CHAPTER 2

The terminology of akinesia, bradykinesia, and hypokinesia: past, present and future

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Abstract

The terms akinesia, hypokinesia, and bradykinesia are extensively used to describe difficulties observed in motor function. However, these terms are inconsistently used in the literature nowadays, and they often cover a broader range of motor function disturbances than the exact translations from Greek would predict. The purpose of the present study was to investigate the origin and change in meaning of these terms over time, particularly in relation to Parkinson's disease. To this aim we studied a selection of medical and neurological textbooks and their references, together with works of experts in the field of movement disorders from 1817 till 2012. Subject indexes and tables of contents were searched for the words (or their German or French translation) akinesia, bradykinesia, and hypokinesia; paralysis agitans or Parkinson's disease; and extrapyramidal. We found that French authors have introduced the term bradykinesia, with which they initially described the slowness of movement in patients with cervical dystonia, while around 1920 they introduced the 'bradykinetic syndrome' to describe a range of motor symptoms in patients with Parkinson's disease. Akinesia and hypokinesia had already been used in the 19th century, opposite to hyperkinesia, to denote peripheral nerve palsies, but were used in the context of Parkinson's disease in particular since 1920. The use of akinesia, bradykinesia and hypokinesia increased when the prevalence of patients with parkinsonism boomed due to the encephalitis lethargica epidemic in this period, and also with the discovery of levodopa treatment from 1961. The effects of levodopa on motor function had to be carefully observed and recorded, and akinesia was the term predominantly used to describe the complex of motor symptoms in Parkinson's disease at that time. With the development of criteria sets and their extensive use from the 1980s, bradykinesia replaced akinesia as most popular term. The last decades, myriad medical papers have been published, and with the introduction of the internet also have become easily dispersed and accessible for a large public. The giant increase in the publication number over time also increased the heterogeneity in use of the different terms. To avoid confusion and errors, we provide some suggestions on the use of terms in the future, although a widely supported consensus is needed to decide upon the exact terminology. Most importantly, we believe that accurate descriptions of the different motor disturbances, as James Parkinson already did, still seems the best solution.

Introduction

"The active movements are slow and not as fluent as they used to be. It takes a while before the muscles obey the mind" (Oppenheim, 1894 [1]).

The terms akinesia (AK), hypokinesia (HK), and bradykinesia (BK) are extensively used to describe difficulties observed in motor function. Although the exact translations from Greek would indicate *no* (a-), *decreased* or *smaller* (hypo-) and *slow* (brady-) movement (-kinesis), these terms often cover a broader range of motor function disturbances than the exact translations would predict, and are inconsistently used in the literature nowadays. The purpose of the present study is to investigate the origin and change in meaning over time of the terms AK, HK and BK. Since these terms, at least today, are inextricably linked to Parkinson's disease, we will focus on the changes in terminology since the introduction of the shaking palsy / paralysis agitans by James Parkinson in 1817 [2] up to the present.

Methods

We consulted medical and neurological textbooks published between 1817 and 2012. In order to secure a representative list of books from this period, we selected textbooks in English, German and French language from two standard books, *The founders of neurology* [3] and *Garrison's history of neurology* [4] (see Table 2.1).
Additionally, three important 20th century neurological multivolume handbooks were added [5,6], notably *'Handbuch der Neurologie'* by Lewandowsky (1910-14; supplements in 1922-29), *'Handbuch der Neurologie'* by Bumke & Foerster (1935-37) and *'Handbook of Clinical Neurology'* by Vinken & Bruyn (1968-2002) to which we added a selection of commonly used 20th century textbooks and works of experts in the field of movement disorders (Table 2.1). Subject indexes and tables of contents were searched for the words (or their German or French translation): akinesia, bradykinesia, and hypokinesia; paralysis agitans or Parkinson's disease; and extrapyramidal. Chapters on paralysis agitans or Parkinson's disease were studied entirely. In addition, we searched for relevant literature in the reference lists of consulted books and papers. Moreover, a literature search was performed in Medline to identify English written potentially relevant articles published between 1950 and 2012 to study the ways and contexts in which these terms have been used over time, using "bradykine*[ti] OR akine*[ti] OR hypokine*[ti]", filter: English. This search revealed 1122 articles, the titles of which were screened for relevance, and eventually

190 papers were selected and screened for the words akinesia/akinetic, bradykinesia/bradykinetic, hypokinesia/hypokinetic to create an overwiev of the use of terms over this time period.

Results and discussion

19th and early 20th century

From paralysis agitans to Parkinson's disease

Symptoms and signs of what we now recognize as Parkinson's disease have been described before James Parkinson's well-known *Essay on the shaking palsy* (1817; e.g. see [7,8]). The cardinal motor features ascribed to this disease since then, i.e. lessened muscle power (*paralysis*) and tremor (*agitans*), led to difficulties to distinguish the disease from other disorders with similar manifestations. Charcot, in collaboration with Vulpian, for example, struggled to differentiate between paralysis agitans and other tremorous disorders such as multiple sclerosis: "In all these descriptions, our own included, there was a total confusion between paralysis agitans and multiple sclerosis" (from: Goetz *et al.* 1995, p.113 [9], referring to Charcot, 1869).

In 1879, Charcot suggested to use the term Parkinson's disease instead of paralysis agitans, as it became known that tremor was not always present in those with Parkinson's disease and, more importantly, rigidity was recognized as the major cause for the motor disturbances, and not paralysis [9] (p.119). Charcot (1879): "According to that author [Parkinson], decreased muscle strength always accompanies the disease, and it is probably true for a good number of cases. But this is far from being the rule. Many patients, including ours today, maintain, at least for a long time, good muscular strength" [10] (p.1068). Conceivably, this change in major hallmark focus followed a change in clinical practice: while the descriptions of Parkinson and other authors from the first half of the 19th century had been predominantly observation based, from the last decades of this century physical examination was increasingly conducted [11]. The concept that slowness and impaired initiation of movements were not fully explained by rigidity, but had to be considered a separate feature, was cautiously put forward by some authors around 1900, such as Charcot in his 9th lesson in 1887: "More commonly, muscular rigidity only comes on or predominates in the most advanced stage of paralysis agitans. Yet, long before rigidity actually develops, patients have significant difficulty performing ordinary activities; this problem relates to another cause" [12]. It was also mentioned

by Oppenheim: "The hindering and slowness of active movements is primarily caused by the muscle tension. However, as it may be encountered at a stage in which muscle tension is still normal, the disturbance can be regarded a distinctive symptom to some extent" [1] (p.807; translated by JS), and Lewandowky: "The poverty of movement is particularly related to muscle stiffness. In the past, this has not usually been interpreted as a separate symptom, but as an inevitable consequence of the hindering of active movement. Zingerle [Hermann Zingerle, 1879-1935, JS] was the first to point out that it must be regarded as a separate symptom" [13] (p.943; translated by JS).

