

## OCCASIONAL PAPER

**Hughlings Jackson's neurological ideas**

George K. York III and David A. Steinberg

Department of Neurology, University of California at Davis and Fiddletown Institute, Fiddletown, CA 95629, USA

Correspondence to: George K. York III,  
University of California at Davis and Fiddletown Institute,  
21201 Ostrom Road,  
Fiddletown,  
CA 95629, USA  
E-mail: gkyork@ucdavis.edu

Hughlings Jackson's neurological ideas are scientifically valid and practically useful. He began by emphasizing the focal lesion as the key to analysing patients' symptoms. He proclaimed that 'Epilepsy is the name for occasional, sudden, excessive, rapid, and local discharge of grey matter.' He eliminated any need for a direct appeal to metaphysical agents by asserting that the nervous system is an exclusively sensorimotor machine constrained by the newly discovered conservation laws. In constructing his neurophysiology he accepted the phrenological assumption that the nervous system is composed of a number of physiologically discrete organs, each with a single function accessible to the diagnostician. By observing the march of epileptic seizures he developed the idea of somatotopic representation. He claimed that the nervous system is an evolutionary hierarchy of three levels connected by the process of weighted ordinal representation. His assertion of the Doctrine of Concomitance further separated the concerns, and the institutions, of the neurophysiologist from that of the psychiatrist. He came to reject the idea of the unconscious because he could not observe unequivocally unconscious behaviour at the bedside. Each of these ideas emerged from contemporaneous scientific streams, but Hughlings Jackson was the one to incorporate them into practical medicine. These neurological ideas gave physicians the methods, tools, principles and structures with which to establish a new science of clinical neurology.

**Keywords:** clinical neurophysiology; John Hughlings Jackson (1835–1911); cerebral localization; history of neurology; history of 19th-century medicine

**Introduction**

John Hughlings Jackson (1835–1911) elaborated the neurological ideas that became foundations of modern neurology. Biographical details for him can be found in his obituaries (John Hughlings Jackson, *BMJ* 1911; John Hughlings Jackson, *Lancet* 1911), in the biographical sketches of his lifelong friend Jonathan Hutchinson (Hutchinson, 1911), his colleague and amanuensis James Taylor (Taylor, 1925) and in a modern biography (Critchley and Critchley, 1998). Greenblatt studied his early influences (Greenblatt, 1965) and York and Steinberg provide a catalogue raisonné of his published writings (York and Steinberg, 2006).

As a practising neurologist, Hughlings Jackson intended his ideas to be as useful at the bedside as in the laboratory. The Victorian popular culture in which he lived considered science the way by which society would progress in material and social ways, but hospital medicine in London was not especially scientific in 1860.

Evolution was one biological idea that was widely influential in Victorian science. As a physician, Hughlings Jackson largely avoided the public acclaim heaped on Darwin, Huxley and Spencer, though his conceptions were ostensibly irreligious (Jensen, 1998). His adaptation of evolutionary physiology to medicine established a way to think about the nervous system and eliminated the need for a metaphysical cortical physiology.

Received July 10, 2011. Revised July 31, 2011. Accepted August 3, 2011

© The Author (2011). Published by Oxford University Press on behalf of the Guarantors of Brain. All rights reserved.

For Permissions, please email: journals.permissions@oup.com

This article traces the development of the neurological ideas that became the basis of scientific neurology. The Jacksonian formulation of neuroscience is the result of an explicit scientific method, an assumption about the nature of the nervous system, and a clear and comprehensible neurophysiology. Neurology and psychiatry drifted further apart conceptually and institutionally on account of his Doctrine of Concomitance, a rigorous and sophisticated evolutionary structure for brain and mind. His neurological ideas emerged from the work of his predecessors and contemporaries, and from his own keen insight. They ensure that modern neurology is Jacksonian neurology.

## The neurological method

Writing in 1863, Hughlings Jackson expressed his unhappiness with contemporaneous case analysis. In his first systematized method, a privately circulated pamphlet, he wrote, 'In studying the Natural History of Diseases of the Nervous System, I have experienced great difficulty, not only in arranging notes of cases, but also in thinking of the disease as a lesion of a certain physiological system' (Hughlings Jackson, 1863). In the January 1863 preface, he said that his interest was not in the details but in understanding how the nervous system works. He wrote, 'To sum up, I care very little about the fate of the details of the scheme, and will willingly sacrifice all of them, if I can make a better arrangement' (Hughlings Jackson, 1863).

