***NOTA HISTÓRICA***

# Luigi Luciani (1840-1919) - the Italian Claude Bernard with German shaping, and his studies on the cerebellum with projections to nowadays.

## *Luigi Luciani (1840-1919) - o italiano Claude Bernard com formação alemã, e seus estudos sobre o cerebelo com projeções na atualidade.*

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## RESUMO

Luigi Luciani (1840-1919) was an illustrious Italian citizen and physiologist whose research scope covered mainly cardiovascular subjects, the nervous system, and fasting. He published in 1891 a modern landmark of the study of cerebellar physiology - "Il cervelletto: nuovistudi di normal and pathología physiology" / "The cerebellum: new studies on normal and pathological physiology." In his experiment, a dog survived after cerebellectomy, reporting a triad of symptoms (asthenia, atonia, and astasia). In this way, the eminent neurophysiologist improved the operative technique and sterile processes to redirect the issue of cerebellar symptoms. Luciani died at age 78, a hundred years ago, and left mainly the understanding of the role of the cerebellum in regulating postural tone and muscle strength, which represented a step forward in understanding cerebellar motor physiology. In recent decades, cognitive / affective function has been added to the cerebellar motor, and there has also been a better understanding of cerebellar circuits.


**Keywords:** cerebellum, asthenia, atonia, astasia, Luciani


## ABSTRACT

Luigi Luciani (1840-1919) foi um ilustre cidadão e fisiologista italiano, cujo escopo de pesquisa abrangia principalmente assuntos cardiovasculares, sistema nervoso e jejum. Ele publicou em 1891 um marco moderno do estudo da fisiologia do cerebelo - "Il cervelletto: nuovistudi di fisiologia normale and patologica" / "O cerebelo: novos estudos sobre fisiologia normal e patológica". Em seu experimento, um cão sobreviveu após a cerebelectomia, com o relatório de uma tríade de sintomas (astenia, atonia e astasia). Dessa maneira, o eminente neurofisiologista aprimorou a técnica operatória e os processos estéreis para redirecionar a questão dos sintomas cerebelares. Luciani morreu aos 78 anos, cem anos atrás, e deixou principalmente a compreensão do papel do cerebelo na regulação do tônus postural e da força muscular, o que representou um passo adiante na compreensão da fisiologia motora cerebelar. Nas últimas décadas, a função cognitivo / afetiva foi adicionada à motora cerebelar e, também, houve uma melhor compreensão dos circuitos do cerebelo.


**Palavras-chave:** cerebelo, astenia, atonia, astasia, Luciani

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## INTRODUCTION

The life span of Luigi Luciani (figure 1), from 1840 until 1919, was in parallel with many transformations that lead to the unification of many different states into the modern Italian nation[1,12].

In Italy, Neurology acquired the status of clinical discipline at the beginning as "clinic of mental diseases" but at the end of the 19th century and first decades of the 20th, eminent Italians constructed modern national neurology, many neuropsychiatrists[1,4,12]. Luciani was among the pioneers who contributed with the neurology by means on his investigations on cortical localization and cerebellar functions[1].

An analysis of Luciani´s work shows his talent in several areas of the physiology, as on the beginning of the modern cerebellum research, besides on the physiology of the cardiovascular system, the cerebral cortex, and fasting. In this way, the basis on his cerebellum studies helped to build up the long path for an understanding of the cerebellum complex function, from Luciani´s motor view until the nowadays cerebellar cognitive affective syndrome[2].

## DISCOVERING THE CEREBELLUM

The term cerebellum corresponds to the little brain that has always been seen as a distinct subdivision of the brain, but more anatomical work was added throughout the 18th century. Malacarne (1776) defined the cerebellar foliation, and by the beginning of the 19th century, the classical descriptive anatomical work was completed, and an experimental study of the functions of the cerebellum began. At this time, the first understandings into the function of the cerebellum were gotten[7,8].

