

Filippo Lussana (1820–1897): from medical practitioner to neuroscience

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Abstract Filippo Lussana's scientific activities are neglected in neurological field. His activity could be divided into two phases: as a medical practitioner and the academic period, as a clinical neurophysiologist. The focus of his various research studies was the central nervous system, including balance disorders (the role of the cerebellum and semicircular canals), taste innervation, pain and speech disorders (theories of brain localisation). Lussana's clinical method and direct dealings with patients laid the groundwork for his subsequent academic activities as a neurophysiologist, in Parma and later in Padua. Influenced by phrenological theories, he also conducted interesting studies on synaesthesia for which he determined a brain site. He contributed to the neurophysiology of taste, emphasising the role of the facial nerve. With his study on muscle sense, he also joined the debate on the role of the cerebellum in balance, setting the foundation for later studies on this organ by Luigi Luciani.

Keywords History of neurology · The left frontal lobe · Speech · Taste · Cerebellum · Synaesthesia

Brief academy biography

Filippo Lussana (Fig. 1) was born on 17 September 1820, in Cenate San Leone (later renamed Cenate Sopra), close to Bergamo. He attended grammar school in Clusone and then Bergamo, where he developed a passion for the Humanities [1]. In 1839 he enrolled at the Faculty of Medicine of Pavia University. His attendance at the Institute of Human Anatomy directed by Professor Bartolomeo Panizza (1785–1867) was instrumental in his future clinical and research activities. The Institute had a long tradition in the field of neuroanatomy and its Director had published works on the optic pathways and brain areas involved in vision [2]. Panizza took an interest in his pupil's development to scientific maturity and with him forged a mutual, affectionate friendship, which Lussana demonstrated on various occasions through dedications and acknowledgements in his scientific publications. In April 1844, Lussana graduated after the discussion of seven scientific medical–chirurgical thesis (theses defendendae) and with a final dissertation on his poem by the title of “Gli amori della Fucagrostide Maggiore” (The Romance of the Major Fucagrostide), dedicated to the water-plant *Phucagrostis Major*. After graduating, Lussana began his medical and scientific career as a medical practitioner in the northern Italian valleys of Bergamo. His direct contact with his patients and daily medical practice became the cornerstones for the treatises he wrote during his university career. Lussana's publications were the result of close observation of phenomena presented by the sick during their lifetime and the lesions subsequently encountered on the anatomy table with postmortem examination for an anatomico-clinical evaluation. The anatomico-clinical method introduced by Giovanni Battista Morgagni (1682–1771) was becoming more widespread in clinical practice and its

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most esteemed representative was Jean-Martin Charcot (1825–1893) [3]. Lussana, in his daily general practice, managed to develop a keen interest in taste, the relationship between sensations and movement; he was able to develop concepts on the functions of gustation, speech, the cerebellum and the origin of vertigo. When he was awarded the chair of Physiology at Parma University in 1860, he had been practicing general medicine for almost 15 years. During this period, however, despite his many professional commitments, he had managed to pursue his studies, embodied in the publication of some 40 scientific works, the majority of which were neurological observations and post-mortem studies. In 1867, Filippo Lussana was appointed the chair of Physiology at Padua University.

At these institutes he conducted various studies on taste [4, 5], the role of the cerebellum [6, 7] and made a contribution to the study of nervous centres [8, 9]. He wrote treatises on physiology for university students [10], and promoted its medical–scientific dissemination [11]. He produced about 130 papers during his academic career.

In 1889, Lussana was forced to abandon teaching due to ill health. The following year he was appointed professor emeritus and retired in 1891. Filippo Lussana died in Cenate Sotto on 25 December 1897 [1].