However, still many authors insisted upon the concept that all motor symptoms were explained by the prominent rigidity and a single term to describe the slowness of movement and problems in movement initiation was not justified. Extensive descriptions of symptoms and signs were common.

Introduction of the terms akinesia, hypokinesia and bradykinesia

The first term that can be found in textbooks, is AK (see Table 2.1). In the second half of the 19th century, this term was used by several physicians [14-18] in a general sense - originating from the old 18th century nosology of neurosis of sensibility and of movement – as the opposite of hyperkinesia. The latter was used for, for example, muscle cramps, while AK was preserved for paralysis. Moritz Romberg, in the English translation by Edward Sieveking (1853) of his well-known *Manual of the Nervous Diseases of Man*, in the chapter on 'Neurosis of Motility', explained that "the activity of centrifugal motor nerve is manifested by the contraction of the muscular fibers supplied by it, and this manifestation, when abnormal, may be exalted or depressed and extinguished; in the former case we have to do with hypercinesis, in the latter with acinesis" [19] (p.275). AK is also mentioned in texts from the late 19th century to describe the complete loss of movement that occurred in some pain syndromes (known as "akinesia algera", a term introduced by Paul Möbius in 1891 [20], that frequently appears in textbooks up to the early 20th century), or that accompanied hysteria in some cases (Table 2.1). The French (originally Swiss) physician Sigismond Jaccoud (1830-1913), in a chapter on hysteria in "*Traité de pathologie interne*", literally translated "l'akinésie" as "l'abolition de motilité", opposite to "hyperkinésie hystérique" that manifested as tonic convulsions [21] (p. 410). At the time working at Lariboisière hospital in Paris, Jaccoud was the first to mention AK in relation to paralysis agitans: "Later, generally after several years, the increasing muscle

Table 2.1. Selection of textbooks and chapters on neurology of the 19th and 20th century

(First) Author or Editor	Year, edition	AK	BK	HK	PD term[$]	Comments
Cooke [84]	1820-3, 1st	-	-	-	-	PD not discussed
Romberg [14]	1840-6,1st	+	-	-	PA	1843 (B1, P2) p.277: acineses is used opposite to hypercineses, not used in relation to PA
Reynolds [15]	1855, 1st	+	-	-	PA	p.225: acineses, or paralyses, and hypercineses, or spasms, are groups of 'inorganic / functional diseases of the nerves'. p.163: PA treated in chapter 'Increased motility–tremors'
Jaccoud [21]	1870, 1st	+	-	-	PA	AK in chapter on hysteria ("the abolition of movement" (p.410)), and related to PA, p.426: "…after several years, the progressive weakness ends in akinesia"
Hammond [85]	1871, 1st	-	-	-	PA	p.707: Symptoms of PA: tremor and muscular weakness
Wernicke [86]	1881-3, 1st	-	-	-	PA	PA in a chapter on MS, when tremor is discussed.
Grasset [87]	1881, 2nd	-	-	-	PA	p.888, on PA: "… characterized by tremor and a progressive decrease in muscle strength." First time rigidity is mentioned with reference to Charcot (p.892)
Schwalbe [88]	1881, 1st	-	-	-	-	PD not discussed.
Ross [16]	1881, 1st	+	-	-	PA, PD	Vol.2, p.791, on PA: "…continuous tremor of the voluntary muscles, and peculiar alterations in the attitudes of the body.
,,	1883, 2nd	+	-	+	,,	Vol.1, p.97: AK and HK are mentioned, not related to PA
Gowers [89]	1886-8,1st	-	-	-	PA, PD	p. 995: "PA …is characterized by the symptoms indicated by its name, muscular weakness and tremor, and also by muscular rigidity"
Wood [90]	1887, 1st	-	-	-	PA, PD	p.141: "…tremors, progressive failure of power in the affected muscles, slowly-developed moderate rigidity, and, in the most advanced stages, peculiar alterations in the habitual positions of the body and in the gait."
Dana [91]	1892, 1st	*	-	-	PA, PD	p.480: Dominant symptoms: tremor, rigidity ('the muscular movements are slow, especially the initiation of a movement'), sensory and vasomotor disturbances.
Oppenheim [1]	1894, 1st	*	-	-	PA, PD	p.804. PA symptoms: tremor, continued muscular rigidity, retardation and difficulty in active movements, a modification of the gait
Dercum [92]	1895, 1st	*	-	-	PA, PD	p.293. Chapter on PA. "… coarse tremor, peculiar facies, slow deliberating, hesitating speech, the peculiar attitude, bread-crumbling action of the fingers."
Mills [17]	1898, 1st	+	-	-	-	p.604. AK in chapter on cerebral paralysis in children: "There are *hyperkineses*, disorders in which motility is exaggerated, rather than *akineses*, or paralyses." PD not discussed.
Church [93]	1899, 1st	-	-	-	PD, PA	p.515. The first where not tremor, but rigidity is regarded the dominant motor phenomenon: '..the slowness of movement'
Hirt [18]	1899, 1st	+	-	-	PA, PD	p.58. Akinesis opposite to hyperkinesis. p.506. PA diagnosis: muscular weakness, tremor, peculiar rigidity, characteristic facial expression, posture, 'propulsion'.

