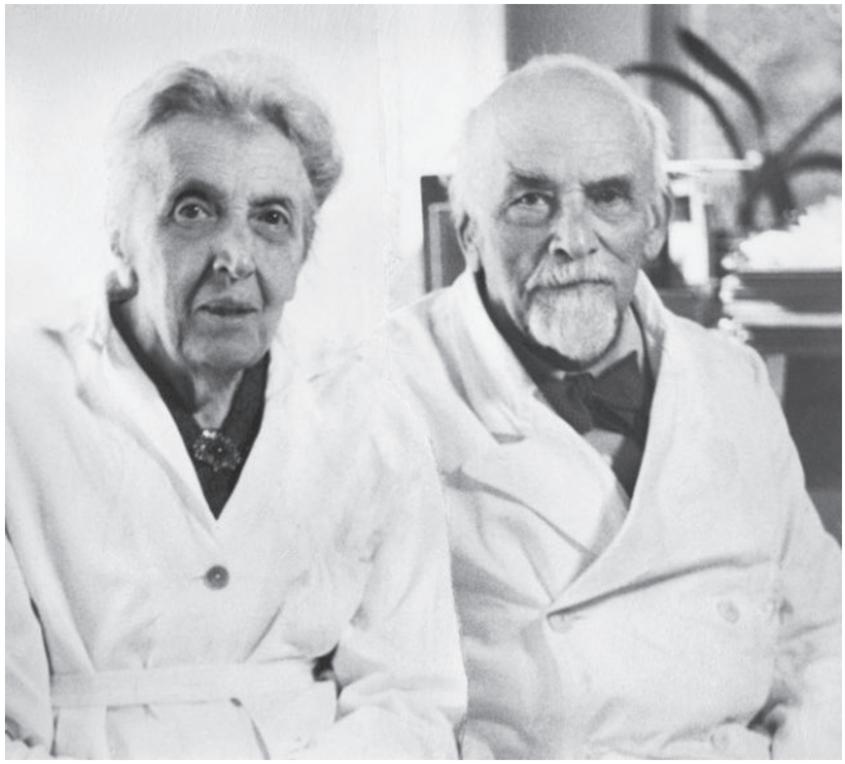

Figure 2. The German neurologist Oskar Vogt (1870-1959) and his French wife Cécile Mugnier (1875-1962), selected by the Soviet government to research Lenin's supposed genius through analysis of the structure of his brain

understand intelligence, or the neuroanatomical basis of mental capacity and talent. In any case, a contract was signed between the Vogts and the director of the V.I. Lenin Institute. They returned to Moscow in February 1924 with all the material needed to perform the study. Despite spending five years examining Lenin's brain, their data and the conclusions reached remain concealed to this day. The "personality cult" and aggrandisement of Lenin's figure were a political weight, to the extent that his cadaver was displayed at a purpose-built, theatre-like mausoleum on Red Square, where astonished citizens and curious tourists form long queues to view it.

There has been great speculation about the disease that led to Lenin's death at the age of 54. Theories include lead poisoning from a bullet lodged near his neck and assassination with arsenic under Stalin's orders: high doses of arsenic cause severe gastroenteritis, encephalopathy with tremor and myoclonus, and, at late stages, polyneuropathy; however, the toxin does not cause seizures, which did present in Lenin.[21] The official ruling was generalised arteriosclerosis, although the Russian authorities appear unwilling to review the diagnosis, with the clinical history and the relevant laboratory report having disappeared. Even the signatures of witnesses, such as the neurologists Kramer and Kozhevnikov, were omitted from the autopsy report. The anecdotal detail that Lenin's arteries were so sclerotic that "when the prosecutor tapped them with tweezers, it sounded as if he were tapping stone" has given rise to the hypothesis of a rare genetic disorder of calcium metabolism.[22] Meningovascular syphilis has been suggested repeatedly due to the pronounced obliteration of intra- and extracranial arteries, which may have caused an aneurysm in the middle cerebral artery.[23] The disease would have been contracted from his former mistress Inessa Armand, and would explain his history of generalised exanthema and the improvement of his headaches following administration of arsphenamine.