The phrenologists Franz Gall and his followers hypothesized that the cerebellum was the organ of sexuality: philoprogenitiveness[7]. Besides, animal experiments began to give a more accurate functional understanding of the cerebellum[7], and neurophysiologists such as Luigi Rolando and Marie-Jean-Pierre Flourens ablated portions of the cerebellum of a variety of animals and observed its consequences. More particularly, the Italian anatomist, Luigi Rolando (1809), gave an account that the cerebellum is the battery that produces the electricity necessary for generating muscular contraction[3]. In this way, Rolando concluded that, if the cerebellum is the battery that generates electricity for muscle activity, its removal would produce paralysis, besides, cerebellar lesions would impair posture and voluntary movement. Regarding his experiments, Rolando removed the young goat cerebellum and observed that the animal could no longer stand up, and it survived for 24 h but died possibly for postoperative sepsis[3]. Thus, Rolando identified the specifically motor symptoms which follow cerebellar lesion, and he concluded that the cerebellum was the brain region responsible for initiating movement.

In France, Marie-Jean-Pierre Flourens (1824), believed that the role of the cerebellum is not that of generating the movement, but to regulate it[3], and he made the fundamental observation that animals are not paralyzed, but with muscle incoordination in cerebellum lesion[7,8]. However, only later, with the development of surgical skill, and aseptic technique, a more accurate evaluation of the effects of cerebellar lesions became possible[7]. As an unfolding, the cerebellar examination evolved from observations of experimental lesions made by neurophysiologists, and also clinical descriptions of patients with trauma to the cerebellum.

Luigi Luciani (1891) gave the description, in a dog that survived the cerebellectomy, of a triad of symptoms (asthenia, atony, and astasis) unquestionably of cerebellar origin, and more about his discoveries are presented in the next section.

In 1894, the Spanish neuroscientist Santiago Ramón y Cajal published what is considered the first modern textbook of neuroanatomy, with a clear depiction of the cerebellar cortex[3]. In addition to illustrating the cell types, Ramon y Cajal also described the two fundamental afferents fibers to the cerebellar cortex: the mossy and climbing fibers. However, earlier, in 1837, the first characteristic cells in the human brain were accurately described by Jan Evangelista Purkinje[7].

These already mentioned 19th-century studies profoundly influenced cerebellar lesion clinical interpretation, as it was shown in the works of two great neurologists, Joseph Babinski, and Gordon Holmes[5,7].

Babinski gave the description of asynergia and adiadochokinesia[8]. In 1899, Babinski observed that patients with cerebellar lesions could not execute complex movements without breaking down them into their elemental movements, and he described the defect as dysmetria. In 1902, Babinski coined the term dysdiadochokinesia to describe the inability to rapid perform movements requiring alternate contractions of agonist and antagonist muscles[2,5]. Babinski, following Flourens concepts, he emphasized deficits in coordination, especially of antagonis-

tic muscles used in rapid movement sequences (dysdiadochokinesis).

Gordon Holmes emphasized more elementary losses in muscle control, and he based his interpretation of the experiments and conclusions of Luciani (1917)[7]. Besides, Holmes, during World War I, as a neurologist with the British Expeditionary Forces working in a field hospital, he had the opportunity to examine the effects of traumatic lesions involving the cerebellum - he reported hypotonia and dysmetria in men wounded by a gunshot to their cerebellum[3]. In 1922, Holmes gave a systematic description of the symptoms of cerebellar lesions in man[3], and he presented reports on cerebellar dysmetria and kinetic tremor [8].

## LUIGI LUCIANI´S WORK ON THE CEREBELLUM

Now, it will be presented some issues about Luciani´s two most important work on the cerebellum, besides some remarks about his approach on brain localization issues.

