Babinski, Joseph

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Joseph Babinski (1857-1932)

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A neuroscientist behind a famous clinician

François Clarac, Jean Massion and Allan M. Smith

Joseph Babinski (1857-1932) was born on November 17, 1857, the same year as Charles Sherrington (1857-1952), but 51 years after Guillaume Duchenne de Boulogne (1806-1875), the father of selective muscle electrical stimulation, and 32 years after Jean-Martin Charcot (1825-1893), the "Napoleon" of *La Salpêtrière.* In the future, these two neurologists would have the greatest influence on him, even though two other great Parisian physicians, Alfred Vulpian (1826-1883) and Victor Cornil (1837-1908), considered him their most brilliant pupil.

I Babinski's life

Babinski's father, Aleksander (1824-1889), colonel in the Polish army, tried to save his country from Russian domination. In 1848, circumstances forced him to leave Poland and emigrate to France, the country of "Human rights"! A few years later he married a Polish national, Henryeta Weren (1819-1897), and took up residence at 142 boulevard du Montparnasse. The couple had two boys; Henri, the eldest, was born in 1855 followed by Joseph two years later. In order to support his family, Aleksander, who was a trained civil engineer, was obliged to spend several years working in Peru.

The French defeat at the hands of the Prussians in 1871 and the brief, but turbulent, episode of the Paris Commune of 1871 were events that profoundly disturbed the young Joseph and represented a threat for the entire Babinski family. Like his brother Henri, Joseph was educated at the Polish school on the *boulevard des Batignolles* in Paris. In 1878, his elder brother, Henri, obtained his diploma from the prestigious *Ecole des Mines*, and as a trained engineer he was able to assist his parents financially at the time Joseph was starting his medical studies.

The Babinski family moved to *170 bis boulevard Haussmann* in 1890 and the two brothers continued to live there after both parents died until their own deaths in 1931 and 1932. Although Henri (1855-1931) was trained as an engineer like his father, he was eventually to become one of the most celebrated culinary experts in France. His famous cookbook, *Gastronomie pratique: études culinaires*, was published under the pseudonym of Ali Bab, and it is still widely cited today. The brothers were very close and their dinner invitations were offered only to a few close acquaintances. These lucky individuals were treated to a unique gastronomic experience, the menus of which can be found in the *Gastronomie pratique*. In later years Joseph Babinski was

severly afflicted with Parkinson's disease, and he did not survive his older brother's death by more than a year.

In due course, Joseph became first an *externe* (the French equivalent of medical clerkship) and subsequently an *interne* in various Paris hospitals in 1879. He graduated in medicine from the University of Paris in 1884 with a thesis on multiple sclerosis. On the strength of a particularly good recommendation from Vulpian, Babinski was chosen to become Charcot's chief resident at La Salpêtrière from 1885 to 1887. Charcot quickly recognized Babinski's talent as a highly astute clinical observer, and he was soon considered to be his favourite student. When Sigmund Freud was at La Salpetrière he described Babinski as the "preferred pupil of the *Maitre*". This is confirmed in the famous painting of André Brouillet (1857-1914), depicting a lecture of Charcot. The painting itself deserves some comment. It seems that Charcot commissioned it himself (Goetz et al. 1995), and one can see the *Maitre* commenting on the condition of Blanche Wittman, a famous hysteric patient, supported by Babinski with Marguerite Bottard (Charcot's faithful nurse) ready to give a hand. No less than 16 pupils of Charcot are represented, most of whom became celebrated neurologists in their own right, such as Pierre Marie (1853-1940), Edouard Brissaud (1852-1909), Alix Joffroy (1844-1908), Victor Cornil (1837-1908), Gilles de la Tourette (1857-1904), and Désiré-Magloire Bourneville (1840-1909). At the periphery, one also finds literary and other celebrities, including the writer Paul Arene (1840-1913), the psychologist Théodule Ribot (1839-1916), Jules Claretie (1840-1913), administrator of the *Comédie Française*, and Alfred Naquet (1834-1916), a radical-socialist *député* (Member of Parliament) who helped to re-establish divorce in 1884.

