

# G.G.J. Rademaker 1887-1957

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Gysbertus Godefriedus Johannes Rademaker was born in The Hague on March 1887, as a son of the minister of the Dutch Reformed Church Geurt Arend Rademaker and his second wife Safke Maria Louize Dorothea Notten. He studied medicine at Leiden, graduating in 1911 after having completed his surgical training at the 'Zuidwal' Municipal Hospital in The Hague. When his brother (who was a general practitioner in Surabaya in the Dutch East Indies) fell ill, Rademaker went out to act as *locum tenens*. He stayed and established his own practice. After working there from 1914 till 1918 as a GP and general surgeon, he returned to the Netherlands leaving behind a practice that has been called "the largest in the Dutch East Indies." Family circumstances compelled him to return to Holland without fixed plans as to his further activities.



Figure 1.  
G.G.J. Rademaker.

Three factors determined his ultimate choice of career: his *peregrinationes academicae* to important clinical centres and laboratories in London, Paris and Berlin; the awakening of his interest in scientific work; the advances in neurophysiology made by Sherrington, and Rademaker's introduction to Magnus, Professor of Pharmacology at Utrecht, who was a good friend of Sherringtons and one of the great neurophysiological thinkers of his day. In 1919, Rademaker joined the group that had been working in Magnus's laboratory since 1914 to develop Magnus's concept of 'Körperstellung' (body posture) - a brilliant neurophysiological analysis of the activities of walking and standing. According to Ter Braak et al. (1977), "Next to Sherrington and Pavlov, Magnus must be named as one of the great promoters of a mechanistic conception of the function of the central nervous system. He had evolved the view that 'normal' body posture is based on an equilibrium of reflex muscular contractions and, together with his collaborators, he had set himself the task to analyse the individual reflexes contributing towards this equilibrium, to trace the receptors involved and to delimit the central nervous pathways. In the course of these examinations the great significance of the midbrain had gradually been brought to light and it fell to Rademaker to verify this view and to define it more precisely."

Thanks to his surgical past, Rademaker proved to be highly skilled in operating on experimental animals. In particular, unlike others - including Magnus - he developed a delicate technique for operations at the level of the mesencephalon and cerebellum, which (combined with effective postoperative care in which, as we shall see below, his wife played an indispensable part) would guarantee the animals concerned a long postoperative life.

To cite Magnus from his Cameron Prize Lecture delivered at the University of Edinburgh on 17<sup>th</sup> and 18<sup>th</sup> May 1891 in which he summarised, a year before his death, "Some results of studies in the physiology of posture - commenting on local static reactions":

"The limbs of mammals, as of other vertebrates, are built up of bony segments, linked by a complicated arrangement of ligaments and moved and fixed by muscles; fasciae also play a role. The whole system is easily movable in different directions. Our problem is to explain how such a movable limb is at times used as an instrument for very different purposes (such as scraping, scratching, fighting, etc.) and moved freely in all joints, whereas at other times it is transformed into a stiff and strong pillar which gives the impression of being one solid column, able to carry the weight of the body. Experiments have shown that this is accomplished by a series of local static reflexes.

We were confronted in the laboratory with this problem during the investigation of decerebellated animals, which had been operated upon by Dr G.G.J. Rademaker, and of which the condition of muscle tone had to be followed during the course of many months. It soon became evident that this was not a simple task, and that the state of tone of a limb at any given moment depended greatly upon the way in which the tone is investigated. If, for instance, a dog is lying down in the lateral position and the resistance of one forelimb against passive flexion is measured with the hand and fingers flexed, often no resistance can be felt. But if the latter are extended and pressure exerted against the pads of the foot, then the forelimbs become strongly extended and can hardly be flexed at all. The same difference can be demonstrated in intact animals. We therefore decided to make a more detailed investigation of these reactions."