After completing their investigation, the Vogts returned to Germany. They were fortunate: the Krupp family, who were powerful industrialists, supported the creation in 1931 of the Kaiser-Wilhelm-Institut für Hirnforschung und Allgemeine Biologie (Kaiser Wilhelm Institute for Brain Research) in a suburb of Berlin, where Oskar Vogt served as director until the Nazi regime forced his resignation, uncomfortable with his international recognition, his French wife, and his Jewish colleagues.[24] The Vogts identified around 200 cortical areas by cytological distribution, and developed novel concepts including "pathoclisis," or selective molecular vulnerability.[25]

The only neuropathologist identified in the review was Ivan Nikolaevich Filimonov (1890-1966), who wrote an influential study on the neuropathology of lathyrism in a patient with a long follow-up of severe spastic paraplegia.[26,27] In Filimonov's patient, cortical Betz cells had been destroyed by terminal lymphoma; however, they were preserved in two cases of recent-onset lathyrism studied in detail at the Cajal Institute in Madrid by Oliveras de la Riva, supported by Professor Fernando de Castro.[28,29] From 1914, Filimonov worked as first assistant to Rossolimo at the Clinic for Nervous Diseases in Moscow; however, both men's destinies changed in 1927, after Lenin, Stalin, and Trotsky had seized power: Filimonov was appointed a member of the USSR Academy of Medical Sciences,[b] whereas his mentor Rossolimo was ostracised. With the Vogts, he studied the individual variability of the cerebral cortex, and in 1933 was appointed director of the department of nervous diseases in Kharkiv, Ukraine.[10]

Neurophysiology: Pavlov's dogs

The greatest pride of "the patriarch of Russian physiology," Ivan Mikhailovich Sechenov (1829-1905), may have been his decisive influence on the young Pavlov.[30] Sechenov proposed the idea of "reflexes of the brain," according to which thought and emotion were purely physiological responses, rather than originating in the soul. He was an exceptionally honest man, an idealist and crusader against injustice; in opposition to Virchow's theories, centred on the cell, Sechenov defended the importance of environmental factors in some diseases. The Tsarist administration accused him of being materialist, immoral, and anti-religious for asserting that "the initial cause of all human action lies outside man."[6]

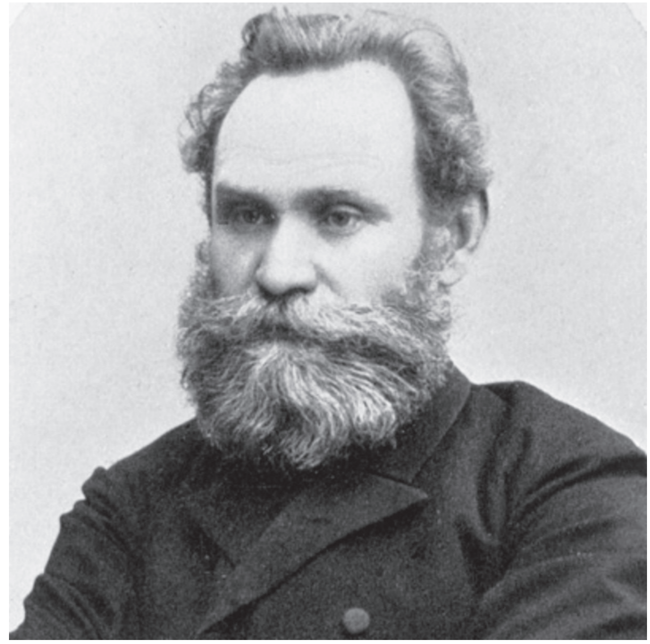

Figure 3. Ivan Petrovich Pavlov (1849-1936)

Ivan Petrovich Pavlov (1849-1936; Figure 3), the son of a cleric, spent the majority of his childhood at a seminary, which he left at the age of 18. He studied in Saint Petersburg with the chemist Dimitri Ivanovich Mendeleev (1834-1907), the celebrated creator of the periodic table of elements. He used chronic fistulae ("Pavlov pouches") in dogs to collect salivary, gastric, or pancreatic secretions produced in response to external conditioned stimuli (such as the famous bell), and even in response to their keeper approaching. Pavlov achieved an astonishing surgical prowess: he was able to insert cannulae into the pancreatic duct, a procedure that Claude Bernard never performed successfully.

