

A critical review of Broca's contribution on aphasia: from priority to Leborgne the hatter

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ABSTRACT

Introduction. Paul Broca's contribution to aphasia as a disorder of the left hemisphere of the brain represents the beginning of the concept of the localisation of specific functions in specific cortical areas. However, his interest in the condition was purely circumstantial, arising from a heated debate at the Société d'Anthropologie de Paris, of which he was founder and secretary. Doubts have been raised regarding priority and the scientific robustness of the observations on which Broca based the proposal of the left second and third frontal gyri as the functional seat of language.

Methods. We consulted original publications by Broca and other Société members involved in aphasia research (1861-1865) at the Spanish National Museum of Anthropology and at the Spanish National Academy of Medicine, which conserves part of the library of Pedro González Velasco, a friend of Broca.

Results. Broca deliberately omitted mention of previous contributions to the localisation of language function in the brain; examples are a communication delivered to the Société in 1861 by Eugène Dally, and another communication delivered by Gustave Dax to the Académie de Médecine in 1863. The localisation of the speech disorders observed in the patients Leborgne and Lelong was proposed arbitrarily following no more than a visual inspection of the brain's surface.

Conclusions. According to the literature, Leborgne and Lelong did not have Broca aphasia; rather, their symptoms were consistent with a variant of global aphasia with verbal stereotypes. The lesions responsible for the disorder in Leborgne, observed by neuroimaging, extend considerably beyond the "Broca area." Finally, there is evidence that other authors had previously signalled the importance of the frontal lobe and the left hemisphere of the brain in speech disorders. Broca may have deliberately omitted mention of these earlier observations.

KEYWORDS

Aphasia, Broca area, history, Leborgne, Paul Broca

Introduction

According to his great-grandson Dr Philippe Monod-Broca (1918-2006),¹ Paul Broca (1824-1880) was one of the giants of French medicine, an equal to Claude Bernard and Louis Pasteur. Francis Schiller,² unbiased by such family interests, described Broca in his 1979 biography (in this author's opinion, the best biography on the French physician) as a man with an

"extraordinary compulsion to grasp, embrace, hold, and deliver diverse knowledge." He was a highly intelligent and surprisingly cultured man, meticulous in his work, at once a physician and a surgeon. His precociousness as a researcher is demonstrated by the fact that during his time as an intern at the Hôtel-Dieu de Paris, aged just 18 years old, he made original anatomical observations of the limbic system and named the nucleus of diagonal band in the antero basal region.³ An experienced

surgeon, Broca's extensive knowledge of cranio-cerebral topography led him to make pioneering contributions to neurosurgery,⁴ including the drainage of an abscess localised through clinical analysis, and an operation performed on a 14-year-old boy displaying focal seizures due to traumatic depression of the skull.^{5,6}

Beyond his great scientific merit, Broca's name has historically been associated with his observations regarding aphasia, which paved the way to the attribution of specific functions to specific areas of the cerebral cortex. He thereby lent support to Franz Joseph Gall's (1758-1828) conception of the brain as a mosaic with 32 localisations,^{7,8} and radically opposed the holistic view of Pierre Flourens (1794-1867), which was based on crude experiments with birds.⁹

Doubts have been raised in recent years as to the priority of Broca's contribution regarding language as a lateralised function located in a circumscribed area of the cerebral cortex. Furthermore, his suggestion that the function is located in the second and third gyri of the left frontal lobe was based only on external visual inspection of the brains of the patients Leborgne and Lelong. The present study aims to shed light on this topic by re-examining original sources.

Methods

The original publications by Broca and other Société members involved in aphasia research (1861-1865) were consulted at the Spanish National Museum of Anthropology, which was founded by a personal friend of Broca, the Spanish physician Pedro González Velasco.¹⁰ The Spanish National Academy of Medicine houses part of González Velasco's library, which was donated to Ángel Pulido, Velasco's student and biographer and the president of the Academy at the time.^{11,12} These publications were critically analysed in the light of current scientific understanding.

