

# Phineas Gage – Unravelling the myth

Malcolm Macmillan updates a familiar tale, 160 years after its inception

Could you survive a small crowbar passing completely through your head? Most psychologists would answer 'Yes': almost all of them learned that Phineas Gage did. Although Phineas' accident occurred 160 years ago this month, its consequences are still discussed in most introductory textbooks of psychology, neuropsychology, and physiology. You might therefore think much has been learned since 1848, when the accident happened, and the publication 20 years later, in 1868, of a significant account of its psychological consequences. But in fact little has been added. Moreover, much of what has been written is completely wrong. So, why should Phineas still be of interest?

## Phineas and the accident

At 25 years of age Phineas Gage was the foreman of a railway construction gang building the bed for the Rutland and Burlington Railroad in central Vermont in the USA. He and his gang were blasting a cutting through a large rocky outcrop about three quarters of a mile south of the town of Cavendish. It was Gage who decided where holes would be drilled in the rock, and how much powder with which to charge them. To focus the explosive force, the powder and fuse would be gently 'tamped' down before sand was added and a more vigorous tamping applied. Only then would the fuse be lit.

For tamping, Phineas used the larger

end of a special crowbar-like tool called a tamping-iron. Three feet seven inches long, it weighed thirteen and a half pounds. It was a one-and-a-quarter inch cylinder, tapered to a point of about one quarter of an inch at one end.

At 4:30pm on Wednesday 13 September 1848 Phineas, apparently distracted, began tamping before the sand had been poured. The tamping iron struck the rock causing a spark to light the powder. The resultant explosion propelled the tamping iron out of the hole and completely through his head. It entered point first, under the left cheekbone, or zygomatic arch and next penetrated the base of the skull, just behind the bony socket of the left eye. Finally it emerged at the top of the skull, probably slightly in front and to the left of the bregma (the junction of the coronal and sagittal sutures), and landed about 20 to 25 yards behind him.

For a short time Phineas may have been unconscious. His gang carried him to a nearby ox-cart where, sitting against its head board, he was driven to the Cavendish inn where he lived. He alighted unaided. Then from a chair on the 'piazza' (New England=verandah) he told his story to the bystanders. He greeted Edward Higginson Williams, the first medical practitioner to arrive, with 'Doctor, here is business enough for you'.

Dr John Martyn Harlow arrived about an hour later and he and Williams managed to stem the profuse haemorrhage. That action and Harlow's subsequent

management of a severe infection undoubtedly saved Phineas' life. Three months later, Phineas was well enough to return to his parents' farm. After probably spending most of 1849 regaining his strength, he travelled to Boston in the November to be examined by Henry Jacob Bigelow, the Professor of Surgery at Harvard, and was presented to the medical students there (Bigelow, 1850; Boston Society for Medical Improvement, 1849; Harlow, 1848, 1868).

## The post-accident history

After the accident Phineas was unable to regain his job as a foreman. Probably some time in 1850 he became an attraction at Barnum's American Museum in New York, and visited the major cities in New England to lecture and exhibit himself. He worked for some 18 months for Jonathan Currier who ran a livery stable and coach-line service from his Dartmouth Inn, in Hanover, NH. Then Gage went to Chile with a man who planned to set up a stagecoach line in Valparaiso (Harlow, 1868).

After many years driving stagecoaches, Phineas decided in June 1859 to return to his family, now living in San Francisco. He had had some kind of illness and arrived in a weakened condition. Several months elapsed before he was strong enough to work on farms south of the city. Not long after, in February 1860, and after ploughing the day before, 'while sitting at dinner, he fell in a fit'. 'Unquestionably epileptic', his seizures gradually increased in severity and on 18 May he returned to his mother's house where he suffered a successive series of them. By 21 May 1860 the seizures had killed him. He had survived for eleven and a half years (Harlow, 1868; Macmillan, 2000, pp.106–109).

How had Phineas survived the injury and lived for so long? Harlow adduced four factors:

- | His 'physique, will, and capacity of endurance, could scarcely be excelled';
- | The shape of the tamping iron left

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behind no 'prolonged concussion or compression';

- I The entry of the tamping iron created an opening for draining the infection, without which 'recovery would have been impossible'; and
- I The portion of the brain traversed by the iron 'was, for several reasons, the best fitted...to sustain the injury.'