For Pavlov, conditioned reflexes constituted an organised response of the central nervous system to different internal or external stimuli. This enabled the interpretation of certain psychological processes as reactions that were of purely physiological nature,[30] and therefore therapeutically manipulable by promoting positive responses (pleasure/reward) and discouraging

[b] Big Medical Encyclopedia [Internet]. Filimonov Ivan Nikolaevich. Available from: http://bigmed.info/index.php/FILIMONOV_Ivan_Nikolaevich [accessed December 2018].

negative ones (pain/punishment).[31] The study of the human mind through an animal model was criticised by psychologists; they also condemned the introduction of a new physiological vocabulary (Pavlov coined the term "higher nervous activity" to replace "reflexes").

Pavlov's studies were praised by the most distinguished scientists of his day, including Santiago Ramón y Cajal. He presented his *Experimental psychology and psychopathology of animals* at the 14th International Medical Congress in Madrid in 1903. Cajal, who presided over the anatomy section, presented his momentous findings on the connection of nerve cells in the spinal cord, olfactory bulb, and retina.[32-34] There is no evidence of personal communication between these two Nobel laureates (Pavlov won his Nobel Prize in 1904, followed by Cajal in 1906), although there may be common features in their respective theories.[35]

Lina Stern (1878-1968), of Jewish origin, was born in Latvia, then part of the Russian Empire. She was the first woman to be awarded a professional degree by the University of Geneva, in 1918, and eventually became director of a physiological chemistry department.[36] Her decision to return to Moscow in 1923 coincided with an increase in Soviet support for the sciences in general. She studied the mechanisms of brain homeostasis and the role of the blood-brain barrier, a term coined by Stern herself. She was also interested in the clinical field, studying the treatment of traumatic shock and tuberculous meningitis; she treated the latter with streptomycin injected into the cisterna magna (despite the risk of causing obstructive hydrocephalus). Stern held a monopoly over the use of this antibiotic in the USSR.[37]

Russian neurology and its characters

In terms of historic relevance, Aleksei Yakovlevich Kozhevnikov (1836-1902), the father of Russian neurology, must be considered the most important figure.[38] In the West, however, Sergei Sergeivich Korsakov (1854-1900), whose name is associated with Wernicke-Korsakoff syndrome, is the best known. Kozhevnikov's visit to London's famous Queen Square was enlightening: he convinced Korsakov of the need for independent neurology departments, in contrast to the situation in Austria and Germany, where neurology was included within mixed services.[39] Upon his return to Moscow in 1888, Kozhevnikov made the significant decision to entrust his student Korsakov with the care of patients with mental illness, establishing a new "neuropathology" department (the term was used in the sense of "neurology" today).

1. Epilepsia partialis continua

Among other initiatives, such as the creation of a museum of neurology,[40] Kozhevnikov is known for describing epilepsia partialis continua, or Kozhevnikov syndrome, in a communication presented to the Russian Society of Neuropathologists and Psychiatrists on 21 January 1894. The syndrome is a particular type of status epilepticus with simple focal motor seizures; duration ranges from an hour to years. The aetiology of the condition varies, with causes including Rasmussen encephalitis and tick-borne Russian spring-summer encephalitis.[41] In a series of 27 patients in Spain, stroke was reported to be the most frequent cause (44% of patients); a high mortality rate was observed among patients with clonic twitches affecting multiple areas of the body or with prolonged duration of status.[42]

2. Davidenkov scapuloperoneal syndrome

Had he not published three studies in German and English,[43-45] Sergei Nikolaevich Davidenkov (1880-1961) probably would not be remembered in the history of neuromuscular disease. He described a phenotype characterised by atrophy involving muscles of the shoulder girdle and distal muscles of the lower limbs, with weakness in foot dorsiflexion (Figure 4). Today, several causes of scapuloperoneal atrophy have been identified: it can be a variant of Charcot-Marie-Tooth disease, as proposed by Davidenkov, or caused by Emery-Dreifuss muscular dystrophy; there are also reports of cases with *TRIM32* sarcotubular myopathy[46] and chronic spinal muscular atrophy in adults.[47] The disease may follow a recessive,[43] autosomal dominant,[48] or X-linked inheritance pattern.[49]