Results

The Société d'Anthropologie de Paris: a discussion of Totonac crania

Despite what one might expect, it was not in the bureaucratic, academic environment of a medical school that Broca demonstrated the connection between loss of speech and circumscribed brain lesions; rather, it was at the Société d'Anthropologie de Paris, an institution founded by Broca himself in 1859 (Figure 1), which was barely tolerated by the authoritarian government of Napoleon III. The society initially had 19 members, all freethinkers, republicans, and radically left-wing; the

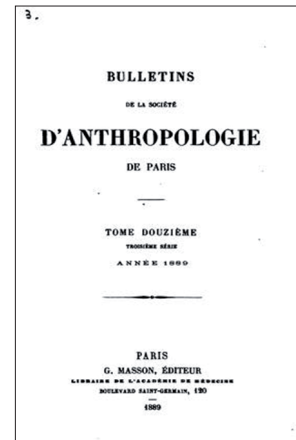


Figure 1. Paul Broca, founder and secretary of the world's first anthropological society, and the society's *Bulletin*, in which the majority of the cited communications were published.

group included the Spanish physician Pedro González Velasco as a corresponding member. It took 5 years for the organisation to achieve official recognition.¹³ It aimed to establish a "naturalistic description of the human species," a non-creationist view of the origin of humankind, which doubtless would have been unpopular with the establishment of the day. The Société's immediate interest in 1861 was the study of the cranium, with a view to determining what evolutionary changes had taken place in humans and what features were of assistance in distinguishing between different races.^{14,15}

The circumstances leading to the controversy around the seat of language could not have been more tangential. Louis-Pierre Gratiolet (1815-1865), a close friend of Broca's from the same town of Sainte-Foy-le-Grande,¹⁶ was at the time the director of the Society's small museum, and a renowned authority on comparative anatomy. At the session of 20 December 1860, during a debate on the significance of brachycephaly in different races, Gratiolet¹⁷ presented the cranium of a 19-year-old man of the Totonac people of the Gulf of Mexico. He later produced a mould of the cranial cavity to deduce the volume of the brain, presenting his findings at the session of 21 February 1861. Besides confirming the subject's marked brachycephaly, Gratiolet also noted the protrusion of the parietal lobe and the low, narrow forehead, "which results in very limited development of the anterior part of the frontal lobes"; this supposedly distinguished the Totonac from white people. "I believe I have demonstrated the clear inferiority of the Totonac

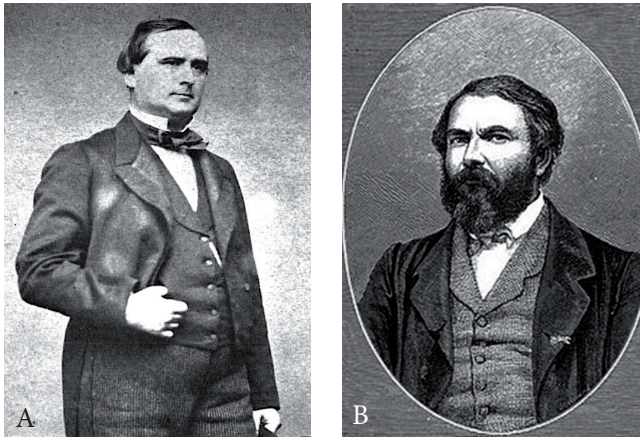


Figure 2. A) The elegant, influential figure of Ernest Aubertin. B) Pierre Gratiolet, an expert in compared anatomy



Figure 3. A) Franz Gall, the originator of the theory of phrenology, palpating a reproduction of a head. B) Bouillaud, Aubertin's father-in-law and a follower of Gall. In 1825, Aubertin suggested that lesions to the frontal lobes may be related with speech disorders.

brain, compared to the white brain," Gratiolet claimed. With time, these remarks would be denounced as racist; similar criticism has been made of Broca himself.⁴

The conclusion of Gratiolet's communication led to a heated debate on the relationship between brain and language: "If intelligence is *one entity*," he argued, "then this must equally be true of the brain. Therefore language, which is inherently and inseparably a characteristic of intelligence, must be *a diffuse function of the brain* [emphasis added]." This deduction was consistent with Gratiolet's holistic conception of the brain.

The dispute between Gratiolet and Aubertin

Simon Alexandre Ernest Aubertin (1825-1893) was the son-in-law of the influential Jean-Baptiste Bouillaud (1796-1881), who at the time was president of the French National Academy of Medicine and dean of the Faculty of Medicine. Aubertin opposed Gratiolet's position, arguing in favour of a "language-coordinating centre in the brain, connected by specific pathways to peripheral organs responsible for pronunciation" (Figure 2).¹⁸ Gratiolet appeared to be unaware of the important contributions made by Bouillaud, who had proposed a hypothesis in 1925 according to which "all frontal lobe lesions cause speech disorders, provided that the damage is bilateral" (Figure 3). However, this is not always true: case VI, a Bicêtre patient studied by Delauney, was diagnosed on 2 May 1823 with "chronic softening of the encephalon." Post mortem examination revealed that "the anterior region of the *left hemisphere* was indurated and yellowish in colour [emphasis added]"; this clinicopathological observation was clearly made prior to any of Broca's.¹⁹

Bouillaud's observations were supposedly based on the clinicopathological details of 63 cases published shortly earlier by Claude-Françoise Lallemand (1820-1823).²⁰ A recent review of this series demonstrates that the lesions were truly bilateral in only seven cases. This raises "doubts about Bouillaud's sincerity [...]" an early case of scientific fraud," according to a recent article.²¹

Bouillaud was not the only pioneer. Aubertin recalled similar observations, such as one made in 1847 by Macquet, who was serving under Blandin at the Hôtel-Dieu. "Broca, who was at the time an intern in the same department, must remember this," he said.