During the early 1890s both Charcot's health and his influence in the medical faculty were waning and, one year before his sudden death on August 16, 1893, Babinski's academic career fell victim to an intrigue among certain professors of medicine who felt the time had come to diminish the great power and influence of Charcot at the Salpêtrière. In 1892 Babinski was a candidate in the *concours de l'agrégation*, a supposedly open competition for future professors of medicine. However, the president of the jury nominated by the French Ministery of Education, Leon Bourgeois, was Charles Bouchard (1837-1915) a former *interne* of Charcot but a subsequent adversary who resisted him, not only scientifically but also philosphically and politically. He was opposed to Charcot's republican and agnostic tendencies. Bouchard shamelessly promoted his own pupils but not those of Charcot, Babinski and Gilles de La Tourette. It was a scandalous bit of nepotism and although Babinski tried to protest the jury's decision, it was without success. As a result, Babinski was never able to obtain a promotion to the rank of "associate professor", which spelled the end of his academic career. However, this obstruction did not entirely thwart his clinical career and he eventually became the head of the neurological clinic at the neighbouring *Hospice de la Pitié*. This enabled him to devote his mornings to clinical practice and his afternoons in his private consulting room throughout his lifetime.

Babinski was an impressively large man, more than 6 ft in height with blond hair and blue eyes (Figure 1). His demeanour was calm and slow both in attitude and movement. He never seemed hurried and invariably showed patience and deliberation when talking with his patients.

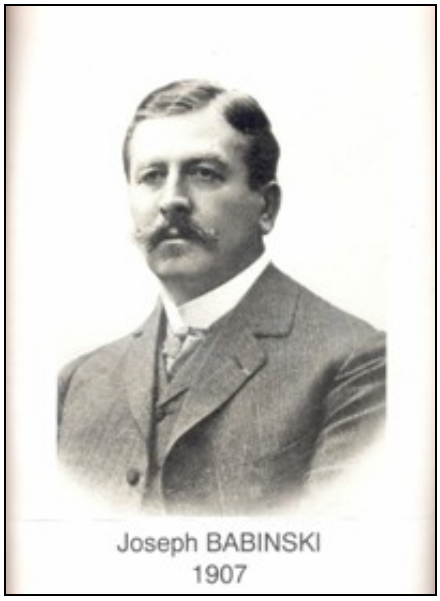

Figure 1: Joseph Babinski, 1907.

He was considered a masterly diagnostician, relying considerably less on neuropathological reports and laboratory tests than most of his contemporary colleagues: "In examining a patient, he more than made up for this by his meticulous scrutiny, conscientiousness, and patience. He was a genius in searching for defects, a man of inexorable logic ... He made little use of technical procedures; he was a clinical neurologist par excellence guided by the maxim *observatio summa lex*" (R. Wartenberg, p. 399 in Haymaker & Schiller 1953). André Breton (1893-1966), the father of Surrealism, was a hospital attendant during the war and had been an *externe* under the direction of Babinski at the Pitié-Hospital from January to September 1917. Breton was very impressed by the Polish neurologist and spoke about him in several of his publications. In 1924, at the conclusion of the *Manifeste du Surréalisme*, Breton wrote: "He pursued the inspection of his patients relentlessly to the point that it was more than a mere physical exam. Here and there he would make a comment, and without putting down his neurologist's hammer and pin, he engaged in his examination with a sacred fever" (*Oeuvres complètes. Tome I, La Pléiade* 1924, p. 346).

In fact Babinski enjoyed a very sucessful carreer, and on June 8, 1899, he founded the *Societé Neurologique de Paris* with Joffroy, Brisseau, Marie, Meige, Souques. It was at these meetings of the society, held at the *Faculté de médecine* in Paris, that he presented the majority of his clinical observations. In 1911 he was elected to the editorial board of the review *La Revue neurologique*. On February 3, 1914, Babinski was elected a member of the Academy of Medicine in tribute to his lifelong commitment and dedication to the practice of medicine. During the First World War (1914-18), he was kept busy examining wounded soldiers returning from the front (see further).

As a patriotic Polish Frenchman, Babinski was thrilled by the Allied victory, and by the recovery of Alsace-Lorraine for France, where in 1919 his pupil Jean A. Barré (1880-1967) became the new professor of neurology of Strasbourg. He was very proud of the reorganization of Europe with the Treaty of Versailles and he was passionate about the rebirth of his native Poland.

In 1925 Babinski was elected president of the *Société de Neurologie* (Figure 2). It was an opportunity for him to give a very prestigious lecture in honour of Charcot on the centennial anniversary of his birth.