Owing to his remarkable talent for unprejudiced analysis of the behaviour of experimental animals as well as to his above-mentioned operative skills, Rademaker turned out to be and undoubtedly was the right man for such an investigation. His first research project involved the infliction of lesions in or near the midbrain, the analysis of the changes in the reflex behaviour, tone and motricity of the extremities produced by these lesions and finally the microscopic-anatomical investigation of material from the experimental animal, after preliminary study of the detailed anatomy of the brainstem with Winkler. He inferred from his experiments that the red nucleus should be considered the principal centre of the labyrinthine and righting reflexes, which were found to be indispensable for a normal distribution of muscle tone. A great many other inferences were drawn regarding the localisation of reflex pathways which did not involve the red nucleus. Rademaker's doctoral thesis (1893) in which the results of these investigations were laid down was bore the title: *The significance of the red nuclei and other parts of the mesencephalon for muscle tone, body posture and labyrinthine reflexes*. Completed in the remarkably short space of time of two years, this study made a deep impression of the medical world of the time, since "it assigned for the first time on the ground of exact experimental research a function to a delimited nuclear area in the

brainstem whose anatomical connections in themselves gave no direct indication of this function” (Ter Braak et al. 1937). Rademaker’s working method proved to be innovative. He drew a significant distinction between acute and chronic experiments, which allowed greater precision about the location of the lesion to be inflicted and helped to clear up the massive confusion associated with the ‘decerebrate rigidity’ model, widely used at that time (e.g., in Sherrington’s laboratory). His thesis was approved *cum laude* at the University of Utrecht, and was translated into many languages (e.g., into German under the title *Die Bedeutung der roten Kerne* in 1937). Subsequent investigators, reviewed by Fulton (1937) “showed that the question is more complex; the red nucleus is but one of a series of levels of elaboration of the righting reflexes.... Rademaker’s monograph nevertheless greatly clarified the issues” (Denny-Brown 1937).

In 1937, Rademaker was nominated as successor of the Nobel laureate Einthoven (1852–1927, inventor of the string-galvanometer 1887, by means of which he produced the first electrocardiograms 1904), to the chair of Physiology in Leiden. He remained in this position until 1967.

His students liked his style of teaching – especially the demonstrations, when he used postoperative findings to elucidate the underlying neurophysiology. During his lectures Rademaker, with his leptosome build, impeccably tailor-made suit, knife-edge creases in his trousers, and highly polished shoes, was the very model of the English gentleman or ‘le gentilhomme’ in the sense given in Larousse: “homme qui fait preuve de délicatesse dans sa conduite.” He let no opportunity slip to express his admiration for Sherrington or similar eminent scientists, and to cite their works. Illustrations show him either working in the laboratory in a messy lab coat or adjusting some piece of scientific equipment in the same laboratory or an animal house, dressed in a three-piece blue tailor-made suit. Cartoons of him circulated in student circles.

In the tradition of the reflexological approach, which dated back to Descartes, was further developed on the basis of the experimental work started by Sechenov (1829–1905) and continued up to the work by the 10-year younger Pavlov (1849–1936), who succeeded Sechenov in the St. Petersburg chair of Physiology, Rademaker set up a new programme of experimental work. He aimed to explain the blink reflex in response to threatening movements on the basis of new data obtained from study of the ‘big decerebrate dog’, e.g., by Goltz (1872–1952) in Strasbourg and other workers in various German laboratories. Rademaker succeeded in revealing the mechanism of this reflex, using ingenious techniques for ablation of parts of the cerebrum (in cooperation with Gelderblom and later with Ter Braak), and to show the clinical relevance of this study later, in cooperation with Garcin at the Salpêtrière in Paris. This was the first experimentally based, neurophysiological and clinical demonstration of a cortical/subcortical reflex – a matter that was attracting a great deal of interest in the neurological world. This method of examination yielded what became known as the ‘Rademaker-Garcin sign’ in the neurological clinic (i.e., the blinking reflex to threatening movements).

During his early years as professor of Physiology in Leiden, Rademaker completed his second monograph, *Das Stehen* [On Standing], which summarised the results of his extensive programme of experiments and parts of his clinical work (1937). This

work was primarily an analysis of cerebellar defect but with much wider significance in relation to the neurological mechanisms of righting, standing and equilibrium. Rademaker devised ingenious clinical tests to investigate the exact nature of the complex abnormalities of posture and movement that had hitherto been loosely categorised as ‘incoordination’, ‘asthenia’, ‘dyssynergia’ and ‘atonia’ (Denny-Brown 1937). Some of the basic reactions that Rademaker established, such as ‘placing’ and ‘hopping’, have become well known to physiologists and clinicians. “That the cerebellum is not in fact an essential part of the mechanism of any of the labyrinthine reactions was an extraordinary finding” (Denny-Brown 1937). Physiologists all over the world – but particularly in the United Kingdom, United States, France and Germany – recognised the work as a classic. “The complete objectivity that Rademaker achieved gives them a timeless quality that also distinguished the investigations of Gordon Holmes on the human cerebellar syndrome ten years earlier” wrote Denny-Brown in his foreword to the English translation of the original German text of *Das Stehen*.

