In search of the brain of Descartes

What, if anything, has psychology learned from the study of famous brains? G. Neil Martin investigates…

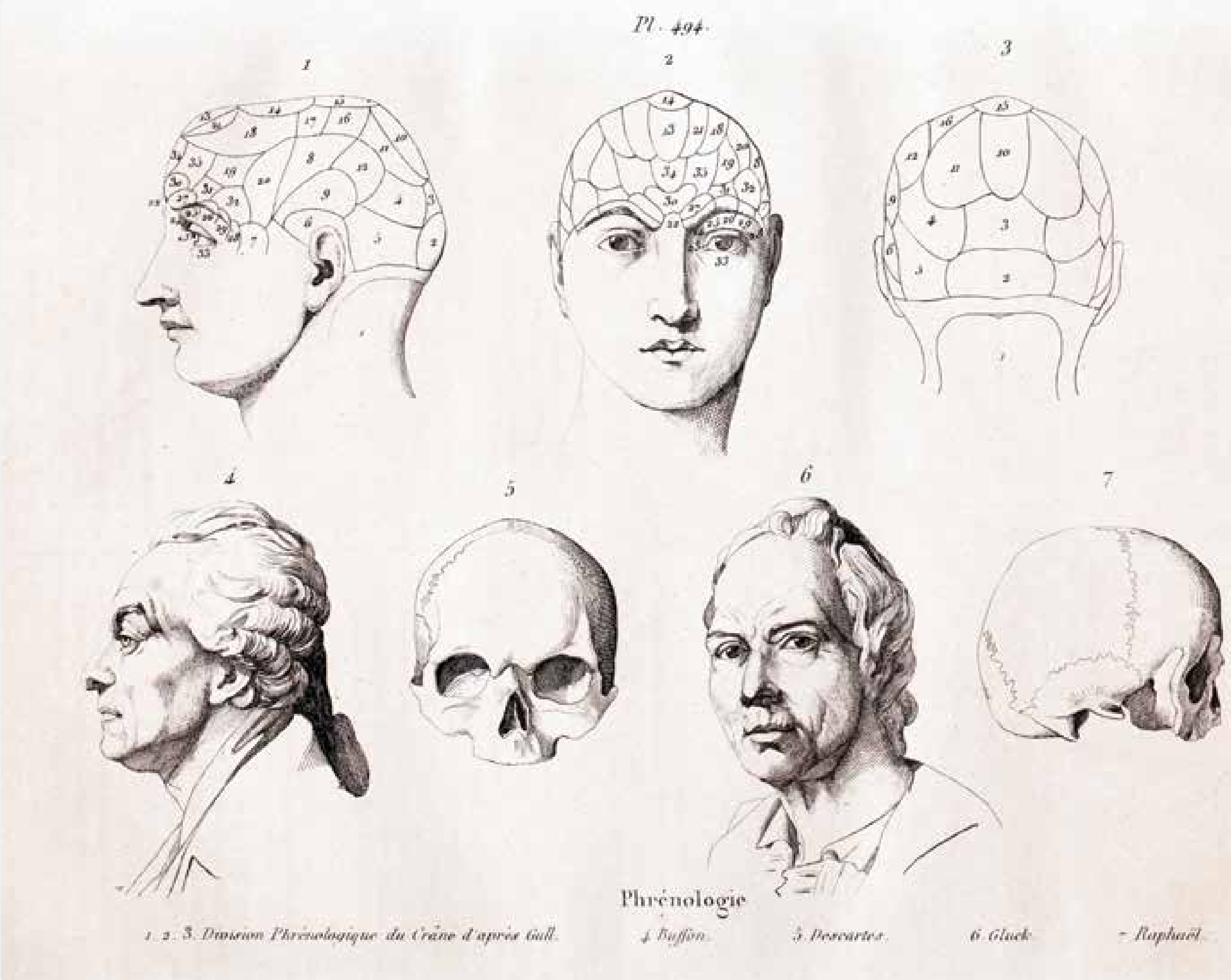
Psychology has its own famous brains – Leborgne, Kim Peek, Henry Molaison, Phineas Gage, EVR, NA, Shereshevsky, HJA. Extensively studied before and after death, they have sometimes provided a theoretical scaffold to support the data. But studies of other, more publicly celebrated brains have sought to shed light on the association between talent or trait and brain geography. This is their story.