A woman of 55 years of age had fallen down a staircase, causing a left orbital haematoma, extending towards the temporal region. She presented no neurological symptoms at admission; however, 11 days after the accident, she complained of headache and displayed slowed responses. Days later, she could respond only 'yes' or 'no,' eventually losing the ability to speak, although she was able to communicate by means of certain signs and gestures. This demonstrates that her intelligence was preserved. The loss of speech was the only functional disorder, as motor function and sensitivity were intact.

The patient died 21 days after admission. "A horizontal cut across both anterior lobes revealed *an abscess in the left lobe of the volume of a pigeon's egg*, and another the size of a hazelnut in the right lobe. We believe this observation to be conclusive [emphasis added]."

An even more demonstrative observation was made by Dr Cullier at Hospital Saint-Louis, in a man who had attempted suicide with a pistol shot, blowing

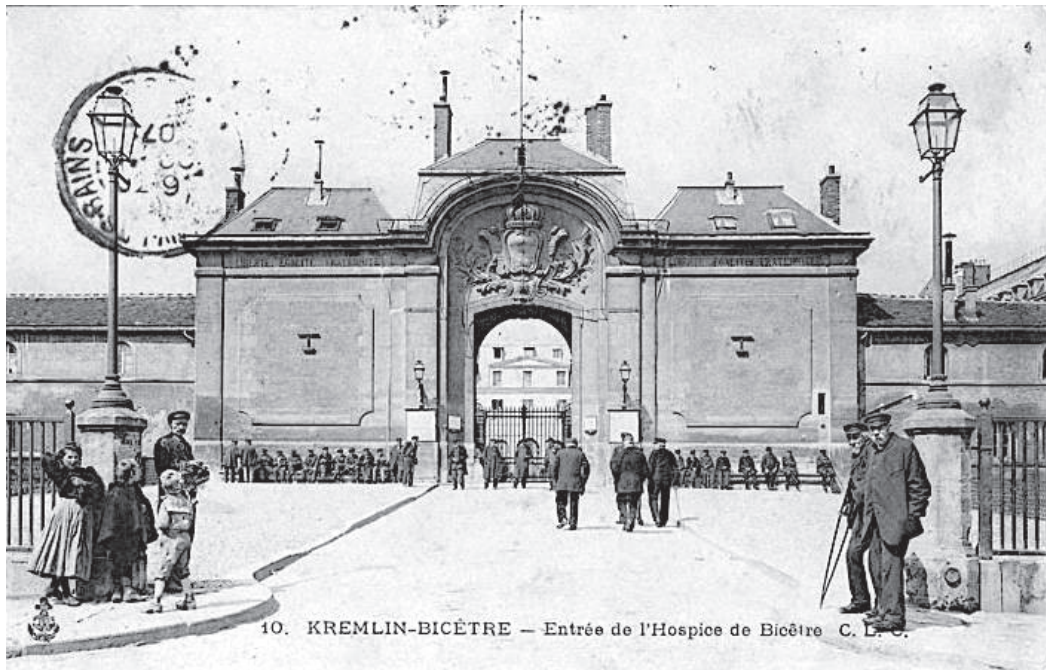


Figure 4. A postcard depicting the Bicêtre hospital (circa 1900)

away the entire frontal bone. During the examination, a spatula was used to apply pressure to the “anterior lobes”; gentle compression of the cortex immediately suspended the ability to speak, with language returning as soon as compression ceased. Although the text does not mention whether the left or right frontal lobe was compressed, Aubertin does mention that “the right lobe, which remains intact, may partially compensate for left lobe dysfunction.”²² This authentic *in vivo* experiment constitutes an interesting pre-Broca observation on the involvement of the left hemisphere in language production. Two years after that turbulent meeting, Aubertin would once more defend his father-in-law's viewpoint, this time describing observations of his own, such as his autopsy of a man who almost entirely lost the ability to speak following a stroke. The intracerebral haemorrhage occupied “no less than the entirety of both anterior lobes,” he concluded.²³ Broca took this opportunity to have the final word in this interminable dispute, with Leborgne's brain in his hand.