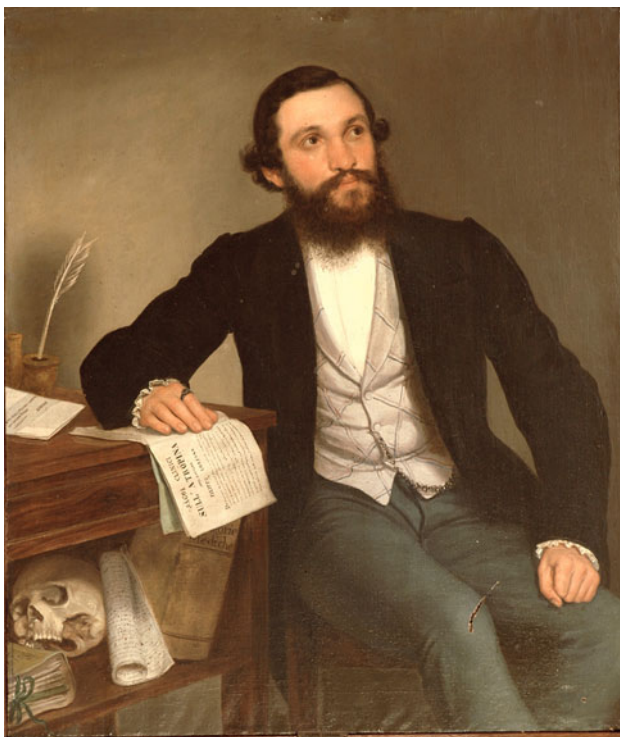


Fig. 1 Filippo Lussana's portrait (1857?), by Albino Angelo Ceroni (1816–1887?). Image courtesy of the Liceo Scientifico “Filippo Lussana”, Bergamo, Italy

Facial nerves in the taste researches

In 1848, he published his first neurological paper on trigeminal neuralgia and morbid phenomena of the senses of smell, taste and hearing enabling him to make anatomical and physiological observations on this nerve. He discovered that in such cases taste was suppressed in the anterior tongue, but conserved in the posterior part. He also observed deafness and suppression of the sense of smell [12]. During his academic career he went on to complete his studies on taste, emphasising the role of the facial nerve compared with trigeminal nerve.

The neurological subjects covered in these works included studies on the taste nerves, and the role of the brainstem in digestive processes. In 1862, five publications dealt with the taste nerves. The most important of these was written in 1862 [13]. Through various experiments, Lussana was able to demonstrate that the chorda tympani nerve was the taste nerve in the anterior tongue. He confirmed the hypotheses advanced by the Turinese physician, Carlo Francesco Bellingeri (1789–1848) [14]. To demonstrate that the chorda tympani branching from the facial nerve was the taste nerve for the anterior tongue, he performed various experiments in dogs. He found that taste was not suppressed on severing the glossopharyngeal nerves, but was so on severing both ends of the chorda tympani. Severing the lingual nerve, before anastomosis with the chorda, did not modify taste. In humans, pathologies causing total destruction of the trigeminal nerve and the severing of the lingual nerve after anastomosis with the chorda, did not alter taste in the anterior part of the tongue. In addition, Lussana demonstrated experimentally and physiopathologically that the ability to perceive the quality of tastes was not uniformly distributed throughout the tongue surface. He indicated that bitterness was localised in the back of the tongue, sweetness at the tip, acidity and saltedness at the sides [15]. He also conducted studies on innervation and the digestive system, addressing the relationship between vagus nerves and gastric secretion. These studies enabled him to resume one of his favourite subjects, namely research into feeding, which he continued during his period at Padua (Fig. 2). He asserted that bilaterally severing the cervical portion of the vagus nerves led to suppression of gastric acid but not pepsin secretion, which was linked to sympathetic innervation. Pepsin secretion was instead suppressed by severing the pneumogastric nerve at subdiaphragmatic level [16].