Dejerine [94]	1901, 1st	-	-	-	PA, PD	p.509. Tremor and rigidity are classic symptoms, no evident muscular weakness.
Monakow, von [95]	1905, 2nd	+	-	+	-	p.461. AK + HK are denoted forms of paresis ("movement can still be performed but not in the correct order or timing"), in contrast to paralysis. PD is not mentioned.
Purves Stewart	1906, 1st	-	-	-	PA	PA symptoms in lectures on involuntary movements (p.70), postures & gaits (p.244): tremor, rigidity, slow and stiff voluntary movements of limbs and trunk.
,, [96]	1908, 2nd	*	-	-	,,	Akinesia algera was added to the previous version.
Starr [97]	1907, 2nd	-	-	-	PA, PD	p.756, on PA: "by tremor, by rigidity of the muscles which produces slow movements, abnormal postures and an unsteady gait with tendency to fall, and by abnormal sensations"
Curschmann [98]	1909, 1st	*	-	-	PA	p. 729. (written by F. Pineles) Symptoms of PA: tremor, rigidity which is associated with slowness of movement.
Lewandowsky [13]	1910-4,1st	*	-	-	PA	1914, Vol. 5, p.940, on PA: tremor, a peculiar muscular rigidity and slowing of voluntary movements, poverty of movement, equilibrium disorders, …
Marie [99]	1911, 1st	*	-	-	PD	in chapter on tremor, no information on other symptoms
Mohr [100]	1912, 1st	+#	-	+	PA	p.546: HK (paresis) and AK (paralysis) are found in motor nerve dysfunction. Chapter on PA symptoms (by H. Curschmann): tremor and rigidity (p.928)
Bing [101]	1915, 1st	*	-	-	PA	In the lecture on dyskinesias in the edition translated by Allen in 1915, p.87: "denominated by muscular rigidity and peculiar shaking movements"
Jelliffe [102]	1917, 2nd	-	-	-	PA, PD	p.500: "hypertonus, rigidity , slowness of movement, increasing stiffness, …"
Strümpell [103]	1922,23th	-	-	-	PA, PD	Vol. 2, p.830. Symptoms: tremor, muscle stiffness, decreased movements and muscle shortening. Rigidity related to decreased movements.
Bouman [25]	1923-30,1st	+	-	+	PA	1930, Vol. 2, 2nd part, p. 76 poverty of movement is called HK, in more severe cases AK. Distinct from rigidity.
Brain [104]	1933, 1st	-	+	-	PA, PD	p.346. 'Bradykinesias' as one type of the "involuntary movements" seen in encephalitis lethargica.." p.450. PA symptoms: tremor is usually the first symptom, followed by weakness, stiffness and slowness of movement.
Bumke [105]	1935-6,1st	+	+	+	PA, PD	Vol. 5, p.429. "A number of symptoms can be addressed under the concept of HK to AK: decreased associated movements, disturbed movement initiation, slownesss and decreased amplitude of movements." Vol. 11, p.368: BK defined as slowness of movement. p. 789 "…is a more or less extensive akinesia (hypokinesia)…which is a poverty of all motor activities, both automatic and voluntary movements".
Wilson [34,35]	1940, 1st	+	+	+	PA, PD	Vol. 2, p.792. AK second symptom after tremor (and followed by akathasia, rigidity, BK, …); HK and AK are used interchangeably: "Bradykinesia or slowness of movement is the counterpart of the muscular rigidity." (p.795)
,,	1955, 2nd	+	+	+	PA	In the index, akinesia is used while in the 1st edition this was akinesis. In the text, akinesis is still used (p. 927). Same for bradykinesia and bradykinesis.

Table 2.1. Selection of textbooks and chapters on neurology of the 19th and 20th century (*continued*)

(First) Author or Editor	Year, edition	AK	BK	HK	PD Terms$	Comments
Denny-Brown [54]	1962, 1st	+	+	+	PA	AK, BK and HK are interchangeably used without definition. p.42: "AK is the cardinal symptom of parkinsonism".
Vinken [106]	1969, 1st	+#	+	+	PD	Vol. 6, *Diseases of the basal ganglia*. HK covering term in both chapters 5 and 6 Under the heading 'Hypokinesia': "difficulty in initiation of movement … restriction in amplitude" (p.181); p.183.:" tremor, rigidity, HK and disorders of posture and equilibrium. … HK is later defined as slowness of movement. AK is mentioned a few times as substitute of HK, but not defined. BK is used only once, and regarded similar to HK (p.181).
,,	1986, 2nd	+	+	+	PD	Vol. 49, 'Extrapyramidal disorders'. Ch. 5, p.65. AK is used as umbrella term for the motor disturbances of PD, The author cites Denny-Brown using HK, but puts AK between brackets to show his preference for the latter term. Ch.6, p.87. AK, HK and BK are used interchangeably. HK is used as 'principal symptom' next to rigidity, postural instability and tremor. AK is used as 'cardinal symptom' for a diagnosis.
,,	2007, 3rd	+	+	+	PD	Vols. 83+84. BK predominant; defined in Ch. 13 p.331: "BK refers to slowness of movement… It encompasses difficulties with planning movement, initiating and executing movement and performing sequential and simultaneous tasks. BK is similar to AK (absence of movement) and HK (poverty of movement)." p. 329. Cardinal features of PD: Tremor, rigidity, BK and postural instability. HK and AK are also used, for similar purposes, though AK can also be seen as the extreme form of HK (p.69).
Ropper [107]	2009, 9th	+	+	+	PD	Mostly BK, but AK and HK are also used. Ch.39, p. 1034. "hypo- and bradykinesia, resting tremor, postural instability, and rigidity are the core features of PD" and "slowness and lack of natural movements (BK and HK, respectively) are …." p.940. "…effectiveness of movement is nonetheless impaired by the patient's disinclination to use the affected parts (HK or AK), by slowness (BK) and by rigidity and tremor.
Clarke [108]	2009, 1st	+#	+	+	PD	Ch. 5, p. 155. Section heading is akinetic-rigid disorders, amongst which PD, and of which AK is "the defining, obligatory and principal disabling feature…comprising slowness of movement (BK), poverty of movement and small amplitude of movements (HK), difficulty initiating movement or with simultaneous motor acts and … fatiguing and decrementing amplitude of repetitive alternating movements…" The UK PDS Brain bank diagnostic criteria are shown, which contain BK but not AK.
Donaldson [72]	2012, 1st	+	+	+	PD	p.139. AK (loss of movement), HK (a paucity of movement) and BK (slowness of movement) are included together under the rubric of AK. p. 160. In the definition of PD, the term AK is used, but for the diagnosis BK is required, defined as 'slowness of initiation of voluntary movement with progressive reduction in speed and amplitude of repetitive actions'. p.242. Cardinal PD features: tremor, rigidity, AK and impairment of posture and balance.