The earlier work of Magnus and de Kleyn, that had focused mainly on peripheral mechanisms and reflex patterns associated with posture, standing and walking, was now supplemented by Rademaker’s findings obtained during experiments focused on central mechanisms. *Das Stehen* was a monumental work, and constituted Rademaker’s manifesto.

His third monograph, *Réactions labyrinthiques et équilibre* [Labyrinthine reactions and equilibrium], was published in 1937. It contained the results of a logical sequence of studies of equilibrium reactions in experimental situations and clinical practice, with an impressive series of deductions from premises, some of which were based on a series of photographs of the various positions of the head in space taken previously from different points of the compass ranging from 0° to 360° coupled with the results of tests performed at the different positions.

The experimental results, which had a direct bearing on clinical practice, attracted a great deal of interest at the time. The tests making use of a tilt table, which Rademaker developed in association with his friend Garcin in Paris, became widely known in the world of French neurology. The text of this monograph was full of new ideas, but never received much attention outside the French-speaking world because an English version was never published. As was pointed out in the book itself, *Réactions labyrinthiques et équilibre* was intended as a follow-up to his previous monograph *Das Stehen*. Guillaïn (1937) wrote a very useful introduction to the book, recommending it to a wide audience of physiologists, neurologists and otologists.

When Rademaker arrived in Leiden in 1937 to take up his position as professor of Physiology, he encountered a situation whereby neurology lectures were read by the professor of Psychiatry, Jelgersma (1937), when the occasion arose. Jelgersma also looked after neurological patients in the department of Psychiatry, where he was assisted for a number of years by the lecturer A. Gans, whose lectures apparently were not overly appreciated by the students.

It was not until Rademaker was made professor of Neurology in 1945, just after the end of World War II, that effective steps were taken to separate the disciplines of psy-

chiatry and neurology at Leiden. Indeed this, including the setting up of the Institute of Neurology at the university, was Rademaker's main task during the early years of his new professorship. He was guided during this process of change by the conviction that the relationship between (neuro) physiology and neurology was more important than the one between psychiatry and neurology, which had received the main stress in the past. After the war years, Rademaker continued to contribute papers on subjects such as lengthening reactions ( ), visual placing and optokinetic reactions ( ), and clinical discussions of ataxia, nystagmus and related subjects.

Research and other activities came to a complete halt in Leiden during the years of the Second World War. The University was closed by the Germans when it protested at the sacking of the Jewish professors at the University that had been ordered by the occupying forces. Rademaker adopted an active resistance stance, and took part in underground activities during these years. These activities included the setting up of a resistance cell (with its own printing press, weapons-cache and sickbay in his laboratory and the adjoining basement). Students, Jewish and others, admired him for his courage in helping them to continue their studies while in hiding. He visited them there regularly, often unexpectedly, popping up like a Scarlet Pimpernel, being transported to their address by the undertaker in his hearse to keep out of sight of the occupying forces or collaborators. These activities were good for a number of anecdotes that circulated among the population of Leiden, helping to keep up their spirits during the dark days of the Nazi occupation.

Rademaker the man had many faces. In Leiden, he was seen mainly as an introverted, unaffected scientist with high ethical standards. American neurophysiologists (such as John Fulton and Derek Denny-Brown) knew him as the 'king of the red nucleus'; French neurologists as the *prestidigitateur* (the magician); English neurophysiologists as the 'microsurgeon with the golden hand'; his students as the inspired 'performer'; and his Dutch colleagues apart from the above epithets as the 'film-maker' who loved to record all details of his experiment – including himself – for subsequent showing on the silver screen (the complete film archives seem subsequently to have been mysteriously lost – possibly destroyed in view of the fire hazard which they were thought to represent). His 'French connection' was often mentioned. This referred in the first place to his wife Maria Josephina Wenceslase Stoltz (Blanche), who came from French Alsace and who literally became his first assistant, in the basement of their apartment in Utrecht, caring for the animals on which he had operated. Her devoted care was crucial for the long-term post-operative survival of these animals, which played a key role in Rademaker's experimental success. Rademaker was a great believer in the education of women, at a time when this was less self-evident than today. They had no children. Among his closest friends were Winkler, Ter Braak, Verbiest, Gorter and Barge.