'I am a brain, Watson,' declared Sherlock Holmes in *The Adventure of the Mazarin Stone*, 'the rest of me is a mere appendix.' Holmes's cephalocentrism (and his narcissism) is no secret; he was not shy about promoting his cerebral credentials and comparing them favourably with his more pedestrian companion. It doesn't take a detective to work that out. But our story, of brains and fame, starts not with double-crossing aristocrats but with Descartes.

Lund, Sweden, 1650, was the location of the burial of the Frenchman, mathematician, logician, Renaissance man. But the body did not rest there for long, and the history of the brain (and skull) of René Descartes since his death is chequered and extraordinary. In 1666 his body was disinterred and relocated to the office of the French Ambassador to Sweden, Hugues de Terlon, and guarded by an army captain, Isaak Planstrom. Terlon was allowed to keep the index finger before the body was returned to Paris for re-burial. During the French Revolution, the body was retrieved again and the skull kept in a local museum. Some have questioned whether the skull did leave Sweden: in 1818, for example, no skull was found inside the coffin. But this was the least extraordinary aspect of the journey of brain and skull of Descartes. A brilliant account of its necroscopic journey was published by Charlier Philippe and colleagues in the *Journal of Neurological Sciences* in 2017.

In 1821, in an auction of the chattels of the estate of Anders Sparrman, among the items listed was 'the skull of the famous Cartesius'. There is evidence that the discarded skull was sold by a Swedish casino operator to a Swedish chemist called Berzilius, who sent it to the Académie des Sciences in Paris. An archivist at the Academy, who tried to determine provenance, discovered that a school headmaster had spotted the skull in the house of a colleague, Jonas Olafsson Bang. Bang's father was a merchant and brewer to whom a debt was repaid in the form of the skull. The debtor was the man who was entrusted to look after the remains for Terlon: Isaak Planstrom. On the forehead of the skull was written (in Swedish): 'The skull of René Descartes, taken by J Fr Planstrom, the year 1666, and the same time when the body was being returned to France.' Bang Jr supplemented the inscription with a few verses of Latin. Both are still on the skull. It is probably the most vandalised famous skull in history.

In 1751 the skull was inherited by a government official, then by an 'economic superintendent' in Stockholm in 1796. It then passed on to a tax assessor, in an auction, then to the official's son-in-law and then to a Professor of Surgery. The Académie des Sciences, when it came into possession of the bones, concluded that they must be those of Descartes. The skull now rests in the Musée de l'Homme in Paris. It is, by all published scientific accounts, quite normal for a human. An endocast reconstruction of the brain of Descartes by Philippe and his colleagues, using CT scans of the skull, was compared with those of 102 individuals



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from the National Museum of Natural History in Paris. It displayed cerebral variation consistent with that of modern brains but with some exceptions: some parietal gyri were wider and the inter parietal sulcus was more apparent on the left side. But did this cerebral expansion signify anything more profound than a neuroanatomical abnormality? Was this a neural expression of his mathematical giftedness and polymathy? In the sober, scientific light of day, probably not, given that the brain was largely no different to a 'normal' brain. But this exercise, and others like it, have not stopped scientists from trying to match anatomical anomalies with special talents.

The brain of a genius

Einstein's is one of the few brains to have been extensively studied at the histological and neuroanatomical level. Einstein died on 16 April 1955, aged 75. His wish was to be cremated but his pathologist, Thomas Harvey, saved his brain – the ownership of which has been disputed ever since.