Here Harlow modestly disguised his own very considerable medical skill by saying only that, in Ambroise Paré's famous words, 'I dressed him, God healed him' (Harlow, 1868).

### The psychological aftermath

The damage to Phineas' brain had profound psychological consequences. In 1868, in fewer than 200 words, Harlow summarised why Phineas' contractors would not re-employ him. That summary, together with a few words from his 1848 report, tell us practically everything we know about Phineas.

Harlow said 'the balance between his intellectual faculties and animal propensities seems to have been destroyed'. Phineas became:

- I 'Fitful', 'irreverent', grossly profane, and showed 'but little deference for his fellows';
- I 'Impatient of restraint or advice' that conflicted with his desires;
- I 'Pertinaciously obstinate, capricious, and vacillating' about his plans for the future – 'no sooner arranged than they are abandoned'; and
- I 'A child intellectually' with 'the animal passions of a strong man'.

Previously he had been:

- I 'Strong and active' with 'an iron will' and of 'nervo-bilious temperament';
- I Of 'temperate habits' and 'possessed of considerable energy of character';
- I A 'great favorite' with his men;
- I 'The most efficient and capable foreman' employed by his contractors;
- I In possession of 'a well-balanced mind'; and

- I Regarded as a 'shrewd, smart business man, very energetic in executing all his plans'.

So 'radical' was the change, his friends and acquaintances said he was 'no longer Gage' (Harlow, 1848, 1849, 1868).

Phineas' mother told Harlow that Phineas entertained 'his little nephews and nieces with the most fabulous recitals' of his adventures that had no 'foundation except in his fancy'. He 'conceived a great fondness for pets, and souvenirs, especially for children, horses and dogs – exceeded only by his attachment to his tamping iron, which was his constant companion during the remainder of his life'. After his first seizure she said he often changed his employment, always finding 'something that did not suit him'.

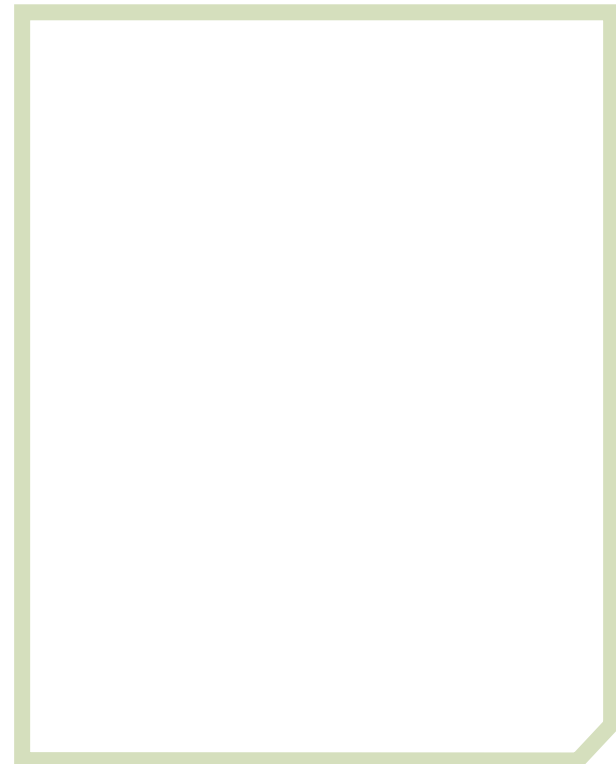
### Which parts of the brain were damaged?

There was no autopsy when Phineas died. His body was exhumed, probably late in 1867, and his skull given to Harlow in early 1868. Nothing was left of his brain. Phineas' skull is all we have as a guide to the damage.

Concussion, pieces of bone, haemorrhage, and infection would have destroyed additional tissue beyond that in the immediate path of the tamping iron, even if we knew exactly what that was. And the precise position of Gage's brain within his skull cannot be known. For those reasons, and because the areas in which various functions are localised varies somewhat among individuals, there will always be uncertainty about which of them were destroyed (Macmillan, 2000, pp.84–86).