The case of Leborgne the hatter

Leborgne was known as “Monsieur Tan-Tan” among the residents of the Bicêtre hospital (Figure 4), and was

introduced as such by Broca at the historic 21 February 1861 session of the Société d'Anthropologie. He was a hatter, or more precisely a designer of patterns for the manufacture of hats and shoes. Certain details about the patient's life have come to light with the discovery of his death certificate in the archive of the commune of Gentilly. Louis Victor Leborgne (1809-1861) was born in Moret-sur-Loing, Île-de-France. His mother died while giving birth to her sixth child when Louis was 11 years old. The family moved to Paris when he was 11; Leborgne's father was a teacher, so he and his siblings probably would have received a good education. He suffered epilepsy when he was young, which did not prevent him from living a normal life. He never married. His father died in December 1840, shortly after Louis was admitted to Bicêtre.^{24,25}

On 12 April, Leborgne was transferred from the hospital's medical wards to Broca's surgical department. The patient was a 51-year-old man complaining of a gangrenous phlegmon on the right lower limb. Broca invited Aubertin to examine Tan-Tan's unusual speech disorder. The assessment of the patient bore little similarity to a modern neurological examination of a patient with suspected aphasia. The physicians concluded that verbal

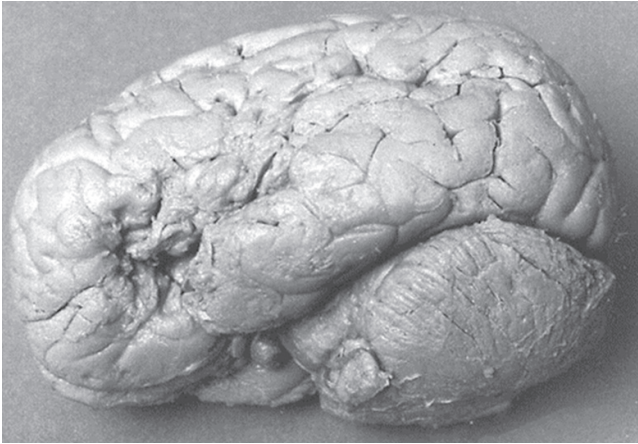


Figure 5. Leborgne's brain, as deposited by Broca at the Dupuytren museum in Paris

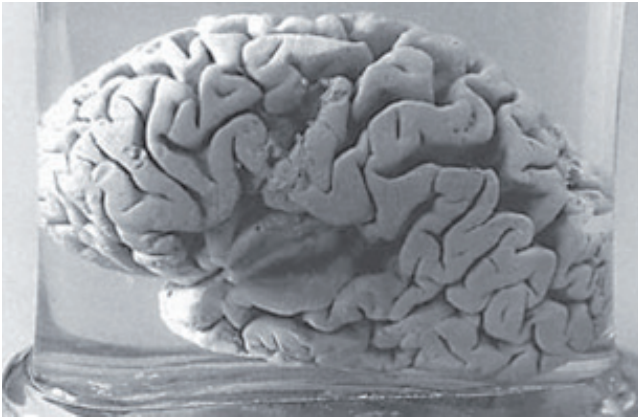


Figure 6. Lelong's brain, stored in a glass jar, at the Dupuytren museum. Besides the involvement of the third frontal gyrus, we can observe diffuse widening of the cortical sulci; this is consistent with dementia, the reason for his admission to Bicêtre.

comprehension was preserved, as he could use his left hand to signal that he had been in the hospital for 21 years; however, he also nodded his head when asked if he had children, when the contrary was known to be true. Leborgne was a familiar face at Bicêtre, having been admitted in 1840 after losing the ability to speak at the age of 30. "He may have crossed paths with Broca in the grounds of Bicêtre [a hospital for chronic patients on the outskirts of Paris^{6,26,27}] in 1845, when Broca was an intern under Leuret and had the chance to perform a detailed neurological examination," writes Monod-Broca.⁴ After losing the ability to speak, Leborgne gradually developed right-sided hemiplegia over the course of ten years.