Davidenkov was born in Riga, the capital of modern Latvia; he was one of Pavlov's most distinguished students and is considered the pioneer of Russian neurogenetics. His father was a professor of mathematics and his mother a concert pianist; this mix of genes may explain his talent for drawing the different postures of prototypical neurological patients and his industrious scientific output.[50]

3. Semiology

In the late 19th century, European neurology was enriched with the description of numerous clinical signs which, if we are sincere, are often nonessential. Russian authors made an important contribution to this trend, with Grigory Ivanovich Rossolimo's (1860-1928) observations being the best known in Western Europe and America. Rossolimo was born in Odessa to an illustrious family of musicians and engineers; this situation contrasted with that of his great friend and classmate, the famous writer Anton Chekhov (1860-1904), who was beaten and humiliated by his father.[51] The Rossolimo reflex is obtained by percussion of the tendon of the extensor hallucis longus muscle; he proposed the reflex as a variant of the cutaneous plantar reflex with extension of the big toe.[52] In fact, it is a myotatic or stretch reflex,[53] and may be accompanied by other exaggerated deep tendon reflexes in patients with spinal cord lesions.[54,55] Rossolimo's name is also used in reference to two other reflexes: first, flexion of the fingers and supination of the forearm in response to percussion of the palmar side of the metacarpophalangeal joint; and second, exaggerated flexion of all five toes in response to percussion of the distal portion of the sole of the foot, in patients with pyramidal tract lesions. After studying the motor pathways of the spinal cord as a young man,[56] and disillusioned with the conflict of the universities, Rossolimo dedicated his final years to his true calling, paediatric neurology. On 18 August 1923 he presented a stroke, which caused left hemiplegia and hemianopsia; his was one of the 14 brains of "geniuses" collected by the Vogts at the Pantheon of Brains in Moscow.

Lazar Solomonovich Minor (1855-1942) was born in Vilna in today's Lithuania, the son of a rabbi. Minor's sign is a curious manoeuvre able to differentiate sciatica from lumbago: upon standing, a patient with sciatica will support their weight on the healthy limb, keeping the affected one bent, whereas a patient with lumbago will support their weight on both limbs. The term "Minor's disease" has also been used in reference to acute paraplegia secondary to haemorrhage into the spinal cord.[57]

The meningeal signs described by Kernig and Brudzinski often accompany neck stiffness in various types of infectious meningitis, although neither is specific.[58] These are probably the best known Russian names in neurology, even among medical students. These authors may have fallen into obscurity if they had not published their respective publications in German and French.[59-62] Born in Saint Petersburg, Vladimir Mikhailovich Kernig (1840-1917) is sometimes referred to as Woldema Kernig, the name by which he was known in Dorpat (in today's Estonia), where he earned his medical degree. It is worth mentioning here the test for the Kernig sign; in the author's words[8]: "Flexion contracture of the legs […] which *becomes evident only after the patient sits up* […] If one attempts to extend the patient's knees [*with the patient seated*] one will succeed only to an angle of approximately 135 degrees" (emphasis added); this is not observed when the patient is supine. Kernig does not mention the presence of pain in his 13 patients; this key detail is explained by traction of the inflamed nerve roots.

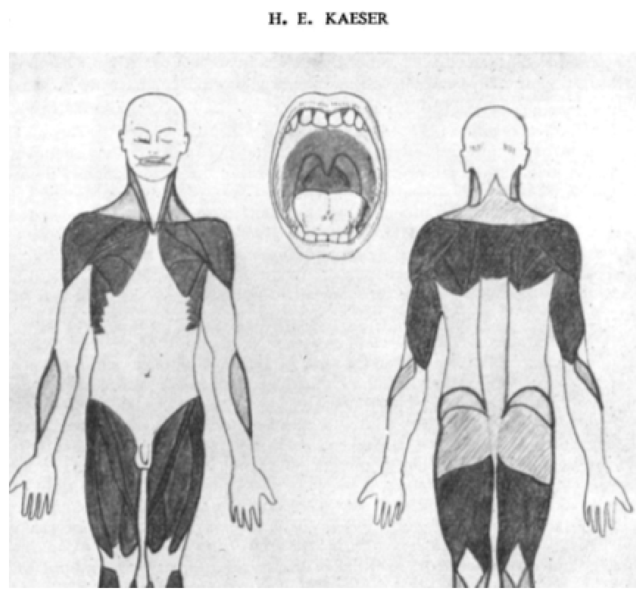

Figure 4. The distribution of muscle atrophy in Davidenkov scapuloperoneal syndrome (from Kaeser[48])