In 1891, Luciani published his famous monograph on the cerebellum-"ll cervelletto : nuovistudi di fisiologianormale e patologica"/"The cerebellum: new studies on normal and pathological physiology." In 1893, this masterpiece was launched in German (figure 2). He formulated his triad of the cerebellar symptoms: atonia, asthenia, and astasia[8], which explained all troubles provoked by cerebellar lesions. Later, he added a fourth sign, dysmetria. Luciani's interpretation of the cerebellar role in many motor functions survives more than a century later, and his terminology has entered the routine of the neurological examination. Through skillful pioneer vivisection, Luciani successfully removed the dog and monkey cerebellum (1891). He distinguished, following complete ablation, three periods designated as: "functional exaltation"-periodic seizures of opisthotonos; "deficiency phenomena"-still referred to as the Luciani triad: asthenia, atonia, and astasia, or intention tremor with discontinuities of movements, dysmetria, etc; "compensation"-tremor becomes less marked, as do asthenia and atonia[6].

Luciani (1891) distinguished between the immediate transient effects of lesions (unstabilized deficiency), and their more lasting effects (stabilized deficiency). He emphasized that the enduring effects of cerebellar lesions could be understood in terms of basic deficits in muscle control. Luciani characterized astasia as an inability to maintain normal fusion and continuity of movement, reflected in the intention tremor that is seen in cerebellar patients. He wrote as quoted by Glickstein[7]…: "To this group of phenomena which include tremor, titubation, and rhythmical oscillating movements, we gave the name astasia for the sake of brevity and owing to their probable common origin."

Luciani was able to construct his model for the functioning of the brain based on survival times that allow him a more protracted observation of more or less extensive functional recovery prone to compensation[11]. In this period, he was a professor of physiology at the University of Florence.

Between the years 1875 and 1885, Luciani's less well-known work is the experimental research in cerebral localization. In 1885, Luciani published, in association with Giuseppe Seppilli, "Le localizzazioni funzionali del cervello"[9] ("Functional Localisations in the Brain"). The central part of the book contains a comparison of the most recent results in cerebral localizations and on the function of the nervous system in general, obtained in the most advanced European research centers[11]. Morabito[11] explains that Seppilli - a doctor at the lunatic asylum in Reggio Emilia - wrote a section on clinical medicine with a comprehensive representation of all the most current medical literature on the topic, as well as providing unpublished clinical case studies[11].

## THE CURRENT STATE OF THE ART

Luciani rightly pointed out the role of the cerebellum in regulating postural tone and muscular force, but as it was demonstrated in the last decades, the cerebellum participates in both motor and non-motor domains.

By the beginning of the 20th century, it was widely accepted that the primary function of the cerebellum was related to motor control, and at this time, it was released several detailed descriptions of the clinical symptoms associated with cerebellar disease in humans. Also, Sherrington (1900) gave a step forward, and he proposed that the cerebellum was engaged with a complex proprioceptive system [8].

However, the roots of modern concepts about the cerebellum, like cerebellar learning and its involvement in cognition and emotion, can be traced to the theories of Marr and Albus (1969-1971), based on a computational theory of learning [8].

Pieces of evidence mostly due to neuroanatomical, electrophysiological, neuroimaging, and clinical studies permitted to study the associations between the cere-

bellum and other parts of the brain and new circuits. It was also discovered in what way they influence outputs like motor function, emotion, memory and, also, cognition.

Recently (2016), a panel of contributors to Consensus Paper about the Symptoms and Signs of Cerebellar Syndrome gave the current concepts on cerebellar functions and the main point is that the cerebellum is involved not only in motor operations, but also in cognitive tasks, and those related to emotional and affective regulation[2] (table 1).

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest.


## FUNDING STATEMENT

There is no financial support


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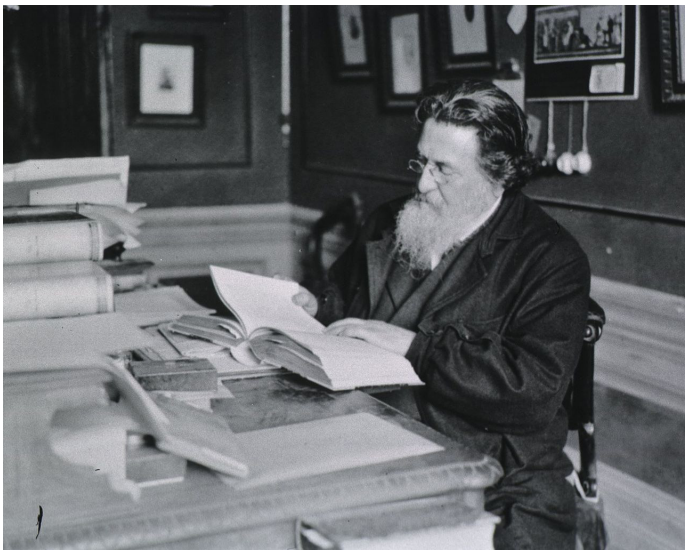