The first study of Einstein's brain was published 30 years after his autopsy. Of the four sections of the brain donated to the study, a lower neuron to glia ratio was found in his brain compared with 'less gifted' brains. The parietal cortex contained more glial cells. But, inevitably, the age of the study, as well as the method of execution, raises obvious problems: members of the control group were younger than Einstein when they died and were from a different socio-economic group, none of the controls had died of a neurological condition, and only one in four of the statistical tests was statistically significant. Other measures had been excluded: the number of neurons, for example, and the number of specific types of glial cells. A second study, published in 1996, found a higher density of neurons in the right prefrontal cortex.

More superficial studies – literally, photographs of Einstein's brain – have found that the inferior parietal lobule is larger than in controls and that the gyrus behind the Sylvian fissure was undivided by a sulcus. Sandra Witelson and her team, in a study published in 1999, noted that the latter feature was absent in 91 controls and that Einstein showed a more symmetrical parietal cortex. At this point, Albert Galaburda enters the fray, arguing that no such differences could be observed. To which, Witelson and her group countered that Galaburda was looking in the wrong place. They say that science progresses through contradiction.

Other photographic studies reported a 'knob' in the right postcentral gyrus which was attributed to the scientist's violin-playing (violinists have been found to exhibit this feature). A subsequent analysis based on new photographs and by the same research group also found differences in the length of sulci, thickness and size of gyri and differences in the configuration of gyri. Additional findings included a 'knob' in the right frontal lobe, an enlarged left motor cortex in the face area, and a large sulcus in the right occipital lobe. The symmetry of the brain was not confirmed. The authors attributed the larger areas devoted to the face and tongue to Einstein's view that thinking was muscular. 'The extraordinary expansion of the lateral part of Einstein's left primary somatosensory and left primary motor cortices', they write, is curious given that 'Einstein wrote that thinking entailed an association of images and feelings, and that, for him, the elements of thought were not only visual but also muscular.' But, as Terence Hines has pointed out in a review of the Einstein's brain literature, whether anyone would have taken this reflection of Einstein's and predicted that his brain would show comparatively larger tongue and face areas is moot.

The corpus callosum also appeared to be different in Einstein. Nine of 10 measures in one study showed differences – the corpus callosum was larger than that of the elderly and larger than that of the young in six areas, for example. The authors of the study suggested that this demonstrated the extensive connections in Einstein's brain compared with normal brains. Hines, again, has pointed out that if one part of the corpus callosum is larger, another one is likely to be too. Hines also remarks that differences have been found in the white and grey matter of bilingual speakers compared with monolinguals, in areas which the corpus callosum studies ascribe to Einstein's genius. Einstein was bilingual. The morphological and histological features in his brain may reflect his bilingualism, rather than his genius.

"On the day of Haydn's burial a gravedigger was paid to remove the head and return it to a group of keen phrenologists in Eisenstadt"

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Killers and composers

Other famous brains studied are just as eminent, or notorious. For example, of the four US presidents who have been assassinated (Lincoln, Garfield, McKinley, Kennedy) only two of the assassins have been tried and executed – the killers of Garfield and McKinley, Charles Julius Guiteau and Leon Franz Czolgosz. Edward Anthony Spitzka, a student in his fourth year at medical school but already the author of several papers on neurology, conducted an autopsy of Czolgosz. His father had testified at the trial of Guiteau. Spitzka Jr is particularly interesting because he also published a study of the brains of six eminent scientists, and scholars from the American Anthropometric Society, a learned society established in 1899 whose chief object 'was the preservation of the brains of its members'. Spitzka was one of five founding members.

His paper, published in *Transactions of the American Philosophical Society* in 1907, is extraordinary in that it provides an account of the brains, at autopsy, of 130 'noble' men and four women. Walt Whitman's was one brain whose donation might have provided Spitzka with interesting study material. However, this was not to be. In Spitzka's words, 'the brain of Walt Whitman, together with the jar in which it had been placed, was said to have been dropped on the floor by a careless assistant. Unfortunately, not even the pieces were saved' (p.176).