Early description of the localisation on the speech

In 1850, he submitted a case report to the “Gazzetta Medica Italiana. Lombardia”, a medical journal addressed

Fig. 2 In 1870, on “Gazzetta Medica Italiana. Provincie Venete”, description of the innervation of the taste by Filippo Lussana



to non-specialists, on a patient he had seen the previous year, presenting with a trauma of the anterior medial section of the left parietal bone with a bone fracture and penetration, causing paralysis of the right limbs and aphasia. Using his surgical skills, Lussana extracted the bone fragments involving the brain matter, and the patient progressively re-acquired his speech. He localised the function of articulated speech in the brain, advocating that his patient had been unable to speak as a consequence of damage to one of its various structures (the left frontal gyrus) and had re-acquired this ability on removal of the bone fragments (Fig. 3) [17]. This theory was confirmed in other clinical cases, described in subsequent publications,

where Lussana demonstrated that a superficial lesion of the frontal gyri was characterised by the lack of “word concepts” and involvement of more posterior brain parts, i.e. the foot of the third frontal gyrus, by the “absence of the concept of words”. One patient with tertiary syphilis with dementia, involving the frontal lobe, presented impairment of intellectual faculties and articulated speech. Lussana went on to describe 16 clinical cases, with a confirmation by autopsy reports documenting the cerebral lesions. He attributed the ability to govern the functions of articulated speech and spontaneous coordination of all body movements to the anterior brain lobes. He described in particular, various patients with speech disorders with

involvement of the left anterior frontal region characterised by “total suppression of articulated speech” and lacked the “concept of words” [18]. These observations were made some 10 years ahead of the studies on aphasia by the French anthropologist and neurologist, Paul Broca (1824–1880) [19], published in 1861. Before Lussana, hemispheric dominance were reported by Jean-Baptiste Bouillaud (1796–1881) in 1825 and Gabriel Andral (1797–1846) in 1840 but they did not emphasise the role of the left hemisphere in the speech [20].

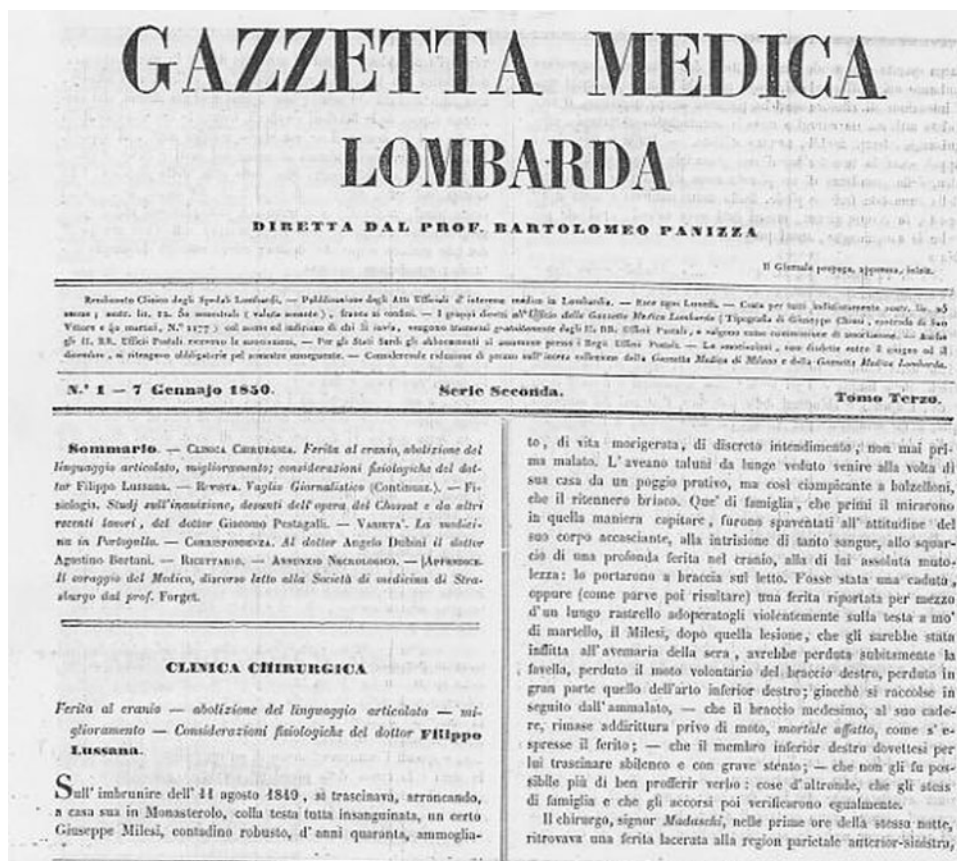
In 1851, Lussana published a collection of numerous clinical cases, with post-mortem reports, describing a series of functions governed by the anterior lobes: thought, voluntary movement control; by the parietal, temporal and occipital lobes: sight, hearing, taste, touch; by the medulla oblongata: respiration, circulation, deglutition. In this essay he remained loyal—and influenced by phrenological theories—to the principles of brain localisation and intuitively attributed different functions to different regions of the brain. Over the years, however, he developed an organic system of interpreting brain functions according to which: cortical centres were not really direct organs of movement, rather they were ideo-motor centres, i.e. they had an almost indirect mental action on the centres of movement. According to Lussana, the voluntary movements