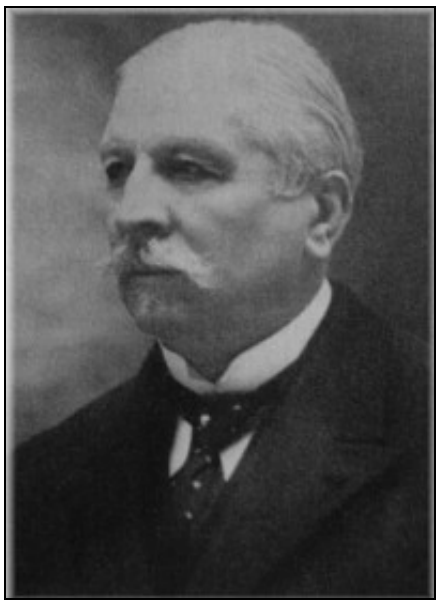

Figure 2: Joseph Babinski on his election to the *Société de Neurologie.*

Babinski was also quite enthusiatic about the nascent field of neurosurgery on the spinal cord and he referred patients to Victor Horsley (1857-1916) in England, who at the time was uniquely able to perform spinal surgery, having conducted his first tumour extirpation on June 9, 1887. Later Babinski convinced two of his students, Thierry de Martel (1875-1940) and Clovis Vincent (1879-1947), to undertake the first sucessful spinal operation in France, earning him the title of the father of French Neurosurgery (Fulton 1933). Babinski never married but adopted three girls. He was quite passionate about classical music, opera and ballet. He often went to the Paris Opéra in the evenings and he was a great admirer of the skilled movements of the dancers. Towards the end of his life Joseph, his brother Henri and a close mutual friend, Louis HenriVaquez (1860-1936), travelled widely around Europe and South America on their vacation.

II Reflexes as tools for diagnosis and evaluation

Reflexes and the famous "sign"

Babinski was perhaps the most impressive when he examined his patients, accompanied by his assistant. It was always done with great ceremony;the patient was examined totally naked and instructed to pay strict attention to Babinski's instructions while the master conducted his examination in complete silence. He would ask patients to perform particular movements or to walk around the room in order to analyse the specific contractions of the various muscles. He was a highly skillful practitioner using the neurologist's hammer to induce various reflexes and localize dysfunction in the nervous system. Tournay (1967) explained that Babinski always sat behind a large table with his favourite instruments arrayed before him: a reflex hammer, pincushion, tuning fork, various objects for grasping, test tubes filled with hot and cold water, and two batteries for galvanic or faradic stimulation.

Reflex testing had been introduced into the neurological examination several decades earlier, in 1875, by two German neurologists, Carl Westphal (1833-1890) and Wilhelm Erb (1840-1921). Babinski's examinations often lasted several hours, as he carefully observed the spontaneous abnormalities in a patient's behaviour. He then systematically proceeded to evaluate the reflexes and reactions with infinite care. According to Khalil (1979), Babinski's first attention to the reflex of the toes occurred during a chance observation of the contrasting responses between two female patients, one an hysteric and the other a hemiplegic. He first published description of his famous "sign" in 1896 at a meeting of the Société de Biologie in a communication of merely 28 lines, the most important of which were:"On the unaffected side pricking the sole of the foot elicits a normal flexion of the thigh on the hip, the lower leg on the thigh and the toes on the metatarsals. On the paretic side a similar pin prick produces flexion of the thigh on the hip, the

lower leg on the thigh, but the toes instead of flexing show an extension on the metatarsal". The pathologic extensor plantar response occurred when the sole of the foot was stimulated, whereas in normal subject, the same stimulation produced a general flexion (Figure 3).

Figure 3: Extensor response.

This first publication was nearly ignored and Babinski felt compelled to give fuller accounts of the reaction in 1898 and 1903, calling it *le phenomène des orteils* and emphasizing its invariable association with pyramidal tract lesions whatever their history or extent. In its simplicity and physiological implications, Babinski's sign has hardly any equal in medicine (see van Gijn, 1996). Massey and Sanders (1989) explained that Renaissance artists such as, for example, Sandro Boticelli (1445-1510), Corregio (1492-1534) and Raphael (1483-1520) had previously observed this phenomenon. In particular in the "Madonna and Child" the foot of the baby shows an extensor plantar response to pressure applied to the sole (Figure 4).

Figure 4: Raphael "Madonna and Child".

Perhaps this phenomenon had been noted by others earlier, but Babinski's description was so precise that it became a sign of fundamental importance in the neurological examination. The theoretical interest of the sign was increased by the studies of Fulton and Keller (1932), who found the sign was absent in lower primates after complete destruction of the pyramidal pathways but strongly present in the higher anthropoids such as chimpanzees, after lesions of the cortico-spinal system. This proved that such a descending system is predominant in these higher forms. Another, lesser known observation by Babinski was the tendency for hemiplegics to pronate the contralateral hand. This test, currently called "pronator drift", was recently validated using modern brain-imaging methods by Teitelbaum et al. (2002). Babinski studied other reflexes and reactions