Luigi Luciani was born on in Ascoli Piceno, Italy, on 23 November 1840 from a prestigious and intellectual family, and at the period of Italy unification. In this way, he was interested in politics, literature and philosophy, besides sciences. He followed medicine, at Bologna and Naples, obtaining a MD degree in Bologna, in 1868. Subsequently, from 1868 until 1874, he acted as assistant to Luigi Vella, a pupil of Claude Bernard, in the Institute of Physiology at Bologna. After from March 1872 to November 1873, he spent his time at Physiological Institute of Carl Friedrich Wilhelm Ludwig (1816-1895), in Leipzig, what was considered by him of extreme importance11.

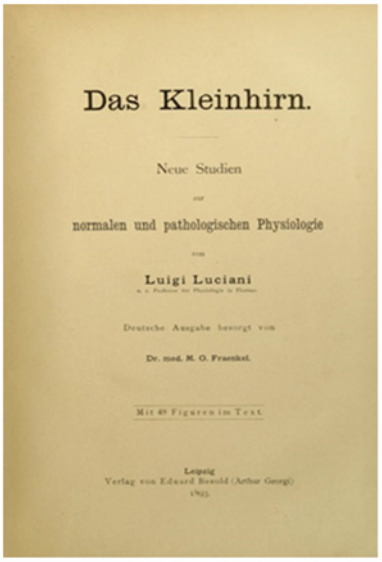
On his return to Italy, he devoted himself to university teaching and research in physiology in several Italian Centers: Bologna and Parma, Sienna, Florence and Rome.

In Bologna and Parma, 1873 to 1879, he worked with Augusto Tamburini and Giuseppe Seppilli on the localization of brain functions, and on epilepsy.

In sequence, in Florence, Luciani remained from 1880 until 1892, and he carried out his most important works, on the cerebellum and about fasting. At his last Chair of Physiology, in Rome, he remained from 1893 until his retirement in 1917. Among his most important publications, produced in Rome, there is on the Human physiology (1898-1903), that having been translated into English, German and Spanish11.

Besides his prestigious public duties and membership of the most prestigious academies in Italy and abroad, he was also nominated Senator of the Reign (1905). He died on 23 June 1919, in Rome, of a urinary tract infection.

Figure 1. Luigi Luciani´s life milestones (From: https://it.wikipedia.org/wiki/Luigi_Luciani#/media/File:Luigi_Luciani.jpg.