PA: Paralysis agitans (or its German ('Schüttellähmung'), French ('paralysie agitante') or English ('shaking palsy') translation); PD: Parkinson's Disease; AK: akinesia, HK: hypokinesia, BK: bradykinesia, *akinesia algera, # akinetic mutism, $ in order of importance, or, if equally important, appearance

weakness ends in akinesia, and this paralysis is added to the tremor" [21] (p. 426; translated by JS).

The term HK in relation to Parkinson's disease appears in medical textbooks quite late, as compared to AK (Table 2.1). In the second edition of *Treatise on the diseases of the nervous system*, Ross mentioned that Albert Eulenburg [22] had introduced the term hypokinesis "to designate the diminution of motor reaction to excitation, while he limits akinesis to its abolition" [16] (p.97), opposite to hyperkinesis, but, in this chapter on general symptomatology, paralysis agitans was not mentioned. Notably, on the same page Ross also stated that he would use the term AK in his text to include both AK and HK "in order not to multiply words". Otfrid Foerster, in *Zur analyse und pathophysiologie der striären Bewegungsstörungen,* connects these terms as he speaks of, and introduces, the term "das hypokinetisch-rigide Pallidumsyndrom" and "der Parkinsonschen Krankheit" [23] (p. 11). On page 71 he writes: "Hence, its [i.e. of the globus pallidum, JS] disturbance results in hindering of voluntary movements and the lack of associated, successive, reactive and expressive movements on the one hand (hypokinetic component), and in increased resistance to stretch, to increased fixation tension, postural abnormalities, to tremor and increased muscle tone on the other hand (rigid component)" (translated by JS). From its introduction, HK is merely used to classify the type of movement disorder, opposite to hyperkinesia, especially in German literature, and not to describe distinct motor function disturbances. The American-born but European-educated neurologist Samuel Alexander Kinnier Wilson (1878-1937; his name is associated with Wilson's disease) in his publication of the Croonian Lectures on disorders of motility and muscle tone in 1925 stated: "... 'weakness' or hypokinesia and 'involuntary movements' or hyperkinesias are but different aspects of activity of the same mechanisms; in one case there is underaction, in the other, overaction, of motor function" [24]. Additionally, some authors use HK as the less severe variant of AK, the latter seen as total abolition of movement, such as the Dutch neurologist Bernard Brouwer [25] (Table 2.1) and Fritz Lotmar, neurologist in Bern, in the chapter on 'das hypokinetisch-hypertonische Syndrom' in Bumke and Foerster: "A number of symptoms can be subsumed under the concept of hypokinesia to akinesia: ..." [26] (p.429; translated by JS). Subsequently, a variety of motor disturbances is enumerated, amongst which absent or negligible reactive or expressive movements, as well as normal accompanying movements in voluntary acts, limitation of voluntary initiating movements ("Bewegungsarmut"/poverty of movement), the slow start and end, and the decreased amplitude of movements. Lotmar uses the word adiodochokinesis (referring to the original application by Babinski) to describe

slowness of movement in rhytmic alternating movements, and adds that the term HK must be reserved for those cases where (what today we would call) decrement is present: “Only the decreased frequency with plateau phase with absent or relatively little slowing of individual movements should be called adiodochokinesis, not, however, only a gradual decrease in the amplitude of successive movements” [26] (p. 430;translated by JS).

BK is mentioned for the first time in 1907, by the French physicians Henri Verger (who became professor of clinical medicine in Bordeaux) and Jean-René Cruchet (who became professor of pathology and treatment in Bordeaux; his name is associated with encephalitis lethargica, Economo-Cruchet disease and spasmodic torticollis, Cruchet disease) [27]. With "bradykinésie spasmodique" they described the slow involuntary movements in a group of patients with symptoms of what we now would describe as cervical dystonia. Notably, in this publication the authors stated that Parkinson’s disease patients were not to be included in this syndrome, as the symptoms of those with Parkinson’s disease were too diffuse. However, in a later publication (*Les États Parkinsoniens et le Syndrome Bradykinétique,* 1925, a 200-page book), they do associate the terms as they speak of "le syndrome bradykinétique", or "the bradykinetic syndrome", which could be seen in Parkinson’s disease, progressive lacunar cerebro-sclerosis and post-encephalitic patients [28] (he also applies the term "kinésie paradoxale", when a person is suddenly able to jump up and move, induced by a certain emotion; p. 15). In this publication, Verger explains that the term ‘bradykinetic syndrome’ was first used by Cruchet in 1921 for the same phenomenon he himself and a certain dr Hesnard referred to as "viscosité musculaire", p. 17, adding that the term “syndrome bradykinétique, qui est d’origine bordelaise” [bradykinetic syndrome that originated from Bordeaux] is preferable. Furthermore, Verger explains the origin of the term BK: “pour dénommer certains types de mouvements involontaires” [to name certain types of involuntary movements]. Confusion occurred when Pierre Marie started to use the term for involuntary slow movements resembling athetosis, p. 18; therefore Verger proposed the following definition: “The ‘syndrome bradykinétique’ consists of a kind of slowness at the start and execution of voluntary movements, without paralysis in strict sense, and without any coordination disorder” [28] (p. 19; translated by JS).

Generally, from Table 2.1 it can be deduced that AK, HK and BK in the context of Parkinson’s disease are not mentioned in neurological textbooks until the 1920s. From 1920, however, these terms are increasingly used.