as well, in particular the withdrawal responses in the lower limbs. Babinski studied the reflexes associated with muscle tendons and skin. He analysed the Achilles tendon reflex in relation to the knee, and ultimately published a series of short notes reviewing the different types of responses, in successively greater detail comparing the responses obtained from normal subjects and from patients. In 1912 he published four lectures in the *Bulletin Médical* with the title "Tendinous and cutaneous reflexes", in which he stated that he considered a reflex to be a means of interrogating the central nervous system: "The hand carrying the neurologist's hammer interrogates the nervous system which replies to the questions asked with clarity through the reflexes. The precious revelations obtained reveal the damage to the fabric of nervous system sometimes with a draftsman's precision. The reflexes disclose the seat and extent of the grave dangers threatening the nervous system."

In 1967 Auguste Tournay wrote a detailed description of Babinski's various scientific contributions under the title of *The Life of Babinski*. Sir Francis M. R. Walshe (1885-1973) wrote the Preface and concluded: "His sign, the extensor plantar, has continued to fascinate me each time I evoke it. So simple it tells so much, seeming to bear fate like the thumb of the Roman citizen at a gladiatorial contest. Some rash essayists have endeavoured to minimize its value, gravely misquoting its discoverer in his misguided labour. Yet neurologists will continue to use it, and it is the essays, not the sign, that will be forgotten."

Pythiatism

When Babinski arrived at La Salpêtrière, Charcot was deeply preoccupied with the problem of hysteria. At this time the hospital administration had decided to renovate and reorganize La Salpêtrière and, as a result, *le pavillon Pariset* became a hospice to epileptics, hysterics and psychotics. Charcot was charged with classifying all these pathologie, by organizing them into syndromes and determining the organic lesions that caused them. As Charcot's assistant, Babinski became familiar with the different techniques of metallotherapy and hypnotism, but he eventually found that some hysterical symptoms could disappear immediately and seemed to reflect the attitude of the people around the patient. In a first publication of May 1893, the 5th *Contracture organique et hystérique*, he presented the case of Gabrielle H., an hysterical patient who was also hemiplegic on the right side. The neurologist was able to dissociate the two deficits, demonstrating that, in the region with a pure hysterical response, most of the time some muscular rigidity was noticed, the various reflexes were never different from normal. By contrast, on the hemiplegic side, the reflexes were exaggerated (Babinski 1900).

At the Société de Neurologie, on November 7, 1901, Babinski attempted to give a definition of hysteria by explaining that suggestion played a major role. He noted that symptoms could be reproduced and extinguished by suggestion. He considered that these psychic troubles should be scientifically named *"troubles pithiatiques"* (a term coming from the Greek, reflecting the "persuasion" and "curable" aspects of the disease). His ideas met with initial scepticism until the meetings of the Société de Neurologie on April 9 and May 14, 1908. Both sessions were devoted to the subject of pithiatism, and despite some great reservations from Raymond, Déjerine and Pitres, Babinski convinced his audience of the validity of the term, pointing out that superficial and deep reflexes are invariably normal in hysterical patients (Babinski 1909).

During the First World War, Babinski was employed by the Military Health Service, not only at *La Pitié*, but also at the *Buffon College*, where he worked with the neurologist, Jules Froment (1878-1946), from the University of Lyon. They analysed the symptoms and syndromes that developed as a result of the war. Moreover, they had to distinguish between patients with nervous organic lesions, from those with "pithiatisme" (what today we would name neurosis or post-traumatic stress disorders) and those malingering by simulating an illness to avoid being sent to the front lines. In 1917 he published an important book *Hysteria, pithiatism, and reflex neurological troubles* (Babinski 1917).

Babinski devoted much time and energy to the elucidation of hysteria and of other related mental conditions. It is remarkable that throughout his investigations Babinski never criticized Charcot's opinion that hysterics suffered from organic brain damage. He changed his previous assertions: "If

my results have led me to abandon the doctrine of my illustrious master, I want to point out that I retain a profound admiration for the great neurologist's important work on hysteria, despite the few errors contained in his imposing work" (Tournay 1967, p. 106).

III Cerebellar symptomatology

At the 12th *Réunion neurologique internationale* (Paris, June 2, 3, 4, 1958) devoted to the cerebellum, Walshe made a presentation on the following topic: "Where is Babinski in the modern neurology?". He stressed that the contribution of Babinski was in line with the long tradition of the French clinico-pathological school developed since Theophile R.M.H. Laënnec (1781-1826) during the first half of the 19th century. Babinski, he said, was also in divergence with the physiological schools developed at the same time by Rudolf L.K. Virchow (1821-1902) and Claude Bernard (1813-1878), estimating that the physiological research should take place inside laboratories, and he remained faithful to the clinical approach in neurology based on symptomatology. For Walshe (1958), this was still the real foundation of Neurology and among the most illustrious success of the semiological approach was the description of the cerebellar syndrome by Babinski. However, beyond the clinical description of symptoms, Babinski, who was aware of the physiological investigations of Luigi Lucciani (1840-1919) and of André Thomas (1867-1963), always returned to the clinical description in an attempt to provide a physiological explanation of the symptoms.

