TITLE PAGE

1. **Title:**

The Babinski sign

2. **Authors**

Jasper M Morrow, Mary M Reilly

3. **Institutional affiliation**

MRC Centre for Neuromuscular Diseases, Department of Molecular Neuroscience, UCL Institute of Neurology (for both authors)

4. **Current appointments**

Dr Morrow
- Clinical Research Associate

Professor Reilly
- Professor of Clinical Neurology and Consultant Neurologist

5. **Corresponding Author**

Name: Dr Jasper Morrow
E:mail: j.morrow@ion.ucl.ac.uk
Postal: MRC Centre for Neuromuscular Diseases
    Box 102, National Hospital for Neurology and Neurosurgery
    Queen Square
    London WC1N 3BG
Phone: 0845 1555 000
Introduction

Joseph Babinski (1857-1932), a French neurologist of Polish descent, was first to describe extension of the big toe following stimulation of the sole of the foot on February 22\textsuperscript{nd} 1896 (Babinski, 1896). He referred to the sign as “phénomène des orteils” (toes phenomenon) but is now usually referred to eponymously as the “Babinski sign” or descriptively as the extensor plantar response. Some authors refer to the Babinski sign as the most important in neurology (Purdy, 2010), whilst others argue it shouldn’t continue to be part of the neurological examination (Miller & Johnston, 2005). Regardless, its importance in neurology is reflected both in the proliferation in the literature of thirty related manoeuvres (Kakitani et al. 2010) and the ongoing use of the sign to facilitate urgent specialist review or scanning. This review will outline how to perform, judge and interpret the plantar reflex and briefly review studies of the reliability of the sign.

Performing the manoeuvre

In his monograph on the Babinski sign, van Gijn details the optimum method (1996):

1. Lie the patient supine on couch or bed with the whole leg exposed
2. Warn the patient that you are going to scratch their sole, and ask them to remain as floppy as possible (preferable to the term relaxed which usually induces the opposite effect)
3. If available use the wooden end of an “orange stick” (thin stick with cotton wool on one end) however any instrument may equally be used if it is not too sharp and has not been used on other patients
4. Any part of the foot may be stimulated (or indeed lower leg, hence the development of numerous other eponymous signs – see below), but best results are achieved by stroking the lateral aspect of the sole of the foot (see fig 1)
Whilst as many as thirty other techniques for eliciting the same response have been described in the literature, none have been shown to be superior (van Gijn, 1996). However it is worth mentioning three variants that have endured may be encountered on neurology rounds:

- Oppenheimer sign, firmly stroking the medial tibial surface
- Gordon sign, firm compression of the lower calf muscle
- Chaddock sign, stroking the skin beneath the lateral malleolus

These are different methods of stimulating the same reflex, although unless the sole is stimulated the flexion of the big toe in the healthy will not be seen as this is part of a separate localised cutaneous reflex. Some patients require a greater stimulus to elicit the abnormal response, whilst for those of a ticklish disposition, a lesser stimulus such as Chaddock sign, may result in an easier to interpret response without excessive squirming. Regardless of what stimulus is used, the key aspect of the Babinski sign is in fact judging what is observed.

**Judging the response**

The normal and pathological responses to plantar stimulation are succinctly described by Babinski in his original communication (1896)

“On the healthy side pricking of the sole provokes... flexion of the thigh on the pelvis, of the leg on the thigh, of the foot on the leg and of the toes upon the metatarsus. On the paralysed side a similar excitation also results in flexion of the thigh on the pelvis, of the leg on the thigh, of the foot on the leg, but the toes, instead of flexing, execute a movement of extension upon the metatarsus.”

A slight diversion into the physiology of the Babinski sign is useful to aid understanding these observations. When the sole of the foot is scratched sufficiently a “flexion synergy” response is seen. This is the simultaneous contraction of muscles which shorten the lower limb, presumably to remove the limb from the noxious stimulus. In a newborn infant, the full response can be seen with contraction of hip flexors including tensor fascia lata, hamstrings (knee flexion), tibialis anterior (ankle dorsiflexion) and extensor hallucis longus (EHL - big toe extension). However by the age of one year, downward inhibition of the reflex from the upper motor neuron via the pyramidal tract
has developed, particularly of the EHL component, such that big toe extension is replaced by a separate localised cutaneous toe flexion reflex (similar to the abdominal reflexes) which results in flexion of the big toe following stimulation of the sole. Thus in healthy adults, with sufficient stimulus, whilst the other components of the flexion synergy response may still be seen, the upward movement of the big toe seen in infants is replaced by downward movement. In patients with upper motor neuron dysfunction there is reduction of the cutaneous toe flexion reflex (similar to reduced abdominal reflexes seen with upper motor neuron lesions) and release of inhibition of EHL activation such that the big toe moves up synchronous to the other components of the flexion synergy response, thus explaining the patterns originally described by Babinski (van Gijn, 1996).

Based on the physiological considerations above, three rules should be borne in mind when interpreting the movement of the big toe. These rules have been shown to improve accuracy of the sign when compared against clinical and electromyographic recordings (Van Gijn, 1976) and when taught to medical students have been shown to improve their performance (Raijmakers et al. 1991).