Records held at the archives of Assistance Publique–Hôpitaux de Paris highlight certain errors in Broca's communication. Leborgne was admitted to Hôtel-Dieu on 21 February 1833 for unidentified causes, with speculation about epilepsy, meningitis, or even heavy metal poisoning due to exposure in his past employment at a foundry. In any case, Leborgne could not return to work, and his father was unable to meet the hospital expenses. Thanks to the influence of the prefect of the Parisian police, he was admitted to Bicêtre on 10 December 1834 (not 1840, as Broca had reported to the Société). A temporary transfer to the psychiatric ward on 13 November 1852 has recently come to light; this was at the patient's request, although the reason is unclear. The patient had become selfish and demanding and was held in low esteem by his roommates, who accused him of stealing. Leborgne used a wheelchair for the last seven years of his life.^{24,25}

He died on 17 April 1861, aged 51, just five days after being transferred to Broca's department. The following day, Broca attended a meeting of the Société d'Anthropologie holding the unsectioned, unfixed brain of Leborgne in his hand, and shared his opinion regarding the burning issue of language and the brain (Figure 5).²⁸ This would be the first of five communications between 1861 and 1865, in which Broca would develop his view of aphemia (his preferred term).²⁸ Upon removal of the meninges, the anatomist noted a cyst the size of a hen's egg (25 x 18 mm) occupying the left Sylvian fissure. Far from a circumscribed lesion, the brain damage was extensive:

A considerable part of the left hemisphere is destroyed [...], as well as the temporo-sphenoidal lobe [the term proposed by Gratiolet] [...], the insula, the area underlying the corpus striatum, [...] and the second and third frontal gyri.

The Sylvian cyst, which Broca himself examined during the autopsy, displayed anfractuous walls. The arterioles had become detached when the pia and arachnoid mater were separated in the 1861 examination; Broca opted not to test the permeability of the middle cerebral artery.²⁹ Broca's description was later confirmed by other authors, also basing their observations on visual inspection of the brain.^{5,30,31}

The brain of Leborgne was submerged in alcohol (the only preservative available at the time) and was stored at the former Couvent des Cordeliers, with orders from Paul Broca that it was not to be sectioned or examined microscopically. The old convent had received a 20 000 franc donation from the renowned surgeon Guillaume Dupuytren (1777-1832) to build an anatomical pathology museum for the display of the countless pieces he had

collected over his career. The museum's walls collapsed in 1940, and Leborgne's brain was lost until 1962, when it was found in the basements of the École de Médecine.⁵ The brain, labelled with exhibit no. 56, is today displayed at the Musée Dupuytren, near the medical school.

In October of the same year, a stroke of luck brought Broca a second case: an 84-year-old man named Lelong, who had been at Bicêtre for eight years, displaying evident dementia. The patient suffered a fractured femur and died 12 days later. The patient had had a stroke one year prior, with right hemiplegia and aphasia (Figure 6). He could utter only five words: "yes," "no," "three," "always," and "lelo" (the last word being a mispronunciation of his own name). Broca was stunned, experiencing a near-stupefying astonishment ("éprouvé un étonnement voisin de la stupéfaction") when he saw the patient's brain. The specimen displayed surprising details in addition to the diffuse atrophy of the cerebral cortex: the affected area was located in the left hemisphere and limited to the posterior part of the third frontal gyrus, potentially also extending to the underlying white matter.³² This largely confirmed the findings from Leborgne's brain, hence Broca's enthusiasm. After being presented to the Anatomical Society, the unsectioned brain was sent to the Dupuytren museum (exhibit no. 60, Houel catalogue), where it remains today.³³

Discussion

Broca's historical role as the original proponent of the theory that such functions as verbal expression are localised in the cerebral cortex invites three main questions. Regarding priority, was Broca truly the first person to establish this theory? Regarding the theory's underlying observations, did Leborgne and Lelong really have Broca aphasia, a conventionally accepted subgroup of language disorders? And finally, should we accept that the cortical region proposed by Broca, comprising the left second and third frontal gyri, was responsible for his patients' language disorders?

Pre-Broca observations of aphasia due to circumscribed lesions

Above, we addressed Aubertin's severe response to Gratiolet, reminding him of Bouillaud's observations regarding loss of speech following lesions to both frontal lobes. He also mentioned cases of his own, including the significant example of the Cullier suicide.²²

There were also other examples, however. For example, the first discussion of loss of articulate speech at the Société d'Anthropologie has gone unnoticed in the literature. The debate also took place in 1861, shortly

before the bitter dispute between Aubertin and Gratiolet. Eugène Dally presented the case of the watchmaker Bouchard (*Correspondance, Bulletin de la Société d'Anthropologie de Paris*. 1861) the same year that Broca described the case of Monsieur Tan-Tan. It would therefore be highly unlikely that Broca, the secretary of the Société, would have been unaware of that case; however, it is not mentioned in his writings.