Three studies were made on the living Phineas to determine the path of the tamping iron. They disagreed about the exit area in relation to the bregma and whether it was right or left of the midline. Harlow (1868) made the first of the attempts using the skull. The entry from under the left cheekbone to the rear of the eye socket posed little problem. Where

the tamping iron had emerged at the top of the skull was less certain. Opting for the exit being 'near' the bregma and 'in' the median line, Harlow concluded that the left frontal and middle left lobes had been destroyed. His attribution of Gage's 'partial' recovery to their functions having been



The first independent evidence of Gage's post-accident travels to Boston, most of the larger New England towns, and New York

taken over by the 'intact' right hemisphere meant that he did not think the right was significantly damaged.

Between 1982 and the present, three CT-based methods have been used to reconstruct the passage of the tamping iron through Phineas' brain. They produced somewhat varying pictures of its travel (Macmillan, 2000, Chapter 5, especially Tables 5.1 and 5.2; Ratiu et al., 2004).

In 1982 Rick and Ken Tyler of Boston used coronal and sagittal CT-scans of Gage's skull to determine the limits of the bony damage. From those images, which were two-dimensional and static, they concluded the brain damage was mostly to the left hemisphere but that the right must also have suffered (Macmillan, 2000, pp.77–79 and Appendix E).

After making X-rays, photographs, and measurements of Gage's skull, Hanna Damasio and her colleagues linearly deformed a 3-D reconstruction of a human skull from a cadaver until it matched those

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measurements. From their collection of brains of about the right size they then placed a 3-D reconstruction of the one that best fitted into this Gage-like skull.

Damasio et al. then modelled the passage of the tamping iron through this Gage-like brain inside the Gage-like skull. They had the tamping iron emerging from under the semi-detached but otherwise undamaged right flap of frontal bone so that the brain damage was more frontal and right of the midline than had been suggested previously (Damasio et al., 1994).

Real light arrived when Ratiu et al. (2004) and Ratiu and Talos (2004) used thin CT-scans to build a three-dimensional representation of Phineas' skull itself, rather than an image of what it might have been like. How well they succeeded is immediately obvious in an illustration from the second of their papers (shown on this cover of *The Psychologist*) (Ratiu & Talos, 2004).

They were the first to see that the diameter of the entry area being smaller than that of the tamping iron required the skull to have hinged open for the iron to pass through it. They connected that fact with the continuous line of fracture beginning under the cheekbone and running to the left parietal bone well beyond the rear of the hole at the bregma. After the tamping iron passed through, the hinge must have been closed by the action of the soft tissues.

From the video clips Ratiu and Talos included in their paper, it can be seen that the line of fracture and the hinging action place the exit left of the median line and slightly in front of the bregma. On their reconstruction, the brain damage was left-frontal – almost exactly as Harlow said.

### The implications and the context

It was a long time before Phineas' psychological changes became known. None were specifically mentioned by Harlow in 1848; nor did Bigelow report

any in 1850. Some memory impairment was recorded privately by Jackson (1849), and an anonymous report the same year very briefly noted a great impairment of his mental powers (Standing Committee on Surgery, 1850). Some detail first appeared in an 1851 phrenological journal's reply to Bigelow ('A most remarkable case', 1851). However, not until Harlow's little-known 1868 report was any real notice taken of the psychological changes, and even in comments on it they were frequently ignored (Macmillan, pp.113–116, 197–199).

Some of this neglect is explicable by the lack of knowledge in the early 1800s about the functions of the brain. Apart from Franz Josef Gall's organology (phrenology), there was no theory before 1848 of what the brain did. That nerves transmitted sensations and controlled movement was known, but it was not even generally accepted that damage to one side of the brain affected movement or sensation on the other. Early descriptions like Bigelow's of Gage being unimpaired probably meant merely that his muscles and sense organs functioned normally.

Johannes Müller and Alexander Bain had argued that willing and moral behaviour depended on an inhibitory function localised vaguely in some 'higher' part of the nervous system or even in the brain, but could advance no supporting empirical evidence (Macmillan, 2000, pp.158–170). But functions like language and personality had not been shown to depend on the way the brain worked.

The context began to change about the mid-1860s; that is, by the time of Harlow's 1868 report. Paul Broca's clinical observations suggested that language functions were localised in the left frontal lobe. A little later, David Ferrier's monkey experiments demonstrated that prefrontal damage caused profound personality changes (Ferrier, 1873).