Some of the famous brains Spitzka describes in his paper, and the features observed by those who studied those brains, are intriguing. Beethoven's brain, according to Johann Wagner who performed the composer's autopsy, showed that 'the convolutions appeared twice as numerous and the tissue twice as deep as in ordinary brains'; Karl Friedrich Gauss's brain was 'remarkable for the multiplicity of fissures and the great complexity of the convolutions. Richness of fissuration is particularly notable in the frontal region'; Robert Schumann showed whole-brain atrophy and distended blood vessels at the base of the brain and new irregular formation of bone mass; William Thackeray had 'a very large brain weighing no less than fifty eight and a half ounces', according to one report; Charles Babbage, whose brain is preserved in the Museum of the Royal College of Surgeons, had a brain weighing 1403 grams and showed a 'well-developed sulcus frontal medialis of Cunningham and a special richness of the anterior part of the inferior frontal convolution'; Ivan Turgenev's brain showed symmetry of convolutions; Friedrich Smetana, who died of paralytic dementia and was described as being of 'delicate frame', showed the atrophy typical of dementia, and atrophy of the auditory nerve (he became deaf) – his brain also weighed 1250g, which is heavy for a brain in this state of degeneration; George Gordon (Byron) had a brain weighing 2238 grams which was 'exceedingly congested' with two ounces of blood discovered in his ventricles.

Even one of neurology and psychology's well-known figures, Franz Josef Gall, co-creator of anatomical personology or phrenology with Kaspar Spurzheim, was included (as was Spurzheim). Four to five ounces of fluid was found at the base of Gall's skull and the right cerebellum was larger (and contained a tumour). Spurzheim's brain weighed 1559 grams. Gall himself was a notorious skull collector: it is thought that by around 1802, he had amassed around 300 of them. In 1800 one observer remarked in relation to the skull of Mozart that 'Everyone in Vienna is very concerned and alarmed lest his head might end up in Gall's collection.' Gall was particularly taken with musicians, concluding from his viewing of various paintings that Gluck, Haydn, Salieri, Beethoven, Mozart and others exhibited 'an organ of music', a phrenological feature.

The fate of Mozart's brain and skull is as peculiar as that of Descartes. A skull thought to be that of Mozart was curated at the Mozarteum in 1901. In 2006, the composer's 250th birthday, a team of forensic pathologists sought to determine whether this skull was that of the musical paragon. DNA from two of the skull's teeth was compared with DNA taken from the thigh bones of Mozart's grandmother and niece on his mother's side. The scientists were unable to conclude that the skull was Mozart's.

Joseph Haydn's brain was another that was sought after for study, but its acquisition was more nefarious than that of Mozart's. On the day of Haydn's burial a gravedigger was paid to remove the head and return it to a group of keen phrenologists in Eisenstadt. By the time it was presented for study, it was apparently already green. The skull has since been reunited with the body and is, by all accounts, buried at a mausoleum in Eisenstadt.

Gall's student, Spurzheim, inspired a collection of his own. Following disagreement over how phrenology should develop, the scientists split in 1813 and Spurzheim engaged in a series of European tours espousing his flavour of anatomical personology. One venue was Edinburgh and one of Spurzheim's staunchest advocates, George Combe, set up a Phrenological Society there and established the first *Phrenological Journal* in 1824. Combe was a passionate phrenologist and probably did more than any other scientist in Great Britain to popularise the philosophy. The Society stored over 2500 skulls. On Spurzheim's death, the scientist bequeathed his collection of around 300 casts and 100 skulls to the Society's museum. These came under the custodianship of the Henderson Trust in 1855 and now form one of the most curious