Evolution of terms after the encephalitis lethargica epidemic

The encephalitis lethargica epidemic of 1918-1928 and the subsequent observations on post-encephalitic parkinsonism seem to have constituted a landmark on the attention to parkinsonism, the search for its pathological substrate, and as a result, on the terminology of its symptoms [29-32]. Specifically, in these years a large number of papers have focused on the differences in symptoms between post-encephalitic patients and patients with Parkinson's disease (which at that time, was still called paralysis agitans quite often, despite Charcot's suggestion). Cruchet emphasized that post-encephalitic parkinsonism and Parkinson's disease had to be regarded as different diseases that both led to the "bradykinetic syndrome", a term he and his French colleagues highly promoted to be used, consisting of 1) slowness of movements ("that is why we have designated this syndrome as the 'bradykinetic syndrome' ", and "rather neglected until we described it"); 2) immobility; 3) characteristic posture; and 4) paradoxical kinesia [33]. He opined, however, that a clear distinction had to be made between "Parkinsonian bradykinesia" (characterized by its insidious onset, at an advanced age, its progressive evolution and late salivation and specifically its particular rest tremor) and "postencephalitic bradykinesia" (characterized by a younger age at onset, calm and impassive mental state, no tremor or not as often, its early salivation, possibility to improve or be cured, and the presence of torsion spasms). BK as described by Cruchet here, is linked to other symptoms as well, as a term covering a variety of symptoms that could accompany Parkinson's disease en post-encephalitic parkinsonism. As an important author at the post-encephalitic period, Kinnier Wilson, in his 1925 Croonian lectures (*vide supra*), stated that, in striatal disease, "voluntary" movement is problematic on different levels: 1) strength or weakness of movement; 2) beginning, course and cessation of movement; and 3) poverty of movement or "Bewegungsarmut" [24]. Contrary to the publication of Cruchet on BK in the same journal, Wilson speaks predominantly of AK ("Parkinsonian akinesia ...seems to me explicable largely by deprivation of, or serious reduction in, normal impulses to movement both of the 'voluntary' and of the 'spontaneous' kind", and "akinesia, or poverty of movement,...") which shows that the preference of the author determined which term was used. In his lectures, apparently, Wilson reserved AK for the movement disorders in Parkinson's disease and "hypokinetic-rigid syndrome" for striatal function disorders in general. BK is mentioned, but not described, but once [24]. Later, in his posthumously published two, respectively three-volume work *Neurology*, HK and AK are used interchangeably to describe poverty of movement, while BK – defined as slowness of movement - is

separately reported on [34,35] (Table 2.1). In German literature most authors used HK and AK in relation to Parkinson's disease, although BK is also found (Table 2.1).

These observations show that in the first half of the 20th century the German and English authors favour AK and to a lesser extent HK to describe the motor function disturbances in Parkinson's disease, while the French use BK, and try to bring this term in vogue.

Second half 20th century

Introduction of levodopa (1960s) necessitating rating and staging scales

The 1960s, including the discovery of levodopa and its beneficial effects on motor function, may be regarded as another major critical period in the terminology of Parkinson's disease symptoms. With levodopa, AK could improve without changes in rigidity, and *vice versa* [36]. Although this independency of symptoms had already been observed in the 19th and early 20th century [1,13], this could now be demonstrated more easily. Research on Parkinson's disease gained momentum and thousands of publications have been written since [37], in particular on the effects of newly developed pharmacological and surgical interventions on motor function.

On the classification and evolution of terms, these developments had two important effects: a certain diagnosis was needed to select the right patients for inclusion in clinical studies, and staging and clinical disability / rating scales were developed to determine the effects of different interventions on motor function. Since 1960 a variety of rating and staging scales for Parkinson's disease have been published with the initial goal to assess symptoms and signs, their relation with disease severity and disability, and to test the efficacy of available surgical and pharmacological treatment [38-42]. As can be seen in Table 2.2, most clinical rating scales use the term BK. The well-known Hoehn & Yahr scale, still often used today, mentions both AK and BK once – as one of the principal symptoms of Parkinson's disease, next to rigidity and tremor, but does not define the terms. Additionally, the need to distinguish Parkinson's disease from other parkinsonian syndromes resulted in the development of different clinical diagnostic criteria sets, some of which were validated with *post mortem* material [43-48] (Table 2.3). The need to make a distinction between post-encephalitic parkinsonism and Parkinson's disease gradually disappeared because of the decreasing numbers of post-encephalitic parkinsonism patients (66% of all patients with a parkinsonian syndrome suffered from post-encephalitic parkinsonism around 1930, while this was only 25% in 1950 and <10%

in 1960 and no new cases after this period [49]), but clinical distinction with for example progressive supranuclear palsy and multiple system atrophy remained difficult. Up to this period, at least two of the following four signs were required to diagnose Parkinson's disease: tremor, rigidity, AK and postural instability (acronym TRAP) [50]. In 1988, Gibb and Lees were the first to publish proposed diagnostic criteria for Parkinson's disease – the *UK Parkinson's Disease Society Brain Bank criteria* - in a paper on the occurrence of Lewy bodies in Parkinson's disease [43]. Though slightly adapted, these criteria are still used to diagnose Parkinson's disease today, but its validity is currently discussed [51]. Hughes mentioned that the authors of the first criteria paper insisted on the use of BK – instead of AK - as principal feature of Parkinson's disease, as this would eliminate patients with essential tremor and cogwheeling, who otherwise would also meet the less strict AK definition [45]. It is noteworthy that, besides slowness of initiation of voluntary movement, Gibb and Lees included progressive reduction in speed and amplitude of repetitive actions in the definition of BK. Next to the development in which the term AK (predominantly used up to that period) was replaced by BK as one of the cardinal signs in Parkinson's disease, the definition of BK was extended: slowness of initiation of voluntary movements with progressive reduction in speed and amplitude of repetitive actions. It is conceivable that the introduction and subsequent extensive usage of the clinical Parkinson's disease criteria, facilitated the use of the term BK in Parkinson's disease. Moreover, the velocity of movement was one aspect of the motor disturbances that could be objectively measured, and therefore BK was frequently used as an outcome measure in clinical (intervention) studies. Additionally, multiple studies focused on methods to quantify this slowness of movement.