In June 1864, Hughlings Jackson gave a lecture at the London Hospital entitled 'On the study of diseases of the nervous system.' In this lecture, he emphasized that the scientific physician should assess the anatomy, pathology and physiology of every case of a patient with neurological disease. He said that most physicians believed that the major impediment to understanding neurological diseases is the lack of a method for doing so. He added that his method was natural rather than artificial, with practical aims. He recommended that those who did not find it useful should simply abandon it. He took an expressly physiological approach to case study, writing:

Just as we study, as physiologists and anatomists, the vegetative life of general tissues, the structure of organs for special functions, and the universal harmony of most diverse functions in individuals, so we ought, as workers in the field of Practical Medicine, to study every case that comes before us; as presenting 1. DISEASE OF TISSUE (Changes in tissue) 2. DAMAGE OF ORGANS 3. DISORDER OF FUNCTION. (Hughlings Jackson, 1864a)

The medical press of the day popularized Hughlings Jackson's lecture, making him a prominent physician in the process (Editorial, 1864). The ensuing publicity pointed physicians to a scientific method for studying neurological disease. He successfully employed his method in a study of patients with rheumatic heart disease, left middle cerebral artery embolism, right hemiparesis and aphasia, which thrust him into the centre of a primary debate of 19th-century medicine: how exactly, does the nervous system work? (Hughlings Jackson, 1864b).

## The sensorimotor machine

At the end of the 18th century, devout investigators believed that the metaphysical soul inhabits and governs at least part of the nervous system. Charles Bell (1774–1842) and François Magendie (1783–1855) proved that the anterior spinal roots carry motor fibres and posterior roots carry sensory fibres, and that peripheral stimulation of sensory fibres evoked a motor response in decapitated animals. They also engaged in an acrimonious priority dispute. What became known as the Bell–Magendie hypothesis implies that reflex movements occur with no involvement of the brain, so at least some part of the nervous system is sensorimotor (Cranefield, 1974).

The English physiologist Marshall Hall (1790–1857) articulated the law of reflex action, which claimed that involuntary movement mediated by the spinal cord occurs independently of any metaphysical action or agent. This confined metaphysical objects to the brain, freeing the spinal cord for its sensorimotor function (Hall, 1836; Liddell, 1960). The German physiologist Johannes Mueller (1801–58) spread the reflex concept throughout the world in his classic textbook *The Elements of Physiology*, published in 1835 and translated into English by William Baly in 1838 (Mueller, 1838). In this work, Mueller said that the spinal cord is a reflector. He agreed that the soul resides in the brain and nowhere else, and confirmed the findings of Bell, Magendie and Hall. He argued that the function of the brain and spinal cord was partly dependent on the mind and partly independent of it.

The Yorkshire physician Thomas Laycock (1812–76) published a series of articles on hysteria in the *Edinburgh Medical Journal*, and in his final 1839 chapter he considered the scientific, medical and philosophical foundations of the study of hysteria (Laycock, 1839). He came to a remarkable conclusion: 'This slight historical sketch furnishes ample proof, in addition to that I have already given, of the truth of the proposition, that the cranial ganglia, although the seat of consciousness and will, are subject to the same laws which govern the other ganglia' (Laycock, 1839).

Addressing the Medical Section of the British Association for the Advancement of Science in 1844, Laycock reiterated these general physiological laws that the brain, although the organ of consciousness, was subject to the laws of reflex action, and in this respect did not differ from the other ganglia of the nervous system (Laycock, 1845).

Hughlings Jackson doubted any sort of metaphysical physiology. He wrote in 1864, 'There is no more difficulty in supposing that there are certain convolutions superintending those delicate movements of the hands, which are under the immediate control of the mind, than there is one, as Broca suggests, for movements of the tongue in purely mental operations' (Hughlings Jackson, 1864a). In other words, at least some part of the cortex had an explicitly motor function.

In 1868, he made the crucial next step. Saying that neurological function is exclusively sensorimotor, he wrote, 'The psychical, like the physical, can only be functions of complex combinations of motor and sensory nerves' (Hughlings Jackson, 1868b). In other words, for the purposes of clinical neurology and experimental

physiology, the nervous system is an exclusively sensorimotor machine; there is no need to refer to metaphysical agents or actions.

The 1870 experiment published by Fritsch and Hitzig (1870) found that weak galvanic current of the frontal cortex of dogs evoked movement of different parts of the body, demonstrating the cortex contains motor centres. David Ferrier (1843–1928) extended their work to primates, showing an extensive array of cortical motor centres (Ferrier, 1873). In his widely publicized 1884 Croonian lectures, Hughlings Jackson praised Ferrier and pronounced his own mature views on the subject. He said, ‘A man, physically regarded, is a sensorimotor mechanism . . . If the doctrine of evolution be true, all nervous centres must be of sensory-motor constitution . . . Are we to believe that the hemisphere is built on a plan fundamentally different from that of the motor (and sensory) tract?’ (Hughlings Jackson, 1884).