determined in the cortex could be the effect of a sensation perceived at the time or restored in the inner memory circuit of the brain [21]. He further investigated his various theories on brain localisation focusing in particular on speech disorder, with special emphasis on the contribution by the French school. He endeavoured to more clearly define the role of articulated speech and motor activity, stressing that the various centres were not isolated entities, but the each function was part of an integrated whole [22]. Lussana’s studies on speech localisation were not considered by other neuroscientists, and Lussana himself did not remark his observations; maybe he emphasised Gall’s theory of specific cortical regions correlated with specific behaviour or special psychic function.

Muscle sense and cerebellum

In 1856, Lussana published a paper, which made an important contribution in defining the cerebellum as the structure that controls movement [23]. The physician wrote the first observations on the function of cerebellar “muscle sense”. Marie-Jean-Pierre Flourens (1794–1867) had already demonstrated that this organ coordinated movement [24]. Based on his observations, Lussana became

Fig. 3 In 1850, on “Gazzetta Medica Lombardia” the first description of a case of articulate speech disorder after a trauma by Filippo Lussana



convinced that destruction of the cerebellum led to suppression of a physiological nervous element governing the execution of muscle movements. The element was a sense element, i.e. it possessed muscular tactile sense and a sense of resistance, allowing to distinguish between extension, cohesion and gravitation of bodies. He maintained that “muscle sense” intervened in coordinated movements in synergy with tactile, visual and auditory sensations, and these converged in the cortical cerebellar matter, where they interacted with the voluntary motor centres of the cerebral cortex and ganglia centres through the Purkinje cells [6].

He explored the concept of muscle sense, and his experiments highlighted the role of the cerebellum in maintaining balance and coordination. He concluded that sensations (muscle, visual, auditory) were needed to regulate movement, confirming his clinical observations on 140 patients. Movement disorders were characterised by a lack of muscle sense, and the cerebellum was the site of this sense. Lussana’s doctrine on the site of muscle sense was believed to indicate the cause of cerebellar ataxia [7, 25]. The consequences of loss of sensory control on motility were not completely accepted because Luigi Luciani (1840–1919) refused that the cerebellum had only a muscle sense. Luciani recognised Lussana’s contribution on cerebellum that has a control on muscle through the posterior columns by superficial, pain and deep sense fibres. Luciani conducted experiments more meticulously than any of his predecessor because he had the possibility to observe animals alive for at least 1 year after excision of the cerebellum. His researches concluded that cerebellar symptoms stemmed from three essential phenomena: hypotonia (decrease in muscle tone), asthenia (decrease in muscle working capacity, lack of strength) and astasia (instability caused by modified distribution of muscle tone) [26]. During his period in Padua, Lussana distinguished balance disorders from vertiginous symptoms. He considered the cerebellum to be the structure in which movement coordination for the upright position and locomotion was localised [27].