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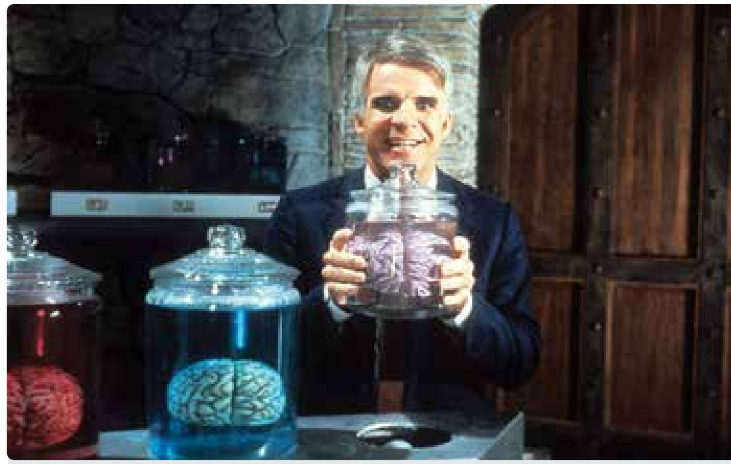
He has offered to donate his brain to science, but science has yet to return his call.

Flying over a landscape

Vladimir Ilyich Lenin, Bolshevik Party founder, leader of the Russian Revolution and subsequent head of state, died in January 1924, probably due to strokes, and seizures brought on by them. At autopsy, infarcts and atherosclerosis were found in many blood vessels. His brain was studied by a German neuroscientist, Oskar Vogt, who as part of an arrangement with the Russian government directed a new brain research institute set up in Moscow. Over two and a half years, Vogt took tens of thousands of sections of Lenin's brain and studied them, delivering his report to the Soviet Union in 1929. According to Marina Bentivoglio in a review in *Brain Research Bulletin*, this is the only known report on Lenin's brain to have been written by Russian investigators.

Vogt found some distinctive features. The pyramidal neurons in Layer III of the cortex were large and numerous; the layer was also wider and Layer IV thinner. Given the assumed role of the neurons in this layer as association neurons, Vogt concluded that Lenin was an 'athlete in associative thinking', a neurobiological correlate of the Russian's well-documented mental agility.

Vogt himself was aware of the superficial nature of the exercise. In his report, he remarked that 'It is like flying over a landscape, when one seems a number of towns; only the talented investigator of architecture can readily spot characteristics (like peculiar buildings) to identify individual towns.' Vogt naturally regarded himself as a talented pilot.



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Brain box

Cinema has had a fruitful, if slightly bonkers, relationship with science (see Frayling's 2005 book *Mad, Bad and Dangerous* for a superb survey of this eccentric world). Perhaps the most seminal, cerebral (literally) influence on films and TV, particularly those from the 1950s onwards, but the legacy flows through even to today's creations, is Curt Siodmak's novel *Donovan's Brain* (1942) where a very wealthy tycoon (Donovan) dies in a plane crash but his brain is kept alive by a mad (naturally) scientist. It inspired the films *The Lady and The Monster* (1944), *Donovan's Brain* (1953) and *The Brain/ Vengeance* (1962). The latter involved a brain in a jar controlling a doctor to track down the killers of the brain's body. Throughout all these efforts is the recurring theme of revenge and retribution, a dish served best via a disembodied brain, sometimes in a jar, sometimes not. The film of the book was parodied in the more famous *The Man with Two Brains* (1983), in which Steve Martin's Dr Hfuhruhurr invents 'the cranial screw top method of entering the brain whereby a large section can be unscrewed without having to shave the head.' He later falls in love with a disembodied brain called Annie.