Dr Marc Dax (1770-1837) spent his professional life almost exclusively working in an old people's asylum in Sommières, a small village between Nîmes and Montpellier. He would never forget an experience in the Napoleonic Wars in which he treated a cavalry officer with a sabre wound to the left parietal region. It seemed to Dax that the officer had lost his "memory for words." Trauma-induced aphasia was not a novel concept: in 1814, Baron Dominique Jean Larrey extracted a bullet lodged above the orbit of a soldier who "was speaking like a child."³⁴

Dax returned to the asylum after the war, and observed numerous patients with aphasia and right hemiplegia. Nobody had previously made this observation.^{35,36} Dax had not the slightest experience of presenting scientific communications, and was already 67 years old; however, the cases he had gathered had convinced him of the key role of the left hemisphere in language. He took the opportunity to attend the 1936 Congrès Méridional, held in nearby Montpellier, and presented a communication entitled "Lesions of the left half of the brain coinciding with the forgetting of the signs of thought." He could not have chosen a less provocative title nor a less appropriate forum: the main subject of the congress was the development of industry and the fine arts in the south of France. Incomprehensibly, the manuscript that Dax handed to the organisers after his address never went to print. Marc Dax died the following year, and the communication was forgotten.

His son Gustave Dax (1815-1893) later became a busy general practitioner in Sommières, the same village where his father had worked. He cannot have had many free moments, as almost three decades would pass before he revised his father's unpublished manuscript, adding further observations on his own patients, bringing the total to over 40 cases. Encouraged by news from Paris of Broca's research, he hurried to finish the manuscript and send it to none other than the exclusive Académie de Médecine on 23 March 1863.³⁷

The man responsible for deciding whether to publish was the Academy's president, Louis Francisque Lélut. The manuscript was not excessively long (at just four pages), although it is possible that it was poorly organised or

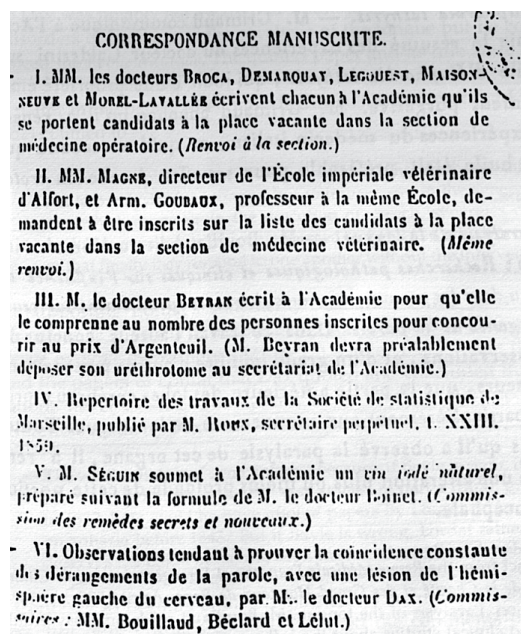


Figure 7. Programme of the bulletin of the Imperial Academy of Medicine (24 March 1863 session), listing Broca (I) as an applicant for a surgical position. On the same page appears the name of Marc Dax (VI) and the title of his communication “Observations tending to prove the constant coincidence of disturbances of speech with a lesion of the left hemisphere of the brain.”

that some of the purely clinical observations made were taken from the literature. While this may have been the case; a role may also have been played by what we may euphemistically refer to as the “sociology of knowledge”: physicians from an obscure, provincial town, novices who moreover were trained at the medical school of Montpellier (a rival of the Paris school), who were so bold as to present their ideas for publication by the Academy of Medicine, no less.^{38,39} This is certainly a possibility. However, other explanations have been considered, including the influence of Broca himself.

The decision to reject the article took two and a half years, and the editor’s response could not have been harsher. Lélut imagined that the Daxes were followers of “the pseudoscience of phrenology,” arguing that should their hypothesis be correct, the same principle would have to be applied to all pairs of organs, with the left eye or kidney fulfilling a different function to its counterpart. The reply ended with the stinging phrase: “[...] I hope that Dr Dax might forgive me, but the decision has been made and I have neither the time nor the will to discuss it further.”

Gustave Dax eventually saw his work in print in the 28 April 1865 edition of the *Gazette Hebdomadaire de Médecine et de Chirurgie*. Just six weeks later (on 15 June 1865), Broca published an important follow-up paper to his numerous articles on the subject in the *Bulletin de la Société d’Anthropologie* (Figure 7).⁴⁰ What could have motivated Lélut to delay his rejection of the Daxes’ paper for 36 months? Was Broca secretly given certain information about Dax’s ideas and intent to publish, prompting him to rush to publish his own theories?