The shift in usage of terms over time in the second half of the 20th century can evidently be observed in Figure 2.1, but can also be clearly seen in the various volumes of the *Handbook of Clinical Neurology* (HCN), which - in the three series covering the period between 1968 and 2011 (series 1 and 2 edited by Vinken and Bruyn, series 3 by Aminoff, Boller and Swaab [52]) - contain several volumes on movement disorders (see Table 2.1). In Volume 6, the first volume on movement disorders of the original series, HK is the term mostly used (although AK and BK are also used for similar symptoms) to describe the movement disorder of basal ganglia diseases including Parkinson's disease, and comprises loss of associated movements such as decreased arm swing, hesitancy in initiating movements, and restriction in amplitude [53] (p.135). It can be deduced that the London trained, Boston neurologist Derek Denny-Brown, a renowned author of that period, favored the term HK in his chapter on basal ganglia diseases (although in his own book *The basal ganglia*

Table 2.2. A selection of commonly used clinical rating scales in Parkinson's Disease

Clinical rating (impairment and/or disability) scale	Year	Terms
Northwestern University Disability Scale [38]	1961	No terms, only disability is scored
Hoehn & Yahr Scale [40]	1967	Only AK and BK (without descriptions of the terms) are mentioned in the text, as hallmarks of PD: "The clinical picture of one may be dominated by tremor, of another by rigidity or akinesia." Mainly descriptive symptoms are used: stiffness, slowness, handwriting disturbance, loss of arm swing.
The Parkinson's Disease Rating Scale by Webster [41]	1968	BK of the hands is the first item to be scored (slowing of movement rate on a 4 point scale, including writing disturbances). BK is together with rigidity and tremor one of the hallmarks of PD. No report on HK. AK is only mentioned in the text accompanying the scale: "the masking has been attributed to rigidity of the facial muscles but I see no reason why AK is not just as likely an explanation."
Schwab and England activities of daily living Scale [42]	1969	No terms, only disability is scored.
Columbia University Rating Scale [109]	1971	Contains one item (25/25) of BK which includes slowness, poverty of movement, hesitation on initiating movement and arrest of ongoing movement, and freezing. No AK or HK.
Clinical rating scale section of "Classification of extrapyra–midal disorders: proposal for an inter-national classification and glossary of terms" [56]	1981	In the movement profile section, under the heading 'HK', rigidity and AK have to be scored on a 4-point scale (the latter including BK for 'slight AK' and HK for 'moderate AK', while AK is used for 'severe AK').
Unified Parkinson's Disease Rating Scale (UPDRS) Part III motor examination [110,111]	1987	Items 23-26 are about slowness of movements of the extremities (no terms are used), item 31 is about body BK and HK: slowness, hesitancy, decreased arm swing, small amplitude & poverty of movement. With the introduction of the MDS-UPDRS in 2008, body BK is called 'global spontaneity of movement'.

AK: akinesia, BK: bradykinesia, HK: hypokinesia; MDS: movement disorder society; PD: Parkinson's disease. Modifications of scales in which no new items have been added, have been omitted.

Table 2.3. Diagnostic criteria in Parkinson's disease

Developers	Year	Description of publication	Terms
Gibb & Lees [43]	1988	On neuropathological findings, especially on Lewy Bodies, in patients who have not been diagnosed with PD.	BK is stated in the criteria, not in the text, and is defined. Diagnosis of PD: 1. BK (slowness of initiation of voluntary movement with progressive reduction in speed and amplitude of repetitive actions); 2. one of the following: muscular rigidity, rest tremor (4-6Hz), postural instability. AK or HK are not mentioned.
Ward & Gibb [44]	1990	Discusses validity of two criteria sets and results of a literature study and proposes new diagnostic research criteria for 'probable' PD.	In the introduction section they state that AK, resting tremor and rigidity are cardinal signs, in the results and conclusion section they use BK, tremor and rigidity. HK is not mentioned. To establish a diagnosis of probable PD, at least two of the three cardinal features of parkinsonism (tremor, rigidity, BK) are required, next to 4 other requirements.
Calne *et al.* [46]	1992	Proposed criteria for diagnostic subgroups in PD: clinically possible (1), probable (2) or definite (3), depending on the presence of one or more of resting tremor, rigidity, BK, or impaired postural reflexes.	The salient clinical features of PD have been discussed extensively in the literature (refers to a previous paper in which he used HK instead of BK as prominent feature). They comprise: (1) resting tremor, (2) rigidity, (3) BK, and (4) impairment of postural reflexes. Together they make up the syndrome generally termed 'parkinsonism'. BK is used, but not defined.
Hughes *et al.* [45]	1992	Re-evaluated clinical diagnosis in 100 cases with idiopathic PD according to their pathological findings and tried to establish clinical features with a positive predictive value to discriminate between PD and non-PD cases. The London Brain Bank criteria were applied (authors from the same research group as the original paper).	"The conventional criteria for diagnosis of PD are the presence of at least two of the following cardinal features: AK, rigidity, and resting tremor, in the absence of any exclusion criteria". "Some insist on the presence of BK as an essential cardinal feature, thereby eliminating cases of essential tremor with cogwheeling which would satisfy the less strict definition" (refers to [43]). 'Akinetic/rigid' is used as a clinical feature (not described), BK as a criteria symptom. HK is not mentioned.
Larsen *et al.* [47]	1994	Proposed criteria for diagnostic subgroups in PD, with special importance to resting tremor, asymmetrical disease, response to dopamine agonists and presence of atypical clinical features like dementia and clinical autonomic failure at onset and pyramidal or cerebellar signs	AK/BK is coupled, not defined, and is seen as one of the hallmarks (next to rigidity, tremor and postural abnormality)
Gelb *et al.* [48]	1999	Proposed clinical diagnostic classification based on comprehensive review of the literature regarding the sensitivity and specificity of the characteristic clinical features of PD. The levels of diagnostic confidence are differentiated: definite, probable and possible.	BK is mentioned, "the presence depends on how it is defined and is assessed - but is certainly not unique to PD, also occurring in normal ageing, Alzheimer disease....etc.", but not defined. No AK or HK.
Berg *et al.* [51]	2013	On validity of the current diagnostic criteria that are based on motor symptoms only, and not on non-motor symptoms. The UK Parkinson's Disease Society Brain Bank clinical diagnostic criteria are used (see [43]).	BK is used as one of the hallmarks of PD. Akinetic-rigid disorder is used once. No HK. BK is described as in [43].