It was Ferrier who rescued Gage from the obscurity of the journal in which Harlow's 1868 report was buried (Ferrier, 1876, 1877–1879, 1878), but 10 years elapsed before Harlow's findings gained

acceptance. A theory of frontal functioning was even further away. Gage was literally ahead of his time.

### Facts vs. the common picture

There are just four primary sources of information about Gage: Harlow (1848), Bigelow (1850), then Harlow again (1868) – the only physicians to have examined him and published their observations – and finally J.B.S. Jackson (1870), who added a few facts of his own to what Gage's family and others had told him. Anything not from these sources, or similarly documented, is not a fact about Phineas Gage.

This is not to say these primary sources are entirely reliable. Harlow, for example, writing in 1868 while in contact with Phineas' mother, reported that Phineas died in 1861, whereas funeral parlour records prove conclusively that he died in 1860. (In this article and elsewhere

I have silently corrected other dates dependent on this one.) Similarly, a curious relic recently found by Dominic Hall, Curator of Harvard's Warren Anatomical Museum, suggests that Phineas went to Chile in 1854 and not in 1852 as reported by Harlow.

First the facts. Harlow's picture of Phineas is at total variance with most later portrayals. A fair composite of today's accounts would have a pre-accident Gage who was reliable, industrious, mild-mannered, temperate, genial, friendly, affable, the favourite of his peers and elders, showing considerable promise – a peaceful, happy and tranquil man.

The composite of modern writers has the accident transforming this Phineas into a restless, moody, unpredictable, untrustworthy, depraved, slovenly, violently quarrelsome, aggressive and boastful dissipated drunken bully, displaying fits of temper, and with impaired sexuality. He is a waster: unwilling to work and unable to settle down. He spends most of the rest of his life in travelling circuses or drifting around fairgrounds to exhibit himself as a human freak, and dies penniless.

The facts about the real Phineas may have a slight resemblance to the modern pre-accident representation, but he can hardly be recognised in the post-accident picture.

Second, interpretations. Many interpretations of Phineas' behaviour have been made to support particular theories. Thus Vincent and others matched his allegedly changed sexuality – not mentioned in the sources – to that of some post-lobotomy patients; others, like Damasio and colleagues, portrayed Gage's

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## Gage outside science

The story of Phineas Gage has entered popular culture, leading to plays, films, TV programmes and YouTube skits, poems and stories, sculptures, bands and songs, and even a team of lawyers who apply behavioural science to legal education. My favourites (partly because I was consulted on them!) are the plays 'That Elusive Spark' by Janet Munsil (see [tinyurl.com/3eua9q](http://tinyurl.com/3eua9q)) and 'The Ballad of Phineas P. Gage' by Crystal Skillman (see [tinyurl.com/4ju2y4](http://tinyurl.com/4ju2y4)), and the song 'Phineas Gage' by Dan Linder (see [tinyurl.com/3hf6jx](http://tinyurl.com/3hf6jx)).

damage and behaviour such that they matched those of a selection of their own modern patients (Macmillan, 2000, pp.329–330). Distortions like these were great enough to justify devoting some 50 pages of my book to analysing them, and for MIT Press to allow me to include facsimiles of the primary sources (Macmillan, 2000, Figure 15.2 and Appendix A).

Third, long-term effects. Every scientific and popular picture of Phineas I know of has him impulsive and unreliable until his death. Yet his year and a half working for Currier, and the demanding motor and cognitive skills required of a stagecoach driver are inconsistent with this long-term outcome (Macmillan, 2000, pp.104–106).

### A social recovery?

Could Phineas have made some kind of 'social recovery'? There are a few reports of people with brain damage similar to his who recovered without formal treatment. In each instance, someone or something gave enough structure to their lives for them to relearn lost social and personal skills.

Here we may speculate about Phineas' daily routine. Some detail may be inferred from a recently discovered contemporary account of stagecoach driving on what seems to be the very route Phineas drove. He would have had to rise early each driving day, prepare himself, feed and groom the horses, harness them to the coach, and be at the departure point by 4am. There he would have had to deal politely with the passengers, load their luggage (up to 50 pounds each), and collect fares, and so on, before beginning a 13-hour journey over 100 miles of poor roads, often in times of political instability or frank revolution. All this – in a land to whose language and customs Phineas arrived an utter stranger – militates as much against permanent disinhibition as do the extremely complex sensory-motor and cognitive skills required of a coach driver (Macmillan, 2000, p.104–106).