Broca was sensitive to the accusations that in all likelihood would have reached him, accusations of what looked a great deal like scientific misconduct. “I do not wish to let you believe any longer that I have sinned through ignorance or by voluntary omission,” he wrote in his 1865 article. He even made inquiries of his own, asking a Mr Gordon, librarian at the faculty in Montpellier, whether he remembered Marc Dax’s oral presentation. Neither Gordon nor 20 physicians who were present at the Congrès Méridional recalled the disputed communication. However, this was not entirely true. Charles Jacques Bouchard (1837-1915), an unruly student of Charcot, remarked during a presentation to the Société de Biologie on 1 August 1864 that “the audience are already aware of Dax’s theory on the localisation of language in the left hemisphere.”³⁵ The message, delivered at a conference with little relation to medicine and to an inappropriate audience, was lost.

An unexpected endorsement was given by the well-known local physician Raymond Caizergues in a letter to the *Montpellier Médical* (February 1866 issue) entitled “Note at the service of the history of medicine.” He assured that Marc Dax had in fact distributed copies of the manuscript among attendees of the conference, and that he had found one of these among the papers of his late grandfather, who had died in 1850. Regardless, later efforts to find the manuscript have yielded no results. “Broca was less than truthful in denying that he was aware of Dax’s paper,” write Cubelli and Montagna, in a rather emphatic accusation.³⁸ These researchers reveal how the same page of the same journal (the 24 March 1863 issue of the *Bulletin* of the Imperial Academy of Medicine) includes announcements both of Broca’s application for a surgical position and the reception of Gustave Dax’s manuscript, with the expressive title “Observations tendant à prouver la coïncidence constante des dérangements de la parole, avec une lésion de l’hémisphère gauche du cerveau, par M. le docteur DAX” (“Observations tending to prove the constant coincidence of disturbances of speech with a lesion of the left hemisphere of the brain, by Dr Dax”).

In the town marketplace in Sommières, today named La Place des Docteurs Dax, stands the house where Marc Dax was born, which now features a commemorative plaque from the World Federation of Neurology; the inauguration ceremony was attended by MacDonald Critchley and F. Lhermitte.³⁶

Monsieur Tan-Tan's language disorder

Broca aphasia (the prototype of expressive or motor aphasia) is characterised by reduced verbal fluency (output), difficulty producing words, phonemic paraphasia (e.g. "telentone" for "telephone"), agrammatism, and minimally affected or unaffected verbal comprehension. It is almost always caused by superficial embolic infarctions of the ascending branch of the middle cerebral artery, and usually improves rapidly. Another typical feature, agrammatism, is a form of economising language, with sentences limited to the essential words⁴¹: predominantly nouns, with very few articles, prepositions, or auxiliary verbs.⁴²

The condition bears no relation to the disorder reported in Leborgne and Lelong, who were reduced to the use of repetitive utterances with relative preservation of prosody and verbal comprehension.⁴³ This is an atypical, severe form of global aphasia, which presents no distinctive neuroimaging findings.^{44,45} This type of verbal stereotypes has been observed in other famous aphasic patients, including Lenin ("vot-vot") and Baudelaire ("cré-nom").⁴⁶ The theory of apraxia of speech as an explanation for Leborgne's speech disorder is not widely accepted.^{47,48}

The term "aphemia," proposed in Broca's second communication, was not widely adopted mainly due to the similarity to the Greek word for "infamy." Years later, the term "aphasia" ("absence of speech") was proposed by Armand Trousseau, on advice of a Greek philologist named Chrysaphis.⁴⁹ The term "aphemia" has been used in recent years to refer to apraxias of speech due to lesions limited to the pars opercularis in the lower motor cortex.⁵⁰ Broca appears to have been satisfied with Trousseau's term, and uses it in later manuscripts.

Clinico-pathological correlation: the Broca area

When Broca appeared before the Société d'Anthropologie with Tan-Tan's brain in his hand, he pointed out only the considerable lesion visible on the surface of the left hemisphere. This was sufficient, however, and the brain was stored for posterity, unsectioned, in a glass jar. Broca dedicated no fewer than four communications to the brains of Leborgne and Lelong in 1861, plus an additional one in 1865.