The brain in the jar motif echoes one of psychology and philosophy's most famous 'thought experiments', so-called because little thought appears to have gone into them. The most common version is the 'Brain in the Vat' poser in which a mad scientist (of course) removes the brain and places it in a vat of life-sustaining liquid. The brain's neurons are attached to a supercomputer. The brain functions, and it exists. In what way, therefore, can we be sure that our brains are not simply brains in a vat? It is a variant of an old conundrum – Descartes posed the same question with his Evil Demon concept, as did Plato with the Cave Allegory. All of the brains in the films above cope very well in a vat, in a jar, in fact, in any receptacle the mad scientist (him again – and yes, it is usually a him) has chosen to keep it in. The most dramatic example of brains having a life of their own is found in *Fiend Without a Face* (1958) in which the thoughts of scientists are given material form by several volitant brains with antennae that terrorise several of the US Army's finest warriors. Once seen, never easily forgotten. Other brain-related horrors from the 50s onwards include *Creature with the Atomic Brain* (1955), *The Brain from Planet Arous* (1957), *The Brain Eaters* (1958), *The Brain That Wouldn't Die* (1962), in which the brain died, *The Atomic Brain* (1964), and *They Saved Hitler's Brain* (1968), in which they saved Hitler's brain.

collections of skulls and casts to have survived the phrenological frenzy of the mid-19th century. It includes Gall's life mask, his wife's death mask and a cast of his own skull and brain.

As an indication that ideas in psychology and neuroscience never die – they just retire and re-appear at sporadically unpredictable intervals – Oiwi Parker Jones and colleagues at the Oxford Centre for Functional MRI of the Brain, in the UK, have recently published a direct test of the phrenological hypothesis. They took MRI scans of 5724 'skulls' (the head was imaged and the contour measurements of the skull extracted) and correlated the undulations and bumps with the types of faculties described by Gall and Spurzheim. They found no significant associations, concluding 'according to our results, a more accurate phrenological bust should be left blank since no regions on the head correlate with any of the faculties that we tested'.

Other brains described by Spitzka in his review include those of Gaetano Donizetti, Napoleon III, Paul Broca ('no further records' and nothing of note reported), Ludwig II of Bavaria, Hans von Bülow (the composer) and Oliver Cromwell. Cromwell's case is unusual because it is thought he must have had three heads – at the time of the study, one skull was in the Ashmolean, one was on public display, and one was in Beckenham.

Spitzka found that, overall, noted individuals had heavier brains, echoing Arthur Conan Doyle ('It is a question of cubic capacity,' said he; 'a man with so large a brain must have something in it.'). He also noted that 'a period of decrease with age is deferred for a decade among the more intellectual persons', a conclusion based on anecdotal data but lent some credence by more systematic and rigorous 21st-century studies of the relationship between education and risk of dementia (greater education is considered to be a protective factor). Spitzka also found individual differences at the career level: 'Brains of men devoted to higher intellectual occupations such as material sciences involving the most complex mechanisms of the mind…are generally heavier still' (p.251). Specifically, the average brain weight of men from the 'exact' sciences ($N = 9$) was 1542g; natural sciences ($N = 48$) was 1453g; fine arts and philosophy ($N = 24$) was 1479g; and government, politics, law and the military ($N = 23$) was 1516g. At a national level, Americans had the heaviest brains (1519g), followed by the Brits (1481g), the French (1456g), then the Germans/Austrians (1439g).

The lure of the special

While there are singularly interesting facts associated with many of the brains we have looked at (and see also 'Flying over a landscape'), they're little more than trivia. There are no statistics, there are no uniform and consistent methods, there are no theories. Why would there be? This was the turn of the century, a time when psychology was still called moral philosophy. But studies such as Spitzka's were the forerunners to those such as Peter Garrard and his team's study of Iris Murdoch in 2005, Anna Cantagallo and Sergio Della Sala's 1998 study of Frederico Felllini, and S. Dueguez and colleagues' studies of Luchino Visconti (hemineglect) and Charles Baudelaire (aphasia), the latter published in one of two volumes of Neurological Disorders in Famous Artists in 2007.

Which brings us to where we came in, and to what the study of famous brains can reveal. It could be argued that this endeavour represents nothing more than modern phrenology: the seeking of causal relationships between function and structure when all that exists is illusory correlation, if correlations are there to begin with. Post hoc ergo propter hoc and the perils of Heschl's gyrus – just because one part of the brain is bigger or longer it does not necessarily follow that it is responsible for a specific function; it could simply reflect a fluke of development and of fitting into a confined, bony space. Special brains will always be special: their specialness, their eminence, the fame of the owner, will guarantee a special place in the laboratory, under the microtome, navigating the stereotaxic atlas. The result, however, may be as quotidian as a diary. Even psychologists are not immune to the lure of the special. The special may have no special secrets to reveal, but we will keep trying to uncover them, as talented investigators of neural architecture.