Hughlings Jackson invoked the newly discovered conservation laws to claim that the nervous system is a purely physical mechanism. This neurological idea forms the basis of clinical neurophysiology. The ostensibly atheistic principle that the nervous system is exclusively sensorimotor excludes any reference to metaphysical objects or actions, and forms the basis of modern physiology. It was a brave assertion in Victorian London, in that Darwin’s theory of evolution by natural selection evoked the ire of the Bishop of Oxford. Unlike Darwin, however, Hughlings Jackson was a practising physician with no public acclaim. He made his materialistic claim 10 years after *The Origin of Species*, by which time much of the passion had died out.

## The phrenological assumption

Classically educated physicians at the turn of the 19th century approached patients with neurological disease by following humoral principles. In this world, Franz Josef Gall (1758–1828) produced a strikingly contrary programme. Promoting the primacy of the brain, he insisted on examining the nervous system in order to assess its health. He founded the pseudoscience of phrenology, but he was also a careful neuroanatomist who published treatises on the nervous system. He proposed that the nervous system is subdivided into a number of discrete organs located in the cortex, each organ with a distinct function. He thought that these functions could be assessed by palpation of the head in a technique called cranioscopy (Temkin, 1947; Young, 1970).

Gall’s neurological functions include a variety of sensory, motor, mental and moral activities, such as the sexual instinct, love of progeny, memory, language, pride, vanity, colour vision and religious sensibility. The French physiologist Marie Jean Pierre Flourens (1794–1867) led the opposition to phrenology from a position atop the French scientific establishment. He suggested that the cortex is omnipotential; when one function disappears, they all disappear, when one recovers they all recover. Because of his prominent position, Flourens and his work became scientific orthodoxy in the 1840s and 1850s (Flourens, 1824).

Meanwhile, the physician Jean-Baptiste Bouillaud (1796–1881) used experimental evidence of a different sort to support the ideas of his teacher Gall. Using what we would now call

clinicopathological correlation, Bouillaud taught his students that language was localized in the anterior lobes and that certain cerebral organs serve different movements. One student, Pierre Paul Broca (1824–80), kept Gall’s concept of the localization of function alive despite Flourens’s opposition. Broca’s friend Charles Edouard Brown-Séquard (1817–94) brought French experimental physiology to the UK and gave instant scientific credibility to the new National Hospital for the Paralysed and Epileptic in Queen Square, London. He also was responsible for John Hughlings Jackson becoming a neurologist (Young, 1970; Temkin, 1971; Schiller, 1979; Aminoff, 2010).

Hughlings Jackson, like Brown-Séquard, rejected cranioscopy and the superstructure of phrenology but accepted the idea that the nervous system is composed of discrete organs, each with a different function. Also like Brown-Séquard, he taught that studying the anatomy, pathology and physiology allows the astute physician to both diagnose neurological disease and to learn the function of the organs involved. He combined the motor system, the language system, auscultation of the heart and an understanding of anatomy, pathology and physiology to consistently localize aphasia in the left inferior frontal lobe.

Hughlings Jackson did not invent the neurological idea that the nervous system is an aggregate of distinct organs, each with a single function. Instead, he adapted it from his teachers and predecessors Brown-Séquard, Bouillaud and Gall. Like Brown-Séquard he supplemented theory with laboratory studies gleaned from the literature. He used this idea, and his own scientific creativity, to develop a model of cerebral localization of focal lesions that persists today. Even lacking electrical and radiological studies, using the phrenological assumption produces tolerably consistent diagnoses.

## Epilepsy

### The nature of the epileptic discharge

In the 1850s, Robert Bentley Todd (1809–60) was the foremost English-speaking authority on epilepsy. In his Lumleian lectures of 1849, he claimed that nervous tissue stored an electrical force very much like William Faraday’s galvanic force (Todd, 1849; Reynolds, 2004, 2005). His published collection of clinical lectures was the foremost textbook of clinical neurology in the 1850s, used by a generation of medical students including the young Hughlings Jackson (Todd, 1855).

Hughlings Jackson’s first recorded neurological writing appears in the 5 February 1859 entry of the Minute Book of the York Medical Society (Greenblatt, 1964). He cites Todd’s textbook to support his views of facial weakness, in which Todd wrote ‘The phenomena of the epileptic fit depend upon a disturbed state of the nervous force, in certain parts of the brain—a morbidly excited polarity’ (Todd, 1855).

Hughlings Jackson wrote in 1867 that epilepsy is a ‘sudden disorderly expenditure of force’ (Hughlings Jackson 1867a). He did not say what comprised that force. Later that year he expanded this view, saying that ‘the ill-nourished nerve-tissue is

more unstable, over-ready, “excitable”; there is discharge too soon; its Time is shortened’ (Hughlings Jackson, 1867b).

Shortly thereafter Hughlings Jackson published his landmark ‘A study of convulsions’ in the *Transactions of the St Andrews Medical Graduates’ Association* (Hughlings Jackson, 1870). This classic treatise observes that ‘A convulsion is but a symptom, and implies only that there is an occasional, an excessive, and a disorderly discharge of nerve tissue on muscles’ (Hughlings Jackson, 1870). In this classical description of the epileptic discharge, Hughlings Jackson assumed that the epileptic discharge originated in the cortex. He refined this dictum in 1873 when he wrote ‘Epilepsy is the name for occasional, sudden, excessive, rapid, and local discharge of grey matter’ (Hughlings Jackson, 1873).