Babinski's principal cerebellar symptoms

Babinski's. observations on the movements of cerebellar-damaged patients started from his first presentation on *asynergia* in 1899 until his invited lecture on "Cerebellum illness symptoms and their significations" (Babinski and Tournay, 1913) at the International Congress of Medicine in London, where he received an extended ovation for his presentation. His original contribution concerned *hypermetria* (dysmetria), *adiadocokinesis*, *asynergia* and cerebellar catatonia, this last one being mainly related to extracerebellar lesions. He showed that, generally speaking, in contrast to tabes dorsalis, the cerebellar symptoms were not enhanced by the absence of vision.

According to Babinski, *hypermetria*, in relation to cerebellar damage, was first described by Huppert in 1878 (Babinski 1913). Hypermetria was exemplified by the finger-nose pointing test, where past pointing was the classic cerebellar sign. Babinski showed that in contrast to locomotor ataxia (tabes dorsalis), where the leg movements were misdirected, in cerebellar hypermetria the direction of movement was preserved, and in his opinion the misdirection was due to an exaggerated "impulsion" (i.e. the first agonist muscle burst), which could not be checked by a timely and efficient antagonist braking action. Much later this was definitively confirmed experimentally in the monkey by Vilis and Hore (1977).

Another sign of cerebellar pathology described by Babinski (1902) was *adiadochokinesis*, which he defined as an impairment in performing rapid successions of alternating movements such as pronation and supination of the hand. The name of diadochokinesis was made by the combination of two Greek words, one meaning succession and the other movement. His interpretation was that the cerebellar lesion "can, without diminishing the muscle energy, provoke a kind of inertia which reflects the difficulty of mobilizing and arresting the movement in time" (Babinski 1913, *Exposé des travaux scientifiques*, p. 142).

The term *asynergia* was introduced by Babinski's first paper on the cerebellum published in 1899 and influenced no doubt by Duchenne de Boulogne (1858,1867), a neurologist specialized in muscular galvanic and faradic stimulation working in Charcot's neurology service at La Salpêtrière in the second half of the 19th century. Duchenne de Boulogne previously used the term asynergia to designate the unsteady staggering gait seen in locomotor ataxia (tabès dorsalis) (Schiller 1995). (Babinski, Exposé des travaux scientifiques 1913, p. 148). Babinski first defined synergy as "an association of movements" (Babinski 1899) then later as "the capacity to accomplish the variety of movements that constitute a single act" (Babinski 1934, p. 197). Surprisingly, Babinski's description of asynergia was mainly based on only two well-studied patients; the most frequently cited was Henri Mouninou, who became Babinski's usual subject for the demonstration of asynergia, till the patient's death in 1925. His post-mortem examination was reported at the April

23, 1925 session of the Academy of Medicine. The autopsy revealed "a single lesion extending from the antero-dorsolateral pons to the medulla oblongata and penetrating deep into the white matter of the cerebellar hemisphere" (Tournay, 1967, p 78), indicating a cerebellar and partially extracerebellar lesion. As reported by Jules J. Déjerine (1837-1915) (1913, 1926, p. 423), "up to this point asynergia had been observed especially in patients with rather complex cerebellar and pontine lesions". Babinski (1899) illustrated asynergia with two examples. The first was the failure of the trunk to lean forward at the onset of walking, which resulted in staggering or falling when the first step was initiated. A second example was the absence of a forward displacement of the hip and knee when the standing patient was asked to look upward by tilting the head and trunk backward (Figure 5).