Unlocking the secrets of the brain (by *Christian Jarrett*: see www.bps.org.uk/digest)

The tales of historical characters like Phineas Gage, Louis Victor Leborgne (better known as Tan Tan) and Henry Molaison have provided generations of students with extreme examples of how brain damage is related to psychological functioning. These case studies have acquired an almost mythical quality – there is an air of mystery around exactly what happened to them, and over the decades each new cohort of psychologists (and increasingly neuroscientists) has used the latest technology to try to establish the precise brain damage or disease involved.

Phineas Gage – the 19th-century railway worker who changed personality after an iron rod blasted through his brain – presents the greatest challenge of the three because his brain was not preserved for posterity. Instead, researchers have used various techniques to try to estimate the damage he suffered, including taking CT scans of his skull.

Most recently, for a paper published in 2012, researchers at the University of California and Harvard used diffusion tensor imaging to map the connective brain tissues of 110 men, and then simulated the path of Gage's iron rod through an average of those maps to estimate how Gage's accident affected the connective networks in his brain.

The findings suggested significant damage to connective hubs in the front and left of his brain, which the researchers interpreted as being consistent with historical accounts of the initial dramatic changes to Gage's behaviour (though the results can't speak to the more recent historical analysis that has suggested Gage made a more profound recovery than previously realised).

A year after Gage's death in 1860, Louis Victor Leborgne was being transferred to the Bicêtre hospital in Paris to be assessed by the French neurologist and anthropologist Paul Broca. He died a week later. Although Leborgne was far from being the first case in which left-sided brain damage co-occurred with a speech deficit (he could only utter "Tan"), he has become famous because later the same year Broca used his brain and case presentation to persuade other experts at the Paris Society of Anthropology that language function is localised in the brain. Some even credit Broca and his study of Leborgne with launching the subdiscipline of cognitive neuropsychology.

Broca made the decision not to dissect Leborgne's brain, which means successive generations of scientists have been able to study it (but this also limited Broca's ability to accurately discern the extent of the brain damage). For instance, in 2007 a team led by Nina Dronkers used high-resolution MRI to scan the brain and they concluded that Leborgne's brain damage was far more extensive than Broca realised – potentially meaning that his speech deficits were not principally caused by damage to what's become known as Broca's area (the posterior third of the inferior frontal gyrus), as Broca had inferred.

The amnesiac Henry Molaison (known in the psychology literature as H.M. to protect his privacy while he was alive) is a more contemporary case – he died as recently as 2008 at age 82 having taken part in hundreds of experiments. When I reported on Molaison's death for this magazine, the eminent memory researcher Alan Baddeley told me that 'H.M. is arguably the most important single patient in terms of his influence on neuroscience'.

Because Molaison lived and died in modern times, we have extensive data and detail on the status of his brain, including insight into the precise tissue that was removed from his hippocampi and beyond as a radical intervention to reduce his seizures when he was a young man. In fact, in 2014 experts separated his brain into 2401 paper-thin slices during a painstaking 53-hour procedure that was broadcast live around the world on the internet.

However, it's telling that even in Molaison's case, for which the latest hi-tech methods have been used to preserve and study his brain, there is still intense debate and disagreement about exactly what damage his brain suffered during that earlier surgery, what other neurological abnormalities he developed through life, and how these do or do not relate to his memory deficits that were so thoroughly documented by legions of psychologists.

We have far more sophisticated scanning and slicing techniques than the neurological pioneers of the 19th century, but the myth and mystery that continues to surround the brains of psychology's most famous cases suggests it may take more than shiny new equipment to unlock their secrets.