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abduktion (60) abduziert (28) abhangen (32) abnormen (27) abtragung (65) achse (63) affe (27) affen (67) allgemeine (34) ansicht (28) april (34) art (85) astasie (37) asthenie (54) ataxie (74) atonie (49) atrophie (25) aufrecht (49) auftreten (53) aufzurichten (47) augen (74) august (28) ausfallserscheinungen (53) aussert (27) basis (34) bassin (29) be (142) bedeutung (29) beider (45) beine (195) beinen (83) bemerkt (94) beobachtet (67) beobachtung (41) beobachtungen (73) beruht (32) beschriebenen (35) bestandig (27) bestatigt (28) bestehen (36) besteht (28) bewegt (26) bewegung (40) bewegungen (241) beweis (27) beziehung (39) biegt (39) bild (33) bisweilen (57) bleiben (29) bleibt (59) bloss (56) blutung (50) boden (80) bringen (30) bringt (35) bulbus (28) centren (30) cervelet (50) charakter (31) cit (35) dafur (29) dans (57) de (189) degeneration (38) del (32) deutlich (63) di (25) direkte (32) direkten (25) drehen (27) dreht (30) dura (27) eeizerscheinungen (36) eichtung (28) einfluss (38) einseitige (27) einzelnen (30) elemente (35) energie (30) ent (40) erde (64) ergebnisse (32) erhalten (54) erkennen (35) erklarung (27) ernahrung (27) erscheint (29) erscheinung (27) erscheinungen (188) est (42) et (125) eucken (45) eumpf (49) experiment (29) experimente (47) experimenten (28) exstirpation (161) exstirpiert (49) extension (46) extremitaten (143) fall (64) falle (90) fallen (156) fallt (85) fand (29) fangt (27) fasern (36) fast (160) fehlen (34) fehlt (43) ferner (33) fest (36) fig (73) findet (50) flanke (37) flektiert (28) folge (64) folgen (117) form (78) forschungen (27) fort (39) frage (29) fressen (33) frisst (48) fuhrt (27) funktion (46) funktionen (39) fur (247) fussboden (40) fusse (25) futter (43) gang (66) ganzlich (45) ge (116) geben (29) gehirn (26) gelegt (38) gelingt (65) genau (27) genommen (25) geringer (36) geschieht (38) gesetzt (38) gesunden (65) gewicht (64) gewohnlich (30) geworfen (39) giebt (41) gleichgewicht (62) gleichwohl (51) grade (38) gramm (73) grossere (28) grosshirn (27) grund (38) halfte (107) hals (42) halt (148) halten (85) haltung (28) hand (62) hangt (27) haut (32) heben (26) hebt (55) hervor (39) hinfallen (34) hinten (65) hinterbein (35) hinterbeine (68) hinteren (59) hirn (35) hohe (40) hund (46) hunde (54) hunden (66) hundin (75) il (48) imd (41) indes (81) infolge (92) insbesondere (54) juli (69) juni (129) kapitel (232) klar (42) klein (89) kleinhirn (368) kleinhirnhalfte (35) kleinhirnkrankheiten (27) kleinhirns (288) kleinhirnschenkel (27) klinischen (59) kompensation (45) konnen (85) koordination (44) kopf (167) kopfe (35) kopfes (71) korper (36) korpers (36) kraft (60) kranken (26) krummt (47) krummung (64) la (132) lage (53) langsachse (36) langsam (46) lappen (25) lasion (28) lassen (62) lasst (96) le (84) leben (41) lebhaft (27) lehre (58) leichter (35) les (106) letzteren (30) lich (28) liegen (27) liegt (44) linie (33) linke (99) linken (212) links (218) loc (33) mai (100) masse (26) methode (31) minder (29) mittellappens (59) mittelst (35) mittleren (49) monate (27) motorischen (25) mouvements (31) muskeln (176) mussen (32) nahe (29) namentlich (44) namlich (45) ne (32) neigung (50) niemals (25) nimmt (44) normal (42) normale (33) normalen (45) nothnagel (27) nystagmus (35) oberen (27) obgleich (45) offenbar (26) operation (181) operierten (100) organ (32) organes (40) pag (55) par (27) paralyse (25) periode (26) physiologie (56) physiologischen (40) plus (37) pons (32) prufung (26) que (45) qui (34) rasch (25) rechts (360) rechtsseitigen (35) reizerscheinungen (39) reizung (42) richtung (34) rotieren (35) ruckwarts (29) sagen (31) sahen (25) scheint (68) schenkel (58) schenkelbundel (33) schielen (48) schreitet (27) schritte (61) schwache (59) schwacher (42) schwebe (33) schwimmen (68) schwimmt (46) schwindel (34) se (28) sehen (49) seite (517) seiten (76) seitenlappen (38) sektion (37) setzt (36) sieht (45) sobald (33) sodass (56) sogar (54) sowohl (58) spater (34) spuren (26) stande (61) stark (98) starke (32) starker (63) stehen (83) steht (48) stelle (36) stellen (46) stellt (41) stellung (53) stets (86) storung (40) storungen (41) strabismus (29) streckt (32) streckung (25) stunden (26) stutze (34) stutzt (26) sucht (37) sur (40) symptom (53) symptome (85) tauben (28) teile (37) thatigkeit (62) thatsache (35) thatsachen (53) theorie (31) tier (474) tiere (88) tieren (93) tieres (109) tonische (53) tonischer (32) trennung (28) treten (27) uber (209) ubrig (28) ubrigen (25) ubrigens (38) umstand (29) un (56) une (34) unseren (34) unten (27) unteren (26) unterscheiden (41) untersuchungen (47) ver (94) veranlasst (26) verhuten (26) vermag (83) vermeiden (34) verschiedene (33) verschiedenen (97) versucht (40) vielmehr (36) vollig (32) vollkommen (32) vollstandig (69) vollstandige (52) vollstandigen (26) vorder (32) vorderbein (29) vorderbeine (61) vorderen (70) vorigen (29) vorn (41) vorwarts (31) vorzugsweis