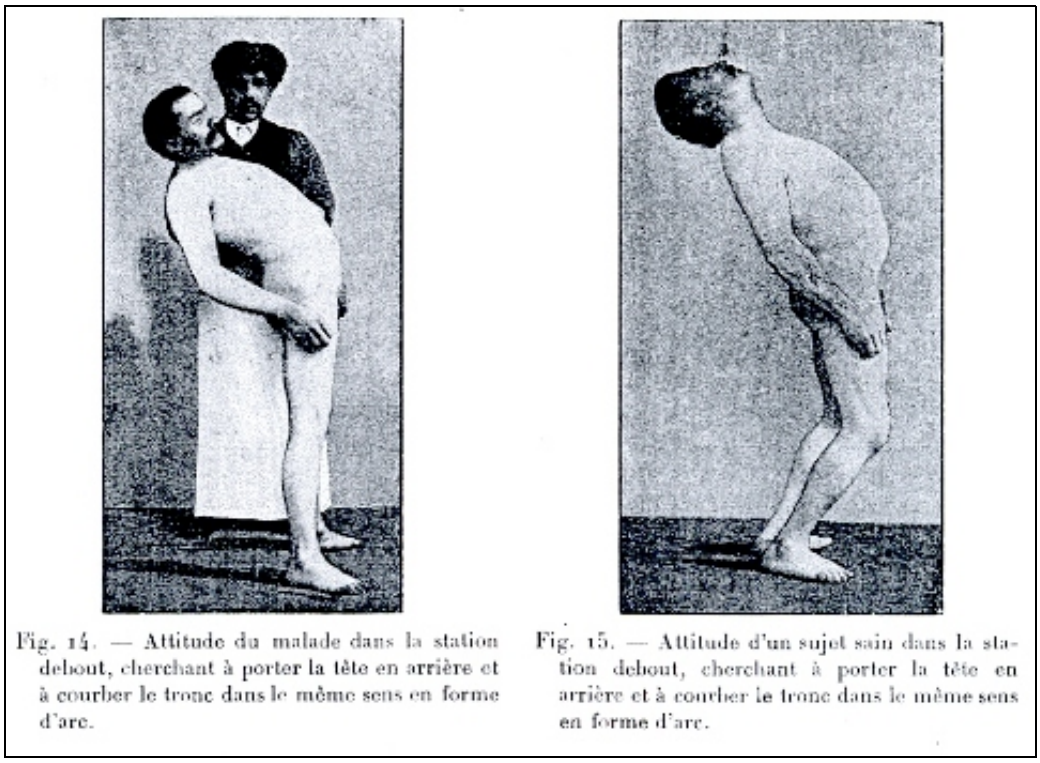

Fig. 14. — Attitude du malade dans la station debout, cherchant à porter la tête en arrière et à courber le tronc dans le même sens en forme d'arc.

Fig. 15. — Attitude d'un sujet sain dans la station debout, cherchant à porter la tête en arrière et à courber le tronc dans le même sens en forme d'arc.

Figure 5: Comparative postural reaction of Henri Mouninou and a normal subject.

The absence of this hip-forward displacement also resulted in falling. These two synergies were evidently related to equilibrium control during movement. In his 1913 review paper on the cerebellum, Babinski provided other examples of the lack of synergy (Babinski and Tournay, 1913). His cerebellar patients were unable to sit up from a supine position. The hip flexion was not associated with a leg extension (in this case the legs were raised above the bed). He also showed several examples illustrating the lack of simultaneous flexion of the hip and knee. For example, when a supine subject was asked to place the heel next the buttock: the hip flexes first, and then the knee flexes with the heel striking the buttock, demonstrating the absence of a harmonious synergy involving the hip and knee flexors (Figures 6 and 7).

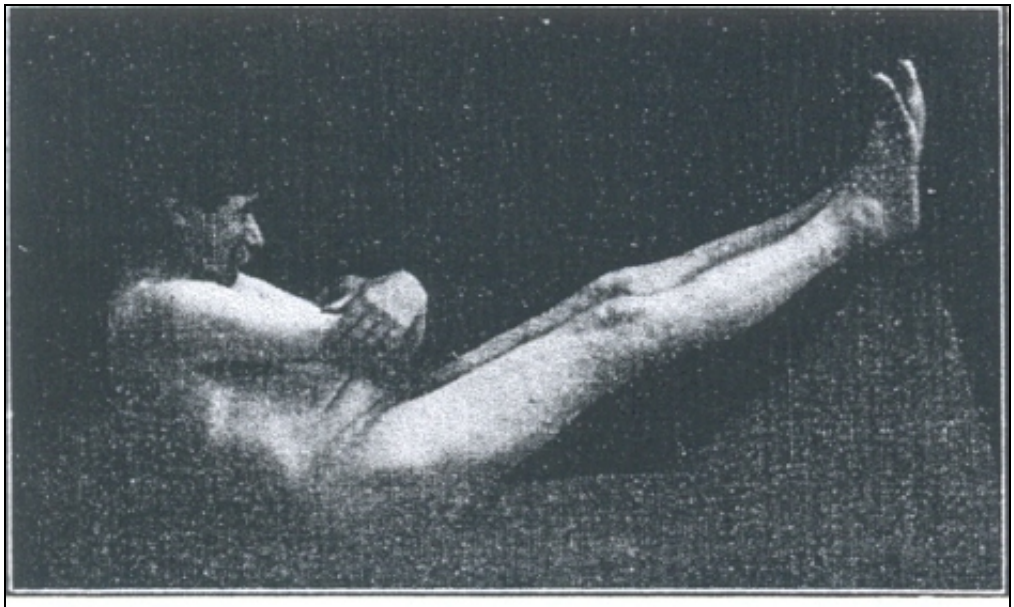

Fig. 12. — Attitude du malade sur le dos faisant effort pour se mettre sur son séant.