His fellow professors and university staff knew him as the well-balanced administrator with high ethical standards, always prepared to listen when differences of opinion arose between colleagues. Finally, after the war years, he became the *eminence grise*, the man with the authority to carry out the most difficult tasks such as

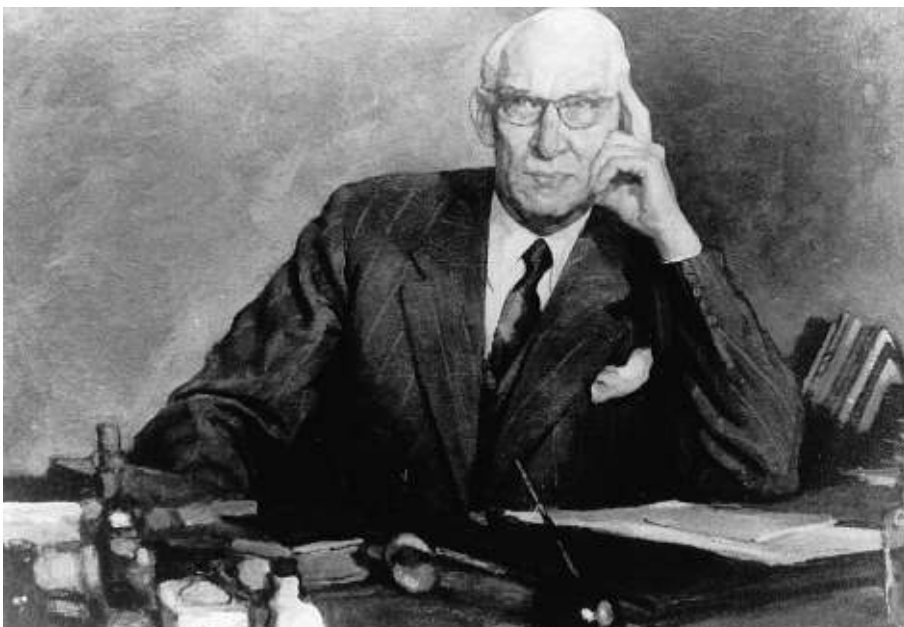
completing the 'plan Cité Médicale' for the Academic Hospital in Leiden in 1935, where the Physiology department and the newly built Neurology department occupied a central place. He was always marked by great objectivity, a sense of humour and the courage to tackle any problem.

Rademaker's first disciples come from his period as professor of Physiology at Leiden. The seeds he sowed bore rich fruit in many, such as the brilliant Ter Braak, later professor of Clinical Neurology in Rotterdam, his 'favourite son' Storm van Leeuwen, later professor of Neurophysiology at Leiden and Utrecht, Verbiest, the first professor of Neurosurgery at Utrecht, and finally Luyendijk, the first professor of Neurosurgery at Leiden. His pupil L.J. Endtz – greatly admired by Rademaker and others – later headed the prestigious department of Neurology in the Leyenburg teaching hospital in The Hague.

Among his followers abroad may be counted Derek Denny-Brown from Harvard and John Fulton from Yale in the United States, and Georges Guillain and Raymond Garcin from the Salpêtrière in Paris. They have borne witness in both speech and written word to his importance for their eminent contributions to neurophysiology and neurology.

In more recent years, Berthoz (1987) has expressed renewed interest in the results of Rademaker's experimental work and the concepts he used in the study of labyrinthine reactions and equilibrium, which are now found to be applicable to key issues in space neurology.

Rademaker was a major scientist who changed our perception of neurology and in particular the approach taken to posture and motor development. He trained a new



*Figure 1. Prof. G.G.J. Rademaker (1887–1973). The painting, currently hanging in the conference room of the neurology clinic in Leiden, was presented to him by his colleagues and pupils on the occasion of his 86th birthday.*

generation of neurologists (including the author of the present review). His publications ( ) remain relevant. In view of all his contributions, his fame is hardly surprising. He received many decorations: Member of the Royal Academy of Sciences in the Netherlands, he was an honoured representative of the Dutch scientific world at congresses abroad; he was promoted to the rank of "Officier of the Légion d'Honneur," and elected member of the *Leopoldino* order in Halle, Germany.