In the first of his 1890 Lumleian lectures on epilepsy, Hughlings Jackson defined nervous discharge as the liberation of energy by nervous elements (Hughlings Jackson, 1890a). In his second Lumleian lecture, he used a chemical analysis to describe the epileptic discharge, saying that it is a ‘physiological fulminate’ like the gunpowder in a cannon (Hughlings Jackson, 1890b). Just as gunpowder can store energy that is liberated when the gun is fired, so the energy stored in nerve cells can be explosively liberated in an epileptic discharge.

## Somatotopic representation and Jacksonian epilepsy

Between December 1867 and December 1868 Hughlings Jackson published a series of articles on the temporal sequence of involuntary movement or sensation in unilateral seizures. On 21 December 1867 he wrote, ‘Then in unilateral convulsions the “aura” nearly always begins in the hand; sometimes, however, in the side of the face, and rarely in the leg. So the speculation is that, although each movement is everywhere represented, there are points where particular movements are specially represented’ (Hughlings Jackson, 1867c).

In August 1868, he identified somatotopic representation in the corpus striatum and thalamus. He published his first description and interpretation of the Jacksonian march on 19 December 1868:

I think the mode of beginning makes a great difference as to the march of the fit. When the fit begins in the face, the convulsion in involving the arm may *go down* the limb. . . . When the fit begins in the leg, the convulsion marches up; when the leg is affected after the arm, the convulsion marches *down* the leg. (Hughlings Jackson, 1868b) (emphasis in the original)

Hughlings Jackson’s surname is associated with a form of focal seizure in which ictal movements ‘march’ through one side of the body, commonly beginning in the thumb. The importance of the Jacksonian march lies in its unambiguous demonstration of somatotopic representation of the body in the brain by recapitulating the sequence of representation of the body in the corpus striatum and the cortex. The Jacksonian march forcefully disproves the theory that all parts of the nervous system are functionally equipotential and validates the scientific idea that analysis of the temporal development of a focal neurological deficit is diagnostically useful. The knowledge of somatotopic representation allowed the

bedside neurologist to predict the presence of focal pathology in the nervous system with tolerably consistent accuracy.

The term ‘Jacksonian epilepsy’ was first used by the French neurologist Jean-Martin Charcot (1825–93), who was the most influential neurologist of the time. Memorializing Hughlings Jackson in 1887, he recognized that somatotopic representation is critical to neurological diagnosis (Charcot, 1887). The astute neurologist expends great effort in discovering the first symptom of focal epilepsy because the localization of that symptom tells the examiner where the pathology lies.

The neurological idea of somatotopic representation underlies scientific localization, in which a physician can predict the nature and prognosis of neurological disease by physical diagnosis. This skill is useful when even the most advanced scanners produce ambiguous results.

## Evolution and dissolution of the nervous system

### Weighted ordinal representation

Herbert Spencer (1820–1903) characterized embryological and mental development as the gradual appearance of more complex and differentiated states and said that evolution is the governing principle for all manner of natural, political, social and psychological phenomena (Spencer, 1855, 1862; Swash, 1989). In these works, Spencer contributed two crucial principles to evolutionary neurophysiology. First, he characterized the evolution of the nervous system as a progression from simple, small, homogeneous elements to complex, large, heterogeneous and integrated forms. This applied to anatomical development as well as psychological development. The more evolved structures were therefore ‘higher’ in both a phylogenetic and a moral sense. Secondly, Spencer characterized evolution as progress away from equilibrium towards specialization, and called the reverse process ‘dissolution’ (Spencer, 1862; Temkin, 1971; Smith, 1982a, b).

Hughlings Jackson included these principles in his neurophysiology. He assumed that the cortex was the highest evolutionary level of the nervous system. As such, it controlled and inhibited the function of lower levels so that cortical disease led to two sets of symptoms, ‘negative’ from loss of the controlling cortex and ‘positive’ from the emergence of the lower centre (Spencer, 1855; Russell Reynolds, 1861; Pearce, 2004). This implied an anatomical and physiological hierarchy of higher and lower centres, with the higher ones suppressing the function of the lower ones. He expresses the physiological relationship between higher and lower functions in Spencer’s evolutionary principles:

The higher the centre the more numerous, different, and more complex, and more special movements it represents, and the wider region it represents—evolution. The highest centres represent innumerable, most complex and most special movements of the organism, and. . . each unit of them represents the organism differently. In consequence, the higher the centre the more numerous, complex and special movements of a wider region are lost from a negative lesion of equal volume—dissolution. (Hughlings Jackson, 1882)

Hughlings Jackson was a practising physician and a practical man, and he sought to make these neurological ideas diagnostically useful. In his March 1884 Croonian lectures at the Royal College of Physicians in London, he explained his ideas to a general medical audience. Hughlings Jackson's idea of cerebral localization considered the nervous system as an evolutionary hierarchy of three levels connected by the process of weighted ordinal representation. Each element of the lowest level represents a particular body part such as the right elbow or the left foot. In the middle level, each element re-represents the entire lower level; each therefore contains a complete representation of the entire body. Similarly, at the highest level, each element contains a complete representation of the middle level, so that each element re-represents the entire body (Hughlings Jackson, 1884). This type of nested representation is ordinal, in the sense that each level is ordered by inclusion.