Polish-born Józef Polikarp Brudzinski (1874-1917) also studied in Dorpat, and later specialised in paediatrics. Although he described various signs in children with meningitis, mainly of tuberculous origin, his name is usually used in reference to the following sign[8]: "passive flexion of the neck [causes] the flexion of the lower limbs in the two joints and the flexion of the lower limbs over the pelvis." It should be noted that in the series reported by Kernig and Brudzinski, diagnosis was confirmed by autopsy only in a limited number of cases, and never by analysis of cerebrospinal fluid. Recent series of children with suspected meningitis report 27% sensitivity for the Kernig sign and 51% sensitivity for the Brudzinski sign.[63]

Neuropsychiatrics

As a distinguished student of Kozhevnikov, Korsakov's dedication to mental illness was circumstantial: his mentor decided to separate the specialties of neurology and psychiatry, as described above. He never lost interest in the biological aspects of psychiatry, and did not lose sight of the importance of the individual in the specialty. Korsakov was famous for his humanism: he abolished the use of restraints on agitated patients and even supported students with financial difficulties.[6] He described amnestic-confabulatory syndrome in alcoholic patients in six articles printed between 1887 and 1891. In short, after an initial period of agitation associated with impaired awareness, the patient appeared to recover normally. After a detailed conversation, it became apparent that he remembered nothing of what had just happened, filling lacunae with imagined responses. Korsakov referred to the syndrome as "polyneuritic psychosis" and later as "cerebropathia psychica toxemica." The term Korsakoff syndrome was proposed in 1897 by the German psychiatrist Friedrich Jolly, before the discovery of vitamin B_1 deficiency. Today, the syndrome is considered an encephalopathy caused by thiamine deficiency. It occurs not only in alcoholic patients but also after chemotherapy-induced vomiting in oncological patients, during weight-loss diets, and in patients treated surgically for morbid obesity, among other contexts. The clinical syndrome does not differ, whatever the cause.[64] In some patients, Wernicke-Korsakoff syndrome may be accompanied by cerebellar ataxia and/or ophthalmoplegia.[65] Karl Wernicke described the syndrome in three patients in 1881; in one case, onset followed profuse vomiting due to sulfuric acid poisoning.[66] The characteristic lesion of Wernicke-Korsakoff syndrome is haemorrhagic necrosis of the mammillary bodies and the medial dorsal nucleus, visible with neuroimaging.[67] The amnestic component is associated with degeneration of the anterior thalamic nuclei.[68]

Vladimir Mikhailovich Bekhterev (1857-1927) was a noteworthy personality; as an adolescent, he presented "acute neurasthenia," according to his self-diagnosis. A compulsive writer, his appearance did not fail to impress his patients: at early-hour consultations in an office crammed with books and papers, his abundant grey hair, penetrating gaze, and mystical air were not to be forgotten.[69] Bekhterev was a man of many talents, from clinical neurology (he described the Mendel-Bekhterev reflex, flexion of the second to fifth toes induced by percussion on the base of the tarsus, and the acoustic blink reflex) to experimental psychology (taking particular interest in psychosocial issues, in accordance with Soviet ideology). He even performed neuroanatomical research: working with Flechsig in Leipzig in 1884 and 1885, he described the superior vestibular nucleus (Bekhterev nucleus), the central tegmental tract, and the tegmental nuclei of the reticular formation.[70] Ankylosing spondylitis is also known as Bekhterev disease.[71,72]

Neurosurgery

As professor of neurology and psychiatry at the Saint Petersburg Military Academy of Medicine during the Imperial period, Bekhterev created an operating theatre in his service, employing the Estonian Ludvig Martynovich Puusepp (1875-1942) as his neurosurgeon. Bekhterev understood the need for neurology to evolve into a medical/surgical specialty practised by a single person, as had happened with gynaecology, ophthalmology, and otorhinolaryngology. Moscow became the Russian capital in 1919, after the October Revolution; this coincided with the radical centralisation of neurosurgery at the hands of Nikolay Nilovich Burdenko (1871-1935), a powerful general surgeon with extensive experience treating head injuries during the First World War and the Russo-Japanese War.[1] The vast Central Neurosurgical Institute was opened in 1935; later, when Burdenko joined the Communist Party, it was renamed the Burdenko Institute (Figure 5). An entire hospital dedicated to neurosurgery, it had 275 beds, eight specialised departments, and several operating theatres; around 3000 procedures were performed annually.[73] It also provided services considered subsidiary, such as a neurology clinic run under the direction of the neurologist Vasily Kramer. Harvey Cushing and Clovis Vincent viewed Burdenko's neurosurgery as "a sort of applied neurophysiology."[74]