As I understand it, relearning in a structured environment is the basis of many brain-damage rehabilitation programmes (such as that at the Oliver Zangwill Centre at Ely in Cambridgeshire). If Phineas Gage did recover, could his employment have provided a similar structure?

Only by filling out the post-accident record can this be determined. I have found a poster advertising one of Phineas' lectures. Matthew L. Lena, my Boston colleague, and I hope to find some eyewitness report of it. Matthew has also

found a physician who said he saw a quite well Phineas in Chile around 1858.

There would be practical and theoretical consequences of a discovery that Gage so recovered. It would add to current evidence that rehabilitation can be effective even in difficult and long-standing cases. But it would also mean that theoreticians of frontal lobe functioning would have to consider whether the lobes themselves and their functions were much more plastic than we now think. Recognition of that kind would, of course, match the now accumulating evidence about the recovery of biological systems in general.

### Why bother?

We will never know with certainty what the pre- and post-accident Phineas Gages were really like; nor will we ever know exactly the parts of his brain that were damaged in the flash that transformed the one into the other. So, why bother?

First, it is always worthwhile correcting the historical record, though the degree of rigor mortis, especially in textbooks, seems too far advanced for even a Dr Frankenstein to re-enliven poor Phineas.

Second, Phineas' story is worth remembering because it illustrates how easily a small stock of facts can be transformed into popular and scientific myth. I was much struck by David Ferrier's remark in an 1877 letter about Phineas to Henry Pickering Bowditch in Boston. He asked Bowditch for the facts about Phineas as they were originally reported because he was 'amazed at the inexactitude and distortion to which they are subject by men who have some pet theory to support'. And as we have seen, scientific myths about Phineas continue to be used to support particular theoretical positions.

The factual record is small, and the most important element of it – Harlow's 1868 report – not readily available, and most who have written about Phineas have been too lazy or slipshod to check it.

Paradoxically, the very slightness of reliable fact which allows myths about Phineas to flourish also makes disentangling those myths a conceptually easy, if tedious, task.

Phineas' primary importance is as a historical marker. We can see how his skull was damaged, but we will only ever have estimates of his brain damage. We also know too little about him before and after the accident to draw detailed conclusions about its effects. Phineas has to be remembered for being the first reported case in which brain damage caused alterations to personality. But we may yet learn the extent of his recovery and what brought it about.

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## Questions about Gage

Matthew Lena and I are interested in the following topics and I would be pleased to supply more specific information to readers who may be able to help.

- | The fate of Dr John Martyn Harlow's case notes and correspondence about Gage.
- | Anything at all relating to Phineas in New England (to about 1854), Chile (to about 1859) and San Francisco, Santa Clara, or Alameda Counties, California (died, 1860).
- | Identity of the 'distinguished Professor of Surgery in a distant city' whom Harlow said had termed Gage a 'Yankee invention' (some time before 1868).
- | Harlow and his wife, Frances Kimball Harlow, especially when living in Stillwater, Minnesota (ca. 1857–1860).
- | Departure/arrival/passenger lists for ships travelling among New York/New England, Panama/Valparaiso, and San Francisco (1850–1868).
- | In Valparaiso and Santiago, Chile, 1850–1860: Livery or transportation businesses (particularly an 'American' or '(James) McGill & Co.' coach line); Dr William Trevitt (American consul) or his nephew Henry; the hospital for American seamen; and activities and publications of physicians or of English-speaking persons.
- | Dr Henry Trevitt and Dr William Trevitt in Wilton, Connecticut and Franklin Co., Ohio (resp.) approximately 1861 forward.
- | A Dr William J. Lo – – – (full surname unknown) residing in Brooklyn Township (now Oakland, Alameda Co.) California in 1860, possibly a teacher of the deaf, or his wife Cordelia (both originally of Maine).
- | Dr Jacob Davis Babcock Stillman and Dr Henry Perrin Coon of San Francisco (esp. personal papers ca. 1867).
- | The Starling Medical College in Columbus, Ohio, and faculty member J. W. Hamilton (ca. 1860).