He introduced weighting in his 1870 *Study of Convulsions* when he proposed that each element of the corpus striatum contains a complete representation of the movements of the body but is uniquely weighted for a particular body part (Hughlings Jackson, 1870). For example, in the middle level, one element contains a representation of the entire body but is most heavily weighted for the right foot, another for the left knee. This weighting explained why if one element is convulsed, the convulsion does not affect the entire body. The Jacksonian march results from successive recruitment of elements of different weighting.

In Jacksonian compensation, if one element is damaged, other elements with less weighted representation continue to act in proportion to their initial weighting. This compensation includes elements of the same evolutionary level and also elements of different levels. In addition, damage to higher levels produces less severe symptoms than damage to lower levels, because higher levels contain more complex and interconnected representations of the damaged area and therefore compensate more fully in the event of brain injury. The concept of weighted representation meant that this system could be a dynamic one (Hughlings Jackson, 1875; York and Steinberg, 1995).

Re-weighting of representation in undamaged areas of the nervous system implies that, in progressive recovery, some areas will become more active and others less active than in the normal, undamaged brain. This aspect caused Hughlings Jackson to write that the loss of a particular movement is 'largely compensated in time by greater activity' of the remaining areas (Hughlings Jackson, 1882). He also noted that higher levels of evolution suppress the function of lower levels, implying that the symptoms of neurological disease are dual in nature, negative and positive. He made the diagnostically crucial point that dissolution can be uniformly distributed through the nervous system or could be local, a principle now known to every practising neurologist. Focal dissolution may involve one neurological organ or several, and could extend through one or more evolutionary levels (Hughlings Jackson, 1884).

In his third Croonian lecture, Hughlings Jackson considered mental physiology in light of his evolutionary neurophysiology (Hughlings Jackson 1884). He reasoned that, if the nervous system is a sensorimotor machine arranged as a three-level evolutionary hierarchy, then the mind must have a similar

architecture. He assumed that consciousness is the product of the highest level of mental evolution, and concluded that subconscious or unconscious mental functions also exist, and should emerge when mental dissolution impairs the highest mental functions.

Dynamic weighted ordinal representation is the principle by which neurologists analyse symptoms based on an understanding of how the nervous system works. Symptoms and signs are positive or negative, disease is focal or diffuse, and the capable examiner uses these principles to make a diagnosis independent of scanners or post-mortem examination. Furthermore, the dynamic aspect of re-weighting of representation establishes the basis of recovery. Jacksonian neurophysiology in the form of weighted ordinal representation underlies modern bedside localization.

## The Doctrine of Concomitance

Hughlings Jackson first enunciated the Doctrine of Concomitance in his Croonian lectures (Hughlings Jackson, 1884). He considered human consciousness the highest level of mental evolution, the analogue of the highest level of evolution of the nervous system. This generated an urgent question: how, if at all, are these two highest expressions of evolution related?

Hughlings Jackson knew at least three theoretical solutions to the mind–body problem. In the first, the 'mind acts through the nervous system through an immaterial agency' (Hughlings Jackson, 1887, p. 37). This version can be recognized as Cartesian dualism. In the second solution, 'activities of the highest centres and mental states are one and the same thing' is a statement of the mind–brain identity theory (Hughlings Jackson, 1887). The third version says that brain states and mental states are intrinsically different, occur in parallel and have no causal interaction between them. This brain–mind theory, a form of psychophysical parallelism, Hughlings Jackson called the Doctrine of Concomitance.

Hughlings Jackson recognized that any solution to the mind–body problem was a philosophical theory, which he specifically termed metaphysical. Under most circumstances he strongly rejected metaphysical explanations for medical observations (York and Steinberg, 2002). Nonetheless, he embraced the Doctrine of Concomitance because it allowed a practical analysis of neurological disease, which conformed to his clinical observation. He did not invent the Doctrine of Concomitance, but claimed that a number of other Victorian scientists and philosophers held similar views. The basic idea can be traced to the German philosopher Gottfried Leibniz's 'two clock theory' in which one clock is timed to strike when the other showed the hour. This is taken as an analogy of the non-causal parallelism of brain and mind.