Neuropsychology

Alexander Romanovich Luria (1902-1977) is undoubtedly the most important figure in neuropsychology not only

Figura 5. The Central Neurosurgical Institute in Moscow; a stamp showing a portrait of Nikolay Nilovich Burdenko (Никола́й Ни́лович Бурде́нко; 1937-1946)

in Russia, but worldwide.[75] A large part of his work was produced at the Burdenko Neurosurgery Institute,[73] reportedly with a pencil and paper in a minuscule room under a staircase. Luria's international recognition was partly due to the publication of some of his works in English[76-78] and the translation of his books to numerous languages, including Spanish.[79,80]

Going beyond the classical theory of cerebral localisation, Luria understood brain function as an adaptive activity involving separate systems; therefore, rather than localisation, he contemplated impairment to be distributed between different parts of the brain, distant from the focal damage; this theory was probably influenced by von Monakow. Complex behaviours were determined not only by feedback circuits, but also by modification of plans and programmes ("feedforward"); this does not preclude the possibility that each area plays a specific role in the organisation of a functional system. In accordance with the received wisdom of the Soviet era, his work followed a social approach, while simultaneously attending to patients' individual personalities. During the Second World War, Luria promoted the creation of a rehabilitation hospital for people injured in the war; treatment was based on the use of his neuropsychological theory and reflexology as therapeutic weapons.[75]

Conclusions

Two periods of Russian neuroscience

The historical transitions of this vast nation brought with them drastic shifts in the development of the neurosciences, with Russia's prolonged isolation from Western Europe playing a decisive role. Under Tsarist rule, Russia was an integral part of European science[1,7]; university professors often had international training, especially those in the major cities of Moscow, Saint Petersburg,[81] and Kazan.[82]

Highly conscious of the language barrier, the intellectual elite produced a good deal of scientific work in German and occasionally in French or English. In 1551, Queen Elizabeth I of England sent a physician named Jacob Robert to treat Ivan the Terrible.[39] Of the numerous foreign visitors to France during the Tsarist period, attracted by Charcot's fame, nearly half were from Eastern

Figure 6. Jean Martin Charcot and his children visiting neurologists in Moscow. Charcot (1) sits in the centre, with his children Jeanne (to Charcot's right) and Jean (5). To Charcot's left sits professor Kozhevnikov (2). The back row includes, from left to right, Muratov (3), Rossolimo (4), Rot (6), and Minor (7)

European countries. Charcot and his family occasionally made courtesy visits to his Russian colleagues (Figure 6).[57]

In October 1917, Lenin called a meeting with the Soviet leaders Trotsky and Stalin, and the Congress of Soviets resolved to seize power by force. The rest of the story is well known: after a signal shot from the cruiser Aurora, anchored on the Neva River, thousands of Red Guards assaulted the Winter Palace.[3] The revolution triggered a civil war, which was followed by drastic change in the organisation of the sciences. After the creation of the Soviet Union in 1922, medical training moved from universities to specialised institutes, under the principle of free, equal access to medicine. Despite there being around 20 000 practising neurologists, professional and scientific standards, lacking official support, have remained poor.[57] In the face of rigid ideological pressure and officially sanctioned control over the sciences, the fields of biology, genetics, and neurophysiology were condemned as "cosmopolitanism" and promoters of these disciplines discredited as "bourgeois semi-scientific idealists."[4] Academic buildings of monumental proportions were constructed; for example, the new Moscow Institute of Neurology (Figure 7), inaugurated in 1945 and directed by Nikolai Graschenkov, a member of the Academy of Sciences of the Soviet Union, or the grandiose Central Neurosurgical Institute run under the inflexible control of Burdenko. In summary, science in Soviet Russia, a country deliberately isolated from the rest of the world, continues to represent a "black hole"; we can expect the neuroscientific achievements to become better known in the future.