Synaesthesia: the first hypothesis

Another subject in the field of brain localisation, which fascinated Lussana, being a lover of poetry and music and an adept figurative artist, was the relationship between sound and colour. He wrote of the possible relationships between sound and colour vibrations, suggesting a parallel between the harmony of colours and the melody of sounds. He sought to explain why perception of certain stimuli was accompanied by another senses: a phenomenon referred to at the time as colour hearing and as *audition colorée*, in

French, but now known as synaesthesia [28]. These studies had been the subject of research by the English physicist, Isaac Newton (1642–1727), who erroneously divided the solar spectrum into seven intervals corresponding to the seven notes of the musical scale. In 1664, Newton used a prism to separate the sunlight. Two years later, he explained that white light could be decomposed into several coloured rays with refraction of its ray. This refraction generated seven primary colours in ordinary succession from minor refrangible red to more refrangible-violet. Newton correlated between amplitude of the band of colours and the wavelength of a musical cord. This incorrect conclusion led Newton to consider that the relationship between sound/colour created a different vibration, which in term stimulates the eyes and the ears and spoke and propagate to the brain. Newton’s view was in contrast to those of Johann Wolfgang Goethe (1749–1832). Whereas, Newton viewed colour as a physical debate, involving light striking objects and entering our eyes. Goethe realised that the sensation of colour reaching our brain is also shaped by our perception. Goethe’s work also demonstrated that Newton’s colours hypotheses were unsatisfactory [29, 30].

In 1865, Lussana had an opportunity to describe the phenomenon of coloured sounds after meeting, in 1864, two young brothers, one a medical student, who reported on the “coloured sensations they felt on hearing different sounds”. The two brothers reported that “it was impossible not to associate or almost identify the very tone of a voice with various correlated colours and that, for example, their perception of high, soprano voices was constantly associated with the colour red and bass voices with the colour black” [31]. This case provided Lussana to correlate the colour, physiology and neurology in the theory of nerve specificity formulated by François Achille Longet (1811–1871) [32]. The Italian physiologist hypothesised a neurological substrate for coloured hearing due to the nearness of colour and language centre. He also correlate phonic language and colour citing Newton [33]. Lussana adopted Newton’s physic theory of sound/colour to explain coloured-hearing synaesthesia. According to Lussana, light rays are conducted by the optic nerve to quadrigeminal bodies and the optic thalamus, where bright sensations are transformed into specific sensation. These sensation became ideas upon arriving at the centre of chromatic talent, localised at the third frontal cerebral convolution connected with language centres based on the phrenology theory: above the orbital area, where they are the centre for colour and melody sound. Both centres are connected with a language area that confers an “emotional aspect” to colours and sounds. The proportion between colour and sound is based on the timing of different musical notes and those of chromatic musical scale. Lussana elaborated a comparative scale between colour and note vibrations. He

tried to explain how these vibrations could be transformed into emotions by different specific cerebral centres of chromatic and musical talents in relationship to the centre of language. He affirmed that coloured-hearing mechanism was based on sound and hearing, but not on vision. The centres of sound, vision and language are adjacent and in mutual communication [31]. Influenced by Gall's phrenological theories, Lussana sought to identify a centre for "coloured" sensations and "melody", determining a location in the anterior brain regions, i.e. the frontal gyri. He went on to suggest that they communicated with each other, giving the person chromatic talent, advocated to underlie creative genius [34, 35].

Conclusions

Lussana's work was oriented around his experience as a medical practitioner and based on listening to patients, believing that "suffering nature gives us verbal insight into our patient's afflictions," and on clinical observation over time. His insight and theories were then tested during his academic career by anatomical-pathological study and laboratory experiments, enabling him to confirm various hypotheses.

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