The Doctrine of Concomitance has had two practical consequences for front-line physicians. First, it has allowed diagnosticians to focus on sensorimotor signs and symptoms, excluding the mental. The resulting neurological diagnosis has the virtue of reasonable consistency. Like Hughlings Jackson, most physicians are only too aware of the effect of the mind on health, but these symptoms are excluded from physical diagnosis.

Secondly, the Doctrine of Concomitance further separated the disciplines of neurology and psychiatry conceptually and

institutionally. Before Hughlings Jackson, alienists had cared for the mentally ill, often in large institutions. The Doctrine of Concomitance meant that neurologists could attend to sensorimotor symptoms while psychiatrists attended to the mental, a separation that extended to the laboratory. The increasing separation of neurology and psychiatry remains incomplete; neurologists still treat mentally ill patients, and psychiatrists regularly deal with brain disease. Yet the Doctrine of Concomitance distanced neurology from psychiatry, and echoes of this separation persist today.

## The rejection of the unconscious

Hughlings Jackson's Doctrine of Concomitance led him to consider the evolutionary structure of the mind. Consciousness, as the highest level of mental evolution, is as the most complex, most specialized, most integrated and most interconnected mental function, analogous to the highest level of the nervous system (Hughlings Jackson, 1887). As a practical physician, he sought to find evolutionary levels of the mind with the aim of treating mental disease.

Hughlings Jackson reasoned that the structure of the mind should strictly follow the structure of the nervous system. He thought that if the nervous system is composed of evolutionary levels connected by a process of representation, and if the mind and the brain are related by the Doctrine of Concomitance, then the mind can also be understood as having evolutionary levels connected by representation. Furthermore, just as states of the highest level of nervous evolution have concomitant mental states, so states of the middle and lower levels of nervous evolution must have concomitant mental levels; but any mental state lower than consciousness must be unconscious. If the combination of weighted ordinal representation and concomitance is correct, then unconscious mental states must exist. This led Hughlings Jackson to consider how far down the evolutionary hierarchy are there concomitant mental states; in Hughlings Jackson's words, '...what is the range of concomitance?' (Hughlings Jackson, 1887).

This statement exposes Hughlings Jackson's dilemma. If the highest level of brain evolution has the concomitant mental state of human consciousness, then lower levels of brain evolution also must have concomitant, unconscious, mental states that emerge when consciousness is suppressed. But no such states are apparent clinically; an unconscious patient is simply unresponsive. He resolved this by rejecting the entire idea of the unconscious, stating that any state of mind is, by definition conscious and indeed cannot be otherwise.

Unconscious mental states are, for Hughlings Jackson, a contradiction. He wrote,

Unconscious states of mind are sometimes spoken of, which seems to me to involve a contradiction. That there may be activities of lower nervous arrangements of the highest centres, which have no attendant psychical states, and which yet lead to next activities of the very highest nervous arrangements of those centres whose activities have attendant psychical states, I can easily understand. But those prior activities are states of

the nervous system, not any sort of state of mind' (Hughlings Jackson, 1887).

Hughlings Jackson had a practical motivation for his rejection of the unconscious. His commitment to the idea of the nervous system as a sensorimotor machine made him reject explanations of nervous system disease in psychological or philosophical terms. As a physician, he aimed to develop a system that was useful at the bedside. This produced extreme empiricism, so that he could not accept a theory that had no visible examples in everyday neurological practice. He specifically disavowed any philosophical interest in the mind–body relationship, saying that 'As an evolutionist I am not concerned with this question, and for medical purposes I do not care about it' (Hughlings Jackson, 1888). This ultimately led to perplexity.

## Commentary: the impact of Hughlings Jackson's neurological ideas

Hughlings Jackson had a seminal impact on clinical neurology. Part of this is the result of his uniquely attractive personality, which elicited comments from many of his contemporaries and students. To use a single example, when the prickly William Gowers unveiled a bust of Hughlings Jackson in the National Hospital, Queen Square, he exclaimed, 'Behold The Master!' Hughlings Jackson was elected a Fellow of the Royal Society but was otherwise invisible to the world outside of neurology. He never received the knighthood bestowed on Jonathan Hutchinson, William Gowers, David Ferrier, Henry Head (1861–1940), Gordon Morgan Holmes (1876–1965) and Charles Sherrington (1857–1952). He received an honorary degree from the University of Leeds in his beloved Yorkshire, but no recognition from the ancient universities.

Hughlings Jackson was not involved in the personal and professional clashes that characterized Victorian science and medicine. He was a convinced agnostic. Though baptized and married in church, he had no belief in a personal God or an afterlife. His closest friend, Jonathan Hutchinson (1828–1913) wrote, 'I do not believe that Jackson had ever made any change in his religious faith. It was one of the simplest form of agnosticism... he was an absolute disbeliever in personal immortality after death' (Hutchinson, 1911). His science reflected this belief. However, he was careful to disclaim any irreligious intent in his neurological ideas, and was personally soft-spoken, socially withdrawn and outwardly modest. He was thus a poor target for vitriol, and there is no record of his receiving personal criticism on account of his ideas.