Figure 6: Cerebellar patient unable to stand up

As a result the main characteristic of asynergia is the dissociation of movements of different body segments which are associated in a single act.

(Examen pendant la marche.) — Lorsque H. M., soutenu des deux côtés, cherche à

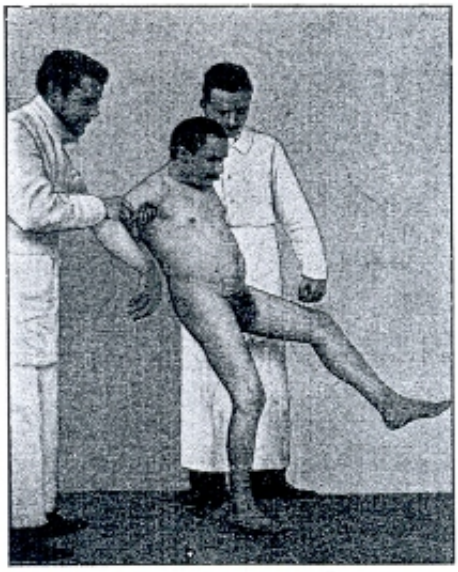

Fig. 16. — Attitude du malade pendant la marche, soutenu par deux aides.

marcher, on constate que le mouvement des membres inférieurs se décompose d'une

Figure 7: Cerebellar patient needing assistance to walk.

In his *Exposé de travaux scientifiques* (1913), Babinski explained in more detail the meaning of his term "asynergie". For example, during locomotion: ”The immobility of the upper part of the body while the legs are moving forward cannot be attributed to muscle paralysis in which locomotion propels the trunk because the muscle force is maintained and the movement components are preserved” (Babinski and Tournay 1913, p. 197). Babinski considered that asynergia and

adiadochokinesis represented a breakdown in the spatial and temporal organization of movement synergies respectively (Babinski 1902).

Is the concept of asynergia valid?

Whereas hypermetria and adiadochokinesis are still accepted as main cerebellar symptoms, it is not the case for asynergia. For this symptom, very strong objections came from several authors, such as Déjerine and Thomas in France and Gordon Holmes (1876-1966) and Walshe in England, the same British neurologist who had recognized the great value of his extensor plantar reflex.

Déjerine, who ultimately became professor of neurology at the La Salpetrière, and close associate of Thomas, a well-known expert on the cerebellum, was one of the first to criticize Babinski's concept of synergy. Thomas stated that "the cerebellum assures body equilibrium by regularly associating the compensatory movements necessary to maintaining stability during movement execution" (Thomas 1911, quoted by Déjerine 1914, 1926, p. 412). This is in agreement with the two observations made by Babinski in his paper of 1899, in which the absence of compensatory movements resulted in a loss of balance in cerebellar patients. However, Thomas suggested that the dysmetria (hypermetria) could be the cause of asynergia by disturbing equilibrium during movement performance. "During walking the movements of the limbs, the trunk, the shoulders, neck and head must combine to maintain balance. If, due to a cerebellar lesion, each of the movements is executed in an unmeasured way, the patient is unable to coordinate them and because he is afraid, he will lose his balance, he walks slowly. As a result we see what role dysmetria plays in the loss of balance whether it is in walking or in stationary standing or whatever movement of the body. Asynergia can only be the consequence of dysmetria" (Thomas 1911, quoted by Déjerine 1914, 1926, p. 472).

Holmes, an English neurologist who treated many soldiers with traumatic head injuries in the battlefield hospitals in France during the First World War, systematically studied the effects of acute cerebellar injuries in 40 men. In his original article in Brain in 1917, Holmes very succinctly reported finding Babinski's asynergia. However, later, he expressed some scepticism, so that in 1939, he stated that the term *asynergie* in Babinski's original sense to signify a lack of co-ordination between wider groups of muscles, including those which should fix segments of a moving limb, to be "unnecessary because it would include symptoms of different origin".