"The story of Soviet psychiatry is yet to be told," begins an article on the concept of "mental hygiene for geniuses"[83]; recent years have seen attempts to compensate for this shortcoming.[84,85] During the "social engineering" ordered by the Soviet governments of the 1970s and 1980s, talented individuals were considered to be antisocial by definition. The Siberian gulags received dissidents with such novel diagnoses as "sluggish schizophrenia," with symptoms including "reform delusions," "struggle for the truth," and "perseverance." The "new Soviet man" would be generous, healthy, and eager to spread the socialist revolution. The All-Union Society of Psychiatrists and Neuropathologists was expelled from the World Psychiatric Association in 1983 on charges of "political abuse of psychiatry"; the Soviets were allowed to return conditionally in 1989.[84,85]

Not everything was negative under Soviet rule. One of the things that today's Russian citizens most miss is the Soviet healthcare system. The 1936 Soviet Constitution proclaimed the right to free, universal, quality healthcare.

The government created an extensive network of well-staffed, specialised hospitals offering outpatient care. By 1970, however, there was greater bureaucracy, facilities had deteriorated, medication was becoming scarce, and pay had decreased for a demotivated, poorly performing staff. Effectively, the old system had become ineffective and difficult to sustain. Today, 11% of outpatients and 2% of inpatients are treated at private clinics.[86] Despite moderate improvements, Russia continues to allocate only 3.2% of GDP to healthcare, compared to 7.2% in the European Union.[87]

The influence of Russian neuroscience in the West

The beginning of this article mentions a discrepancy between the familiarity with many Russian neuroscientists' names and the great lack of knowledge of their lives and works. This is demonstrated by the fact that much of the work of Vladimir Betz, including his images of giant pyramidal cells, was not known until recent years.[14]

In the Spanish context, the work of Pavlov and Luria was known during the Franco dictatorship through translations printed by publishing houses in Latin America. Antonio Colodrón (1931-2018), an important 20th-century psychiatrist, recalls "the rejection of anything with a hint of Russia about it; the conspiracy of silence." He discovered an enthusiasm for Pavlov's reflexology when he came into possession of a second-hand copy of the psychiatrist Anatoly Ivanov-Smolensky's *Essays on the patho-physiology of the higher nervous activity*, translated into Argentinian Spanish.[88] This led to a trip to the Free University of Berlin, before the construction of the Wall; upon his return, laden with German books, he was subjected to a thorough police search at Madrid's Estación del Norte. This trip was the origin of his book *Medicina cortico-visceral*, published in 1965 with a foreword by Faustino Cordón.[89] His defence of the biological basis of human behaviour (which led to an association through Bartolomé Llopis with the school of Gonzalo Lafora) set him in opposition to the official positions of the day. During the 1960s, he shared a practice at the Hospital Provincial de Madrid with the neurologist Alberto Rábano (Figure 8), with whom he collaborated closely.

We should also note Luria's influence on the book *Neuropsicología* by Lluís Barraquer-Bordas and Jordi Peña Casanova,[90] in which the authors give a detailed analysis of Luria's classification of the aphasias, approaching the question first from the perspective of localisation, then from that of neuropsychology (impairment associated with focal brain damage), and finally studying the evolutive elements of aphasia with a neurodynamic approach.

Figure 7. The grandiose new Moscow Institute of Neurology

Sixto Obrador Alcalde (1911-1978), an influential Spanish neurosurgeon in the Franco era, had the privilege to travel to Russia to visit the grandiose Burdenko Institute, an essential point of reference for neurosurgical patients.[91] As mentioned earlier, beginning with Bekhterev the case was made for neurology and neurosurgery to be brought together under one roof. In 1968, Obrador published a controversial article in *Archivos de Neurología* on his view of what the relationship between these specialties should be[91-94]: similarly to the situation in the USSR, neurologists would attend potential surgical patients, except in the case of certain neurodegenerative diseases. This may have been taken into account in the megalomaniacal plan for a National Centre for Surgical Specialties (today the Hospital Ramón y Cajal, popularly known as the "Piramidón" or "Great Pyramid"). Fortunately, the initial plan was abandoned due to time constraints.[c]

[c] *El País*, 4 January 1977.