Few modern neurologists know of his personal modesty and warmth, but they use his neurological ideas whenever they encounter a patient. Neurologists assume that the nervous system is exclusively sensorimotor, that the nervous system is an aggregate or discrete systems and that somatotopic representation applies throughout the nervous system. They know that symptoms can be focal or diffuse, positive or negative, and that recovery is the

rule in patients with neurological injury. Hughlings Jackson articulated all these ideas in his Croonian lectures of 1884.

Moreover, experimental neurobiologists use Jacksonian ideas in analysis of their findings. The Jacksonian formulation of neuroscience is the result of an axiomatic assumption, an explicit method and a clear and comprehensible neurophysiology. Many of the progenitors of neurology were convinced 'Jacksonians', including Ferrier, Gowers, Samuel Alexander Kinnier Wilson (1878–1937), Head, Holmes and Constantin von Monakow (1853–1930). He had a pronounced influence on the Cambridge neurophysiologist Charles Sherrington and those who followed him. He even generated a neo-Jacksonian school of psychiatry headed by Henry Ey (1900–77).

Hughlings Jackson's writings were and are famously dense and difficult to comprehend. Yet their ideas remain alive because of their profundity and utility to the practising neurologist. Reading his articles, which date to the beginning of modern neurology, reward the student with fresh insights into patients with neurological disease. He thought scientifically, and those who now think in the same way use Jacksonian ideas. It is a useful legacy.