Meantime, Frederick Tilney, an American neurologist, showed that muscles are functionally arranged in "synergic units" of antagonist pairs that were more frequently co-activated than they were activated reciprocally (Tilney and Pike 1925). Furthermore, they suggested that the synergic activity of these units was controlled by the cerebellum. At a joint meeting of the American Neurological Association and the neurology section of the Royal Society of Medicine in 1927, Tilney and Pike's suggestion was vigorously opposed by both Francis Walshe and G. Holmes. Walshe objected that cerebellum could not be involved in the control of muscle synergies because Sherrington had clearly shown that this function was already performed by the spinal cord. Holmes felt that in his clinical opinion no such disturbance as asynergia of antagonist muscles existed in sufficient degree to account for cerebellar dysfunction (Discussion reprinted in Brain, 50, pp 377-390, 1927). Finally, in his review published in the *Revue Neurologique* in 1958, on cerebellar syndrome, François Lhermitte (1921-1998) discussed Babinski's definition of asynergia as a specific cerebellar deficit: "If we understand by the term synergy to be that neural organization which presides over a set of several muscles that accomplish an act, this function is certainly not included in the cerebellum … however, the cerebellum is indispensable to its correct execution" (Lhermitte, 1958, p. 447).

As a result, asynergia was not included in the listing of terms and definitions of cerebellar pathology reported by Walker and Botterell (1937, p. 330), nor was it mentioned by Dow in his chapter on the clinical symptomatology of cerebellar disorders (in Dow and Moruzzi, 1958). This failure to mention asynergia was again more recently noted by Fine et al. (2002).

Babinski's aysnergia revisited

Babinski's asynergia fell into disuse until the concept re-emerged in the context of two main lines of evolution in the way of considering the central control of movement. A first line was proposed by Whachholder (1893-1961). According to him, a goal-directed movement is the result not only of the central control of muscles but also of the interactions with the viscoelastic forces and the inertia of the musculosquelettal system and with the external forces such as the gravity forces (1928). Nicolas Bernstein (1896-1966) in 1967 insisted on the redundancy or the excessive degrees of freedom for the achieving a goal-directed movement and he stressed the role of motor learning in building up the most effective coordination scheme to achieve the goal.

A second line of evolution was the suggestion that the cerebellum plays a particular role in motor learning (Ito 1984). Smith (1996) in a review paper, proposed the hypothesis that "cerebellum plays an important role in motor learning by forming and storing associated muscle activation patterns for the time dependent control of limb mechanics. By modulating the co-contraction of agonist-antagonist muscles … the viscoelastic properties of joints can be regulated throughout movement …" Thach et al. (1992), in his review paper on "cerebellum and the adaptative coordination of movement", claims that "for coordinated complex movements, we would propose that the cerebellum is the executive: it learns, initiates, continues and stops them through its actions on the downstream structures" Similarly, the concept of dynamic internal model of movements built up by learning was proposed by Wolpert et al., (1995). These models were used to simulate the dynamic disturbances caused by movement execution (direct dynamic models) and to anticipate the appropriate corrections (inverse dynamic models). Wolpert et al. (1995, 1998) suggested that these internal models might be stored in the cerebellum. Some confirmation is provided by the more recent investigations using fRMI by Imamizu et al. (2003, 2004).

Holmes was correct in claiming that the term of synergy used by Babinski concerned functionally different muscle group actions. The trunk-limb synergy was aimed at preserving equilibrium during movement, the limb extension associated with hip flexion was aimed at providing a support allowing the supine subject to sit down, and the simultaneous flexion movement of several joints, such as hip and knee were used for the smooth performance of a multijoint movement. This new view of the cerebellum as a centre for storing the learned internal dynamic (and inverse dynamic) models used to anticipate the disturbances associated with movement performance gives new meaning to the concept of asynergia. The loss of direct and inverse dynamic commands compensating for disturbances of posture and equilibrium resulting from movements suggests a possible unifying mechanism for explaining the functional diversity of the various mutijoint synergies and their loss after cerebellar damage (see Massion et al. 2004). With his typical perspicacity for clinical observation, Babinski may be credited for noticing that a large variety of functionally different mutlijoint movements associated in a single act were consistently disturbed or absent in cerebellar patients. To this specific cerebellar symptomatology, he bestowed the term asynergia. In contrast to the innate coordinations proposed by Duchenne de Boulogne, the synergies of Babinski were learned and stored in the cerebellum, and ultimately used to anticipate the perturbation of posture, equilibrium and movement trajectories associated with movement performance. In this sense, Babinski was really a prescient prophet for what could only be explained after a long empirical study of cerebellar function.

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