Figure 8. An interesting unpublished photograph (circa 1961) of Alberto Rábano (3) and his disciples. Justiniano Campa (2) was his first student; in 1962 he emigrated to the USA, settling in Charlottesville, where he remains at the time of writing. Antonio Palao Sánchez (4) was without a doubt Rábano's most dedicated student. After working under Gonzalo Moya, and spending time in Valencia under Antonio Trujillano, he moved to Alicante; it was not possible to verify his current situation. Alonso (5) was a healthcare technician involved in electrodiagnosis and physiotherapy. The photograph was taken during a visit by Antonio Colodrón (1), and shows the group of neurologists during consultations.

Political repression of neuroscientists

The 1917 Russian Revolution led to the rupture of key institutions, such as universities, culminating with Stalin's "cultural revolution" between 1928 and 1932. In the name of the revolution, young communists were encouraged to attack lecturers, scientists, and intellectuals, who were accused of being counter-revolutionaries, undermining the regime.[3] This phenomenon was not limited to Soviet Russia, although it was less aggressive during the Tsarist period. The physiologist Ivan Sechenov, a man of great honesty and integrity, was condemned as being materialist, immoral, and anti-religious.[6] Lazar Minor's Jewish heritage prevented him from holding important academic positions, both under the Tsars and after the October Revolution; despite this, he was appointed to the Commission for Preserving the Memory of V.I. Lenin at the age of 70.[57] Ivan Filimonov became a member of the USSR Academy of Medical Sciences, while his former superior Grigory Rossolimo was relegated to private practice.[4]

Pavlov has been described as "the only free citizen in Russia."[95] He was critical of the Tsarist government and its wartime disasters and was hopeful about the Revolution of 1917, although he later distanced himself, opposing the dictatorship of the proletariat. Considered a dissident, his home was repeatedly searched, several of his gold medals were confiscated, and he was ostracised. Lenin eventually gave in to Pavlov's international fame and protected his laboratory, where medications were produced; he also took the opportunity to praise the Soviet authorities' patronage of science. The support from the government was spectacular: a scientific facility nicknamed "Dogtown" was built near Leningrad, housing up to 700 animals in ideal conditions of hygiene.[95]

Some stories were far more dramatic; one example is that of Davidenkov, who was accused of "reactionary Mendelism" for his studies into familial diseases. He witnessed the horror of his son Nikolai (1915-1950) being sent to the Gulag, where he was eventually executed. In the harsh environment of the Burdenko Institute, beset by repression and an atmosphere of fear and suspicion, Soviet neuroscientists worked in isolation, with restricted contact with colleagues abroad.

In the case of Bekhterev, we are struck by the mysterious circumstances surrounding his sudden death, the peculiarities of his autopsy, and the official silence regarding his life. Bekhterev died at the height of Stalin's rise to power in 1927; he had described the latter as "a paranoiac with a dry, small hand" (perhaps due to syringomyelia). The circumstances surrounding his death were bizarre. At a dinner during the First All-Russian Congress of Neurologists and Psychiatrists, two unknown men, later identified as secret-service physicians, approached him and offered him cake. He died in a coma after profuse vomiting, and his body was cremated expediently. Years later, his children were detained, incarcerated, and sent to a Siberian concentration camp, where they died.[23] We cannot escape the irony of the fact that his brain was one of the first to be held at the Pantheon of Brains in Moscow.[11,20,23]

For Lina Stern, a committed communist of Jewish origin, having been awarded the Stalin Prize in 1943 did not protect her from charges of spying for the Americans, maintaining contact with the West, and disrespecting Pavlov. After a tough interrogation followed by a smear campaign, Stern was deported to Siberia, where she was subjected to degrading treatment over a period of five years. She avoided the death penalty, unlike other former members of the Jewish Anti-Fascist Committee.[36,37]

To conclude, Russia has contributed highly significant neuroscientific research, although the country's difficult situation (particularly during the Soviet period) has meant that this work is almost completely unknown internationally. Fortunately, it has been possible to recover some key aspects, mainly through English-language publications by Russian authors over the last decade or more. We can expect to see continued development of the information available in the coming years, particularly on scientific work produced during the forced isolation of the Soviet Union.

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Conflicts of interest

The author has no conflicts of interest to declare.

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