## References

- Aminoff M. Brown-Séquard. An improbable genius who transformed medicine. Oxford: Oxford University Press; 2010.
- Charcot JM. Leçons du mardi à la Salpêtrière [Tuesday Lectures at the Salpêtrière]. Paris: Delahaye & Lecrosnier; 1887.
- Cranefield PF. The way in and the way out. Francois Magendie, Charles Bell and the roots of the spinal nerves. Mount Cisco, NY: Futura Publishing; 1974.
- Critchley M, Critchley EA, John Hughlings Jackson. Father of English neurology. Oxford: Oxford University Press; 1998.
- Editorial. Clinical lectures and reports by the Medical and Surgical Staff of the London Hospital. *Brit Med J* 1864; ii: 524.
- Flourens P. Recherches expérimentales sur les propriétés et les fonctions du système nerveux dans les animaux vertébrés. Paris: Chez Crevot; 1824. Translated as: Investigations of the properties and the functions of the various parts which compose the cerebral mass. In: Von Bonin G, editor. Some papers on the cerebral cortex. Springfield, IL: Charles C. Thomas, 1960: 2–21.
- Ferrier D. Experimental researches in cerebral physiology and pathology. *West Riding Lunatic Asylum Med Rep* 1873; 3: 30–96.
- Fritsch G, Hitzig E. Über die elektrische Erregbarkeit des Grosshirn [On the Electrical Excitability of the Cerebrum]. *Archive für Anatomie, Physiologie und wissenschaftliche Medizin* 1870; 300–32.
- Greenblatt SH. The major influences on the early life and work of John Hughlings Jackson. *Bull Hist Med* 1965; 39: 346–76.
- Hall M. Lectures on the nervous system and its diseases. London: Sherwood, Gilbert and Piper; 1836.
- Hughlings Jackson J. Suggestions for studying diseases of the nervous system on Professor Owens' vertebral theory. London: HK Lewis; 1863.
- Hughlings Jackson J. On the study of diseases of the nervous system. A lecture delivered in June 1864. *Clin Lect Rep by the Medical and Surgical Staff of the London Hospital* 1864a; 1: 146–58.
- Hughlings Jackson J. Loss of speech: its association with valvular disease of the heart, and with hemiplegia on the right side—defects of smell—defects of speech in chorea—arterial regions in epilepsy. *Clin Lect Rep by the Medical and Surgical Staff of the London Hospital* 1864b; 1: 388–471.
- Hughlings Jackson J. Note on the comparison and contrast of regional palsy and spasm. *Lancet* 1867a; i: 295–7.
- Hughlings Jackson J. Remarks on the disorderly movements of chorea and convulsion. *Med Times Gazette* 1867b; ii: 642–3.
- Hughlings Jackson J. Remarks on the disorderly movements of chorea and convulsion. *Med Times Gazette* 1867c; ii: 669–70.
- Hughlings Jackson J. Notes on the physiology and pathology of the nervous system. *Med Times Gazette* 1868a; ii: 526.
- Hughlings Jackson J. Notes on the physiology and pathology of the nervous system. *Med Times Gazette* 1868b; ii: 696.
- Hughlings Jackson J. A study of convulsions. *St Andrews Medical Graduates'. Association Transact* 1869; 1870: 162–204.
- Hughlings Jackson J. On the anatomical, physiological, and pathological investigations of epilepsies. *West Riding Lunatic Asylum Med Rep* 1873; 3: 315–49.
- Hughlings Jackson J. Clinical and physiological researches on the nervous system. No. 1. On the localisation of movements on the brain. London: J. and A. Churchill; 1875.
- Hughlings Jackson J. On some implications of dissolution of the nervous system. *Med Press Circ* 1882; 2: 411–4.
- Hughlings Jackson J. Evolution and dissolution of the nervous system. Croonian Lectures delivered at the Royal College of Physicians, March 1884. *Lancet* 1884; 1: 555–8, 649–52, 739–44.
- Hughlings Jackson J. Remarks on evolution and dissolution of the nervous system. *J Mental Sci* 1887; 23: 25–48.
- Hughlings Jackson J. On post-epileptic states: a contribution to the comparative study of insanities. *J Mental Sci* 1888; 34: 349–65.
- Hughlings Jackson J. The Lumleian Lectures on convulsive seizures. *Lancet* 1890a; i: 685–8.
- Hughlings Jackson J. The Lumleian Lectures on convulsive seizures. *Lancet* 1890b; i: 735–8.
- Hutchinson J. The late Dr. Hughlings Jackson: recollections of a lifelong friendship. *BMJ* 1911; ii: 1551–4.
- Jensen JV. Return to the Wilberforce-Huxley debate. *Brit J Hist Sci* 1998; 21: 161–79.
- John Hughlings Jackson, M.D., F.R.C.P., F.R.S. [obituary]. *BMJ* 1911; ii: 950–4.
- John Hughlings Jackson, M.D. St. And., F.R.C.P. Lond., LL.D., D.Sc., F.R.S. [obituary]. *Lancet* 1911; ii: 1103–7.
- Liddell EGT. The discovery of reflexes. Oxford: Clarendon Press; 1960.
- Laycock T. Analytical essay on irregular and aggravated form of hysteria. *Edinburgh Med Surg J* 1839; 52: 43–86.
- Laycock T. On the reflex function of the brain. *Brit Foreign Med Rev* 1845; 19: 298–311.
- Mueller J. Elements of physiology. Baly W, translator. London: Taylor and Walton; 1838.
- Pearce JMS. Positive and negative cerebral symptoms: the roles of Russell Reynolds and Hughlings Jackson. *J Neurol Neurosurg Psychiatry* 2004; 75: 1148.
- Reynolds EH. Todd, Faraday and the electrical basis of brain activity. *Lancet Neurol* 2004; 3: 557–63.
- Reynolds EH. Robert Bentley Todd's electrical theory of epilepsy. *Epilepsia* 2005; 46: 991–4.
- Russell Reynolds J. Epilepsy: its symptoms, treatment and relation to other chronic convulsive disorders. London: John Churchill; 1861.
- Schiller F. Paul Broca. Berkeley: University of California Press; 1979.
- Smith CUM. Evolution and the problem of mind: Part I. Herbert Spencer. *J Hist Biol* 1982a; 15: 55–88.
- Smith CUM. Evolution and the problem of mind: Part II. John Hughlings Jackson. *J Hist Biol* 1982b; 15: 241–62.
- Spencer H. Principles of psychology. London: Longman, Brown, Green, and Longmans; 1855.
- Spencer H. First principles. London: Williams and Norgate; 1862.
- Swash M. John Hughlings Jackson. A historical introduction. In: Kennard C, Swash M, editors. Hierarchies in neurology: a reappraisal of a Jacksonian Concept. London: Springer Verlag; 1989.
- Taylor J. Biographical memoir. In: Hughlings Jackson J, editor. Neurological fragments. London: Oxford University Press; 1925.
- Temkin O. Gall and the phrenological movement. *Bull Hist Med* 1947; 21: 275–321.

- Temkin O. *The falling sickness*. 2nd edn., revd. Baltimore: Johns Hopkins University Press; 1971.
- Todd RB. On the pathology and treatment of convulsive disorders. *London Med Gazette* 1849; 8: 724–9; 766–72, 815–22; 837–46.
- Todd RB. *Clinical lectures on paralysis, diseases of the brain, and other affections of the nervous system*. London: Lindsay and Blakiston; 1855.
- York GK, Steinberg DA. Hughlings Jackson's theory of recovery. *Neurology* 1995; 45: 834–838.
- York GK, Steinberg DA. Hughlings Jackson's philosophical motivation. *J Royal Soc Med* 2002; 96: 314–8.
- York GK, Steinberg DA. *An introduction to the life and work of John Hughlings Jackson, with a catalogue raisonné of his writings*. London: The Wellcome Trust Centre for the History of Medicine at UCL; 2006.
- Young RM. *Mind, brain and adaptation in the nineteenth century*. Oxford: Clarendon Press; 1970. Reprinted Oxford: Oxford University Press; 1990.