1. Upward movement of the toe is pathological only if caused by contraction of extensor hallucis longus muscle
2. Contraction of extensor hallucis longus muscle is pathological only if it occurs synchronously with reflex activity in other flexor muscles
3. A true up-going toe sign is reproducible, unlike voluntary withdrawal

**Box 1: Three rules to interpretation of the Babinski sign**

The contraction of EHL, seen through elevation of its tendon, is important to distinguish from upward movement of the big toe which is caused by dorsiflexion of the ankle or the illusion of upward motion if the big toe remains stationary whilst other toes flex, neither of which are pathological. Synchronous activity of reflex activity in other flexion muscles ensures that the response seen in the big toe is part of the synergistic reflex and not voluntary. Observation of tensor fasciae lata is particularly useful in this regard as this muscle is activated with flexion synergy, but not during voluntary withdrawal. Finally, a true Babinski sign should be reproducible with repeated stimulation. There are many other pitfalls in interpreting the Babinski sign – see box 2 (van Gijn, 1996).

**Erroneously positive Babinski**
- **Contraction of tibialis anterior**
  This causes the toes to go up passively due to ankle movement without contraction of EHL

- **Very active flexion synergy**
  Following a brisk normal flexion synergy reflex including usual flexion of the toes, the observer sees the big toe return to its neutral position by going up, but this is caused by relaxation of the toe flexors rather than EHL contraction

- **Voluntary toe wriggling:**
  These movements are jerky, inconsistent and not synchronous to flexion synergy in the rest of the leg

- **Relative movement**
  The smaller toes go down, whilst the big toe remains immobile creating the illusion of an up-going toe

- **Isolated fanning of the toes**
  Although suggested by some to be an important feature of the Babinski sign – in fact may be seen in healthy subjects and may not be seen in Babinski sign so is of limited use

**Box 2: Potential causes of an incorrectly interpreted positive Babinski sign**

**Interpreting the sign**

Once decided to be present, interpretation of Babinski sign is straightforward: it implies upper motor neuron dysfunction in the brain or spinal cord. Clinically this information is assimilated with other upper motor neuron signs such as spasticity, hyper-reflexia and pyramidal distribution weakness. It is very uncommon for Babinski to be the only sign of pyramidal tract dysfunction. Common conditions in which a Babinski sign is seen include cerebrovascular disease (stroke), multiple sclerosis and tumours. It is worth noting that dysfunction of the pyramidal tracts need not be structural: infection (eg meningitis), seizures and drug toxicity may all be associated with the Babinski sign. The Babinski sign is very rare in healthy adults, however is normal in infants under the age of one, and may be seen in adults during deep sleep (van Gijn, 1996). However, scratching the soles of your patient’s feet whilst in a deep sleep is not recommended. There may be difficulty in interpreting clinical signs together in conditions where upper and lower motor neuron pathology coexist, such as in motor neuron disease. Similarly, absent ankle reflexes with extensor plantar responses may be seen in Friedreich’s ataxia and B12 deficiency. Situations where there may be pathology of the pyramidal tract without a Babinski sign evident are outlined in Box 3.
Potentially misleading negative Babinski

- **Joint deformity:**  
  Quite common, especially hallux valgus such that the joint can’t go up, although EHL activation may be shown on EMG of these patients

- **Lower motor neuron lesions**  
  Any cause of lower motor neuron dysfunction may mask a Babinski sign which would otherwise be present. For example pressure palsy of the common peroneal nerve which can occur in chronic paraplegia can mask a Babinski sign.

- **Incomplete pyramidal syndrome**  
  If the fibres which innervate dorsiflexor muscles of the foot are not involved

- **Spinal shock**  
  In acute spinal shock no response might be seen from plantar stimulation due to depressed activity of the segmental pathways which mediate the flexor synergy

| Box 3: Potential causes of a negative Babinski sign despite upper motor neuron dysfunction |

**Reliability and reproducibility of the sign**

Studies examining the reliability of the Babinski sign have reported inter-observer Kappa values ranging from 0.15 (Maher et al. 1992) to 0.57 (Singerman & Lee 2008) with others in between (Miller & Johnston 2005; Sisk et al. 1970). All studies were relatively small which together with methodological variations probably explain the range of Kappa values obtained. One recent study directly compared the Babinski sign with the rival signs of Chaddock, Gordon and Oppenheimer and found that Babinski had the highest inter-observer reliability of the four (Singerman & Lee 2008). One study has shown improvement in performance and interpretation of the plantar response when an instructional videotape was shown to medical students incorporating the three key rules to interpreting the response (Box 1) in addition to usual bedside teaching. Overall, these studies suggest that the most important aspect of ensuring reliability of the sign is careful observation and interpretation of the response, rather than the exact method of stimulation.

**Conclusions**
Of all eponymous signs in medicine, Babinski is probably the most well known which reflects that after more than 100 years it remains a valuable part of the clinical examination. Judging the response is more difficult than it first appears with numerous causes of erroneous interpretation and reduced reliability. However if the up-going toe is caused by extensor hallicus longus contraction, synchronous with contraction of other muscles involved in the “flexion synergy” reflex, and reproducible on repeated stimulation, then it is a reliable indicator of upper motor neuron dysfunction.

Key phrases

- The Babinski sign is elicited by firmly stroking the lateral side of the sole of the foot with an orange stick or similar
- Following this stimulus in healthy adults the big toe goes down due to a localised cutaneous reflex
- In patients with an upper motor neuron lesion the big toe goes up due both to inhibition of normal flexion and release of toe extension which is part of the “flexion synergy reflex”
- Correct judgement of the response can be improved by following the three rules in box 1
- Inter-observer reliability of the Babinski sign is reasonable and has been shown to be superior than rival signs

Conflicts of interest:

None

Word count including figure legends, key phrases and text in boxes:

1959
References