Figure 2. Luigi Luciani and his masterpiece "Il cervelletto: nuovistudi di fisiologia normale e patologica" (1891), german version (1893) (Das Kleinhirn: Neue Studien zur Normalen und Pathologischen Physiologie"[10]/"The cerebellum: new studies on normal and pathological physiology") where among the words highlighted, several may be related to cerebellar damage:abduktion (abduction) (60) abduziert (abducted) (28) astasie (astasia) (37) asthenie (asthenia) (54) ataxie (ataxia) (74) atonie (atony) (49)koordination (coordination) (44) nystagmus (nystagmus) (35). It is recognized the Luciani´s triad of atony/asthenia/astasia.
(From: https://archive.org/stream/daskleinhirnneue00luci/daskleinhirnneue00luci_djvu.txt).

Table 1.Cerebelar syndrome: Motor signs looked for evaluation and Deficits characterizing the cerebellar cognitive affective syndrome - Schmahmann's syndrome (From ref.Bodranghien–consensus[2] and Schmahmann and Sherman[13]).

| Motor signs | Cognitive affective syndrome |
|---|---|
| **Oculomotor tests** | **Executive function** |
| Nystagmus, saccadic intrusions<br>Saccadic pursuit<br>Dysmetric saccades<br>Impairedvestibulo-ocular response (VOR)<br>Skewdeviation, esotropia | Deficient planning, motor or ideational set shifting, abstract reasoning, working memory. Decreased verbal fluency, sometimes to the point of telegraphic speech or mutism. Perseverativeideation in thoughtand/oraction |
| **Speech** | |
| Dysarthric speech | **Spatial cognition** |
| **Upperlimbmovements** | Visuospatial disintegration with impaired attempts to draw or copy a diagram. Disorganized conceptualization of figures. Impaired visual-spatial memory. Simultanagnosia in some |
| Decomposition of movement, dysmetria, kinetic tremor, intention tremor<br>Dysmetria<br>Kinetic tremor, intentiontremor<br>Adiadochokinesia<br>Reboundphenomenon | |
| **Lowerlimbmovements** | **Linguistic difficulties** |
| Decomposition of movement, kinetic tremor, dysmetria | Anomia, agrammatic speech and abnormal syntactic structure, with abnormal prosody |
| **Trunkmovements** | |
| Increased sway of the trunk | |
| **Muscletone** | |
| Hypotonia<br>Pendular kneejerk | |
| **Stanceandgait** | **Personality change** |
| Ataxia of stance, titubation, lateropulsion<br>Ataxic gait<br>Ataxicgait | Aberrant modulation of behavior and personality with posterior lobe lesions that involve midline structures. Manifests as flattening or blunting of affect alternating or coexistent with disinhibited behaviors such as overfamiliarity, flamboyant and impulsive actions, and humorous but inappropriate and flippant comments. Regressive, childlike behaviors and obsessive-compulsive traits can be observed. |
| Handwriting | |
| Irregular writing, megalographia, kinetic tremor<br>Kinetic tremor, dysmetria | |