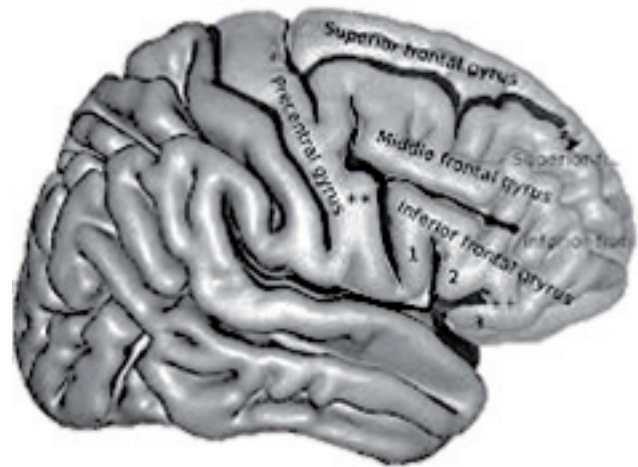


Figure 8. Semischematic representation of the division of the third frontal gyrus (F3): the pars opercularis (1), bordering the lower part of the primary motor area (F4), and the pars triangularis (2), known as the "Broca area"

He continued to be preoccupied by the seat of the "organ of language" in the cerebral cortex. After taking measurements of 11 brains from patients admitted to Bicêtre, Broca arbitrarily decided that language was located in "a quadrilateral measuring 3 to 4 cm high, bordered by the anterior branch of the Sylvian fissure, and measuring 25 to 35 mm in the anteroposterior direction." He modified his conclusions in subsequent communications, attributing Leborgne's and Lelong's speech difficulties to the damage to the second and third frontal gyri.

Almost 150 years would pass before neuroimaging techniques could demonstrate the true dimensions of the lesions in these famous patients. Computed tomography^{51,52} and magnetic resonance imaging studies⁵³ have demonstrated that the lesions affect not only the surface, but also deeper white matter regions of the brain. Effectively, Leborgne's lesion did not only affect the frontal lobe, but rather extended to parts of the parietal and temporal lobes, disconnecting several white matter tracts, with the superior longitudinal fasciculus and the long segment of the arcuate fasciculus being the most significant examples. Lelong's brain is that of a person of advanced age with dementia and a fatal cerebral infarction. The atrophy of the perisylvian cortex is so pronounced that the insular cortex is clearly visible. The cortical tissue damage is limited to the angular gyrus, involving only the most posterior region of the opercular gyrus. Therefore, it was neither the case that

the presented patients had Broca aphasia, nor that the damage was limited to the Broca area.

There is no consensus on the specific borders of the Broca area (Figure 8). Some authors limit it to the posterior one-third of the third frontal gyrus (F3), comprising the pars opercularis (anterior) and the pars triangularis (posterior).^{54,55} Patients with lesions to this area display mutism with a tendency to improvement; speech is affected by stammer due to orolingual and respiratory dyspraxia.^{56,57} Lesions extending to the lower part of the precentral gyrus (F4) are associated with faciobrachial paresis and dysarthria.^{58,59} The Broca area is currently understood to be responsible for other functions in addition to language production^{60,61} and the perception of language-related sounds.⁶²

The rarity of lesions limited to the Broca area led to one of the most heated disputes between neurologists: the controversy between Marie and Dejerine. In 1906, Pierre Marie published a provocative article in *La Semaine Médicale* contesting the dogma of the left third frontal gyrus.³⁰ It is most likely that the selection process for the position of chair at la Salpêtrière, for which Jules Dejerine was also a candidate, played some role. This was not without precedent: Marie and his student Georges Guillain had previously rejected Dejerine's detailed description of the somatotopic organisation of the internal capsule. In fact, Pierre Marie's argument against the dogma of the Broca area was based on a large quantity of autopsy material from aphasic patients with no lesions restricted to that area; instead, these patients' brains displayed cortico-subcortical infarcts due to complete or near-complete occlusion of the middle cerebral artery. The famous "quadrilateral" could not be confirmed until Leborgne's brain was studied by high-definition magnetic resonance imaging.⁵³ Pierre Marie, ever the iconoclast, was right again. He was marginalised for his ideas, and only won his desired position of chair of clinical neurology late in his career.

Conclusions

The great anthropologist Broca was a man of many talents, but did not apply the rigour that characterised his study of the cranium to the problem of the seat of language in the brain. Determining priority has always been problematic in medicine. It is understandable that Broca may have been unaware of the contribution made 36 years earlier by Bouillaud, but there is no doubt that he deliberately omitted mention of the work of Eugène Dally and Marc and Gustave Dax on the role of the left hemisphere in language. It is incomprehensible that Broca should have been satisfied merely with studying

the external appearance of Leborgne's and Lelong's brains, despite writing as many as four articles on the subject in a single year. Given that the extension of the lesions was apparent at a glance, attributing the second and third frontal gyri a significant role in language appears to have been mere speculation. Broca was able to take advantage of the brains being in his possession when he intervened in the dispute between Gratiolet and Aubertin at the Société, thus ensuring his name went down in history.

Conflicts of interest

The author has no conflicts of interest to declare.

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