**The incredible case of Phineas Gage**

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Phineas Gage (1823-1860) is one of the earliest documented cases of severe brain injury. Gage is the index case of an individual who suffered major personality changes after brain trauma. As such, he is a legend in the annals of neurology, which is largely based on the study of brain-damaged patients.

Gage was foreman of a crew of railroad construction workers who were excavating rocks to make way for the railroad track. This involved drilling holes deep into the boulders and filling them with dynamite. A fuse was then inserted, and the entrance to the hole plugged with sand, so that the force of the explosion would be directed into the boulder. This was done with a crow bar-like tool called a tamping iron.

On 13th September, 1848, 25-year-old Gage and his crew were working on the Rutland and Burlington Railroad near Cavendish in Vermont. Gage was preparing for an explosion by compacting a bore with explosive powder using a tamping iron. While he was doing this, a spark from the tamping iron ignited the powder, causing the iron to be propelled at high speed straight through Gage’s skull. It entered under the left cheek bone and exited through the top of the head, and was later recovered some 30 yards from the site of the accident.

The doctor who later attended to him, John Martin Harlow, later noted that the tamping iron was found “several rods [1 rod= 5.02m] behind him, where it was afterward picked up by his men smeared with blood and brain”. The tamping iron was 3 ft. 8 inches in length and 1.25 inches in diameter at one end, not 1.25 inches in circumference, as reported in the newspaper report on the left. It tapered at one end, over a distance of about 1 ft., to a blunt end 0.25 inches in diameter, and weighed more than 6 kg.

Whether or not Gage lost consciousness is not known, but, remarkably, he was conscious and able to walk within minutes of the accident. He was then seated in an oxcart, on which he was transported three-quarters of a mile to the boarding house where he was staying. Here, he was attended to by Harlow, the local physician. At the boarding house, Harlow cleaned Gage’s wounds by removing small fragments of bone, and replaced some of the larger skull fragments that remained attached but had been displaced by the tamping iron. He then closed the larger wound at the top of Gauge’s head with adhesive straps, and covered the opening with a wet compress. Gage’s wounds were not treated surgically, but were instead left open to drain into the dressings.

recon2.jpgWithin a few days of his accident, one of Gage’s exposed brain became infected with a “fungus”, and he lapsed into a semi-comatose state. His family prepared a coffin for him, but Gage recovered. Two weeks after the accident, Harlow released 8 fluid ounces of pus from an abscess under Gage’s scalp, which would otherwise have leaked into the brain, with fatal consequences. By 1st January 1849, Gage was leading an apparently normal life.

Harlow’s case report of Gage’s injuries appeared as a letter to the editor of the [*Boston Medical and Surgical Journal*](http://www.neuro.psychiatryonline.org/cgi/content/full/11/2/281). The report of the “hitherto unparalleled case” contains few neurological details, and was at first met with skepticism, because it was thought that no-one could survive such an extreme injury. Harlow describes Gage’s injury as follows:

[The tamping iron] entered the cranium, passing through the anterior left lobe of the cerebrum, and made its exit in the medial line, at the junction of the coronal and sagittal sutures, lacerating the longitudinal sinus, fracturing the parietal and frontal bones extensively, breaking up considerable portions of the brain, and protruding the globe of the left eye from its socket, by nearly half its diameter.

Harlow goes on to describe how, while examining Gage, he determined that no bone fragments remained inside the skull:

…in searching to ascertain if there were other foreign bodies there, I passed in the index finger its whole length, without the least resistance, in the direction of the sound [of the hemorrhaging?] in the cheek, which received the other finger in like manner.

A second report was published in 1850 by Henry J. Bigelow, a professor of surgery at Harvard University. Bigelow emphasised Gage’s lack of symptoms, and reported that Gage was “quite recovered in faculties of body and mind”. Because of the disbelief with which Harlow’s 1848 report was met, it was, for the next 20 years, Bigelow’s account that came to be generally accepted by the medical community.

Gage did, according to Harlow, retain “full possession of his reason” after the accident, but his wife and other people close to him soon began to notice dramatic changes in his personality. It wasn’t until 1868 that Harlow documented the “mental manifestations” of Gage’s brain injuries, in a report published in the *Bulletin of the Massachusetts Medical Society*:

His contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint of advice when it conflicts with his desires, at times pertinaciously obstinent, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. In this regard, his mind was radically changed, so decidedly that his friends and acquaintances said he was “no longer Gage.”

<http://neurophilosophy.wordpress.com/2006/12/04/the-incredible-case-of-phineas-gage/>

Questions:

1. Where did the tamping iron enter Gage’s head? What lobe(s) of the brain were affected?
2. What were the dimensions of the tamping iron? Length? Width? Weight?
3. Based on what you know of the lobes of the brain, why was Gage able to walk immediately after his injury?
4. Did Gage actually fully recover from his injuries? Support your answer with details from the passage and your knowledge of the lobes of the brain.