## Notes

- Magnus, R.: Some results of studies in physiology of posture. Cameron Prize Lectures. *Lancet* ii ( ) - ; - .
- Ter Braak, J.W.G., W. Storm van Leeuwen and H. Verbiest: *Miscellanea medica in honorem viri clarissimi, Gysberti Godefridi Ioannis Rademaker* (with incomplete list of publications), *Folia Psychiatr. Neurol. Neurochir. Neerl.* ( ) - . Festschrift on the occasion of his silver jubilee as professor at Leiden.
- Fulton J.F.: *Physiology of the Nervous System*. 2nd edition. New York, Oxford Univ. Press ( ).
- ten Cate J., C.U. Ariëns Kappers, G.G.J. Rademaker and G. van Rijnberk: *Nederlandsch Leerboek der Physiologie*. Vijfde deel, tweede herziene en vermeerderde en van een register voorziene druk. Amsterdam, C.V. Swets & Zeitlinger ( ).
- The chapters *Physiology of the cerebellum* ( - ), *The brainstem* ( - ) and *The cerebrum* ( - ) were written by Rademaker, and remained standard teaching texts for many years.
- Rademaker, G.G.J. and J.J. Gelderblom: *Der zentrale Mechanismus des Blinzelflexes auf Drohbewegungen*. *Proc. Kon. Acad. Wetenschappen*, nr. ( )
- Rademaker, G.G.J. and R. Garcin: *Le réflexe de clignement à la menace. Sa valeur diagnostique dans les lésions corticales et occipito-rolandiques des hémispères cérébraux*. *C.R. Soc. Biol. Paris* ( ) - .
- Rademaker, G.G.J. and R. Garcin: *Le réflexe de clignement à la menace (étude physiologique et clinique); la valeur sémiologique de son abolition dans les lésions corticales rolandiques et occipito-rolandiques des hémisphères en l'absence de toute hémianopsie*. *Encéphale* ( ) - .
- Denny-Brown, D.: Foreword to 'The physiology of standing; postural reactions and equilibrium with special reference to the behavior of decerebellate animals' by G.G.J. Rademaker, Minneapolis, University of Minnesota Press ( ) V-VII.

## Biographical References

- Prof. G.G.J. Rademaker ( - ). Festschrift on the occasion of his silver jubilee as professor at Leiden. *Folia Psychiatr. Neurol. Neurochir. Neerl.* ( ) - .
- Storm van Leeuwen, W.: *Levensbericht van Gysbertus Godefriedus Johannes Rademaker* ( maart - april ). *Jaarb. Kon. Ned. Akad. Wetensch.* ( - ).
- Storm van Leeuwen, W.: G.G.J. Rademaker: An eulogy. In: *Proceedings of the 10th World Congress Neurology, Amsterdam, September - , 1961*. Amsterdam, *Excerpta Medica* ( ) - .

## Selected Bibliography

- De betekenis der roode kernen en van het overige mesencephalon voor spiertonus, lichaamshouding en labyrintaire reflexen. Thesis Leiden, Leiden, Eduard Ydo ( ). (German translation: Berlin, Springer Verlag ( )).

Das Stehen. Statische Reaktionen. Gleichgewichtsreaktionen und Muskeltonus.

Unter besonderer Berücksichtigung ihres Verhaltens bei kleinhirnlosen Tieren.

Berlin, Springer Verlag, Monogr. Gesamtgeb. Neurol. Psychiatr. ( ). (English

translation: The physiology of standing, postural reactions and equilibrium with

special reference to the behavior of decerebellate animals. Edited with a foreword

by D. Denny-Brown, Minneapolis, Univ. Minnesota Press ( ).

Reactions labyrinthiques et équilibre. L'ataxie labyrinthique. Paris, Masson et Cie.,

( ).

Experimentelle Physiologie des Hirnstammes. In: O. Bümke and O. Foerster (eds.)

Handbuch der Neurologie., Zweiter Band. Berlin, Verlag von Julius Springer ( )

- .

On the lengthening and shortening reactions and their occurrence in man. Brain

( ) - .

(with J.W.G. ter Braak) On the central mechanism of some optic reactions. Brain

( ) - .