AK: akinesia, BK: bradykinesia, HK: hypokinesia, PD: Parkinson's disease

and their relation to disorders of movement (1962) published a few years earlier, he predominantly used AK [54]). Other authors of this first volume of HCN, refer to Denny-Brown's work, and also use HK. In the second series of HCN, AK is predominantly used, although in this volume the author's preferences also seem to play a role. In chapter 5 ("Clinical pathophysiology of basal ganglia disease"), Ichiro Kanazawaa recalls a sentence from Denny-Brown from the previous series (Vol. 6, 1969), and shows that he prefers to use AK, where Denny-Brown used HK: "Denny-Brown held that hypokinesia (akinesia) is a general feature of all diseases affecting basal ganglia" [55] (p. 65). In chapter 6, the French-Canadian André Barbeau writes: "Parkinsonian akinesia is a symptom complex. We distinguish four main components to bradykinesia (or akinesia): …", using both terms interchangeably to describe the motor disturbances in Parkinson's disease [50] (p. 91). In this volume there is also a reference to a paper that had been published in 1981 [56] by a research group of international neurologists, including C. David Marsden and André Barbeau, which aimed to develop a glossary of terms, clinical classification of disorders of the extrapyramidal system, and to suggest standard rating scales for abnormal involuntary movements and postures. In the classification section of this paper, HK is put forward as the term to be used for the type of movement disorder (opposite to hyperkinesia) and comprises AK as major motor function disturbance:

> "Akinesia" is a disorder characterized by poverty and slowness of initiation and execution of willed and associated movements and difficulty in changing one motor pattern to another, in the absence of paralysis. This may include an inability to sustain repetitive movements and difficulty in performing simultaneous motor acts and may vary in severity from slight (sometimes called hypokinesia) to severe and complete immobility. The term bradykinesia should be reserved for slowness in the execution of movements [56].

In the clinical rating scale section of this paper, both BK and HK are to be scored as less severe forms of AK, respectively as slight and moderate AK [56]. Another well-cited paper that was important for terminology of motor disturbances in Parkinson's disease from that period was written in 1989 by David Marsden, a renowned movement disorder expert and one of the founders of the Movement Disorder Society, who stated in the first paragraph: "Parkinsonian patients exhibit akinesia (inability to initiate movement), hypokinesia (reduced movement), and bradykinesia (slowness of the movement itself). All these phenomena will be subsumed under the title akinesia" [57]. In the third series of the HCN, in which volumes 83 and 84 discuss "Parkinson's

disease and related disorders" (2007), BK is the term mostly used as an umbrella term and as cardinal feature in basal ganglia disorders. Just as in the second series, the authors refer to previous chapters and, at their own discretion, replace the terms used with the one they prefer, for example J. Goldmann who refers to a study in 1961 upon the effects of levodopa on motor symptoms in Parkinson's disease [58] (p.121). The changes in motor function are described as beneficial effect on BK, while in the original article AK was used.

Some authors use the terms interchangeably in their paper or subsequent papers [46, 59-62], or refer to previous papers from other authors and replace the term used with the one they prefer to use, also related to the era the paper was published. Marsden himself reported on BK and AK in Parkinson's disease as the key negative features of loss of normal basal ganglia function, but in his paper he had cited Denny-Brown: "We ourselves regard hypokinesia as the primary symptom of all basal ganglionic human syndromes, indicating that the natural function of these structures is the facilitation of movement" [63] (cited from [64]). These are not isolated examples, but are frequently encountered in publications in this era. Although the potentially most influential publications on terminology prefer the use of AK, and this was the case in the first and second series of the HCN, in general a shift can be seen towards the use of BK (Table 2.1) in the last series. Probably, this shift is to be explained by the increased use of the clinical criteria for Parkinson's disease, and use of objective measures in clinical rating scales for the evaluation of therapeutic interventions.

As from this time, the movement disorder of Parkinson's disease patients is denoted as either hypokinetic-, akinetic- or bradykinetic-rigid, while BK is preferred over AK and HK to characterize this cardinal feature of the disorder. BK is also the term required for the diagnosis of Parkinson's disease, but for this purpose it is defined as slowness in initiation of movements and includes also reduction of speed and amplitude in repetitive tasks.

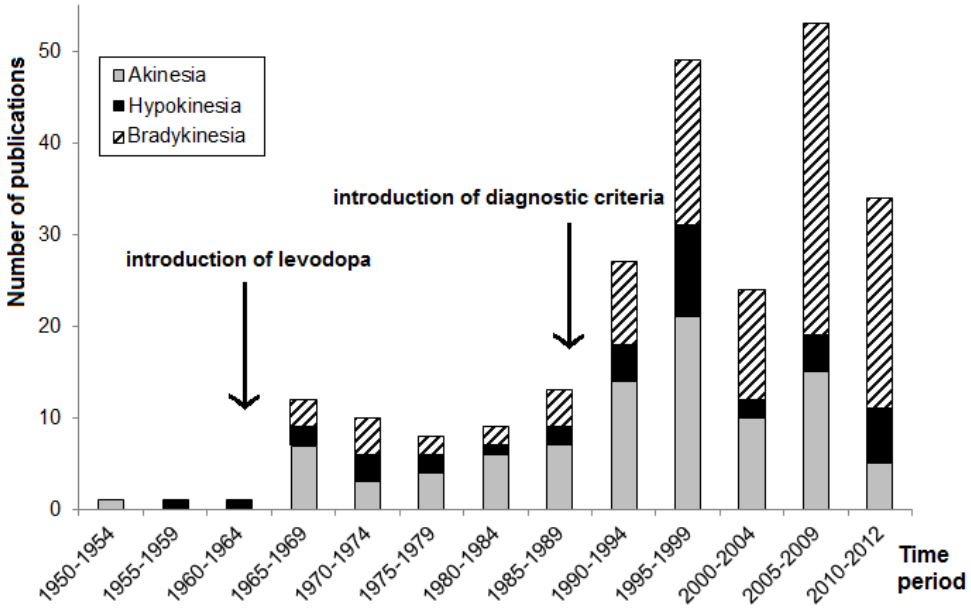
Recent evolution - 21th century

Internet accessibility

The last decades, myriad medical papers have been published, and with the introduction of the internet also have become easily dispersed and accessible for a large public. The enormous increase in the number of publications on movement disorders over time led to an heterogenous use of the different terms as multiple

authors have noticed and reported on: "bradykinesia is often used synonymously with two other terms: akinesia and hypokinesia" [65]; "today, the 'lessened muscular power' mentioned by Parkinson is recognized to be a slowness of movement that is called akinesia, hypokinesia, or bradykinesia, all three terms often being used interchangeably" [66]; "the literature uses the terms akinesia, bradykinesia and hypokinesia inconsistently" [67]; "in clinical practice, the term bradykinesia is often used interchangeably with the terms akinesia and hypokinesia" [68]. Currently, the umbrella term for all motor symptoms in Parkinson's disease alternates between AK and BK: some use BK (e.g. [65,69,70]), while others insist on using AK [67,71,72] for the same purpose.

Figure 2.1. Number of publications on akinesia, hypokinesia and bradykinesia between 1950-2012.



Furthermore, the explicit inclusion of decrement in amplitude or speed over time in the definition of BK causes confusion when this term is used in other movement disorders that are characterized by slowness of movement, but do not show this particular decrement, such as dystonia [73] and progressive supranuclear palsy [68]. Notably, Cruchet introduced the word BK in patients suffering from dystonia, yet the symptoms of dystonia do not comply with today's definition of BK.

Concluding remarks and recommendations

During the past two centuries many articles and book chapters have been published on Parkinson's disease and other movement disorders. Studying a selection of these publications revealed that terminology of motor signs and symptoms has changed continuously, starting from as early as the beginning of the 20th century. With the introduction of the clinical criteria in 1988 and the need to quantify motor function in therapeutic studies, BK is the dominating term in the literature nowadays, although AK and HK are also frequently used (see also Figure 2.1).

From a historical point of view, it could have been expected that the descriptions of symptoms in Parkinson's disease have remained unaltered over time, as the appearance of the disease itself has not changed over the last 200 years. Implicitly one assumes that what is now called, for example, paralysis, is comparable to its content decades or centuries ago. However, as often applies to medical terminology, the use and meaning of terms change over time (e.g. apoplexy, paralysis, aura, vertigo) [74-77]. Charcot, for example, rejected the term paralysis that James Parkinson had used to describe the lessened muscular power he observed, as Charcot recognized that Parkinson's disease patients were not markedly weak. However, with his description of paralysis, James Parkinson may have aimed to point out that those patients suffered from reduced voluntary movements, as Wilson noticed: "Paralysis agitans is not so much a misnomer as some think, for although the patient can innervate his muscles he becomes more and more helpless in his use of them, that is to say, he is 'paralyzed' " [35] (p.796). We have to realize that (patho)physiological concepts had changed from humoral to solidary and at the time of Parkinson the action of nerves was not generally accepted to be of an electric nature. Another example can be found in the work of Oppenheim, who used the word rigidity in all cases with increased muscle tone, thereby also including patients with what we now would denominate spasticity.

From a clinical point of view, one of the factors that greatly hampers the current terminology in Parkinson's disease is the fact that physicians are conditioned to seek unitary explanations for signs and symptoms [78]. Moreover, clinicians cover these signs and symptoms preferably by a single word. It must be questioned, though, whether such grouping of symptoms such as in Parkinson's disease is sustainable and should be maintained, especially since recent studies have indicated that different aspects of the impaired motor function in Parkinson's disease seem to be independent of each other [65,71,79]. Another error-prone aspect of the terminology in Parkinson's disease is the fact that similar words are used on different levels or

categories, for example the use of HK as a classifying term to describe the type of movement disorder (versus hyperkinesia), while HK is also used to describe particular symptoms of that movement disorder, such as decreased arm swing or micrographia. Such variety in classification levels leads indisputably to confusion and inaccuracy. BK, defined as 'slowness in the initiation of movement with progressive reduction in speed and amplitude of repetitive actions' is currently required for a Parkinson's disease diagnosis, but this extensive description excludes its potential use in other movement disorders such as progressive nuclear palsy and dystonia, where no decrement is seen [68,73]. Moreover, the translation from Greek of BK would not predict that decrement is part of this term, and hence leads to confusion.

Suggestions for the use of terms

In line with recent publications on the proposed use of terms in the field of movement disorders, we believe that the book is not closed for discussions on this subject [56,80,81]. In this last paragraph, we will provide some suggestions, but it is clear that a widely supported consensus is needed to decide upon the exact terminology.

First of all, it seems of utter importance to distinguish in which context a term is used: to describe a typical feature of abnormal movement, which may occur in a spectrum of movement disorders beyond Parkinson's disease, to assess the motor impairment in a rating scale, or to establish a diagnosis. We believe that, in accordance with the results of the consensus as published by Barbeau in 1981 [56] and a recent publication by Stanley Fahn on classification of movement disorders [80,81], HK - indicating 'less' or 'a paucity of' movement - is the best term to classify the category of movement disorders, opposite to hyperkinesia. Examples of hypokinetic movement disorders are, amongst others, Parkinson's disease, progressive supranuclear palsy and multiple system atrophy. The term HK likely should not be used to describe separate signs or symptoms such as micrographia, hypomimia or decreased arm swing – rather these hypokinetic manifestations should be reported separately.

Second, for establishing a diagnosis, BK is currently the most popular and important term, as part of the Parkinson's disease criteria and as an easily obtainable and objective measure in hypokinetic disorders. Though, to prevent confusion, we think that BK should be reserved to describe slowness of movement only and not include slowness in initiation and/or decrement of amplitude or speed over time. These features of movement should be reported separately. As a result, this definition

of BK is in accordance with the exact Greek translation and provides utility in other movement disorders like dystonia were slowness of movement is apparent.

AK should – as its translation would predict - be reserved for the total abolition of movement, and may be used in, for example, akinetic mutism, but to our opinion this term is not of additional descriptive value in movement disorders such as Parkinson's disease. Hesitation in ongoing movements or the inability to start a movement, should preferably not be called AK, but regarded and described as separate features of the hypokinetic syndrome.

Exact description of symptoms or signs also helps to prevent 'translational' confusion, i.e. where terms or descriptions of a previous author or from another era are replaced by a new term based on a subjective preference. Compelling evidence shows that changes in velocity of movement are not directly associated with changes in amplitude, and may be dissociated from planning, initiating and/or sequencing of movements [65,71,82]. Consequently, the best way to report on these features of altered movement is to fully describe them – and not merge them into one or two terms.

In particular in the field of movement disorders, accurate descriptions of the motor disturbances, nowadays supported by video images, still seems the best solution – as done by James Parkinson almost 200 years ago. Although the terms he used for the disease that bears his name would not be interpreted in a similar way anno 2014, the disease has not changed.

"Changing the definition of Parkinson's disease will begin a crucial dialogue that will continue to refine the nosology of Parkinson's disease and serve as a more appropriate foundation for forging ahead with a research agenda dedicated to understanding the pathogenesis of Parkinson's disease." [83]

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