and spent years wandering. He died in the custody of his parents.

The physician who treated Gage in the months after his injury, John Harlow, learned of his former patient's death and convinced Gage's family to have his body exhumed in 1866 so his skull could be removed and kept as a record of this unusual medical case. The skull and the offending tamping iron, which had been buried with Gage, have since resided in a Harvard University museum.

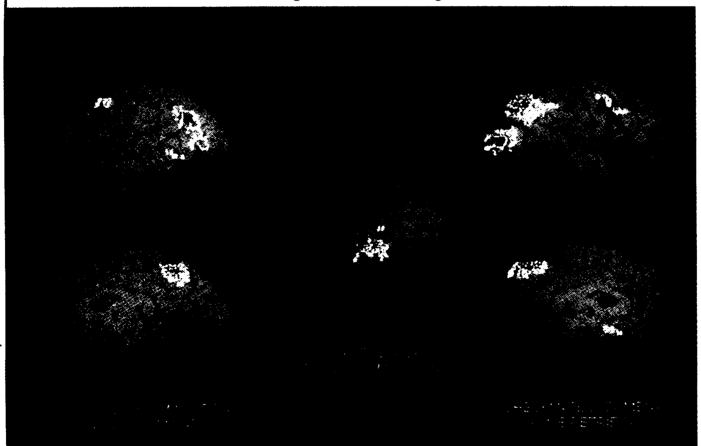
Harlow wrote a paper in 1868 arguing that Gage suffered localized damage to the frontal lobe, an indication that the brain contained structures responsible for "rational" personal and social behavior. But the exact position of Gage's injury could not be determined from his skull alone, and researchers generally dismissed Harlow's theory.

Enter modern technology. Damasio's group created a three-dimensional computerized skull from X rays and measurements of Gage's skull. Their digital version included the tamping iron's entry and exit holes. They then simulated possible trajectories of the projectile through a reconstruction of a human brain that closely matched Gage's estimated brain dimensions.

The rod's most likely path ran diagonally through the middle of the frontal lobes, missing structures involved in language production and muscle control, the scientists report in the May 20 SCIENCE. Gage's injury closely resembles brain damage documented for 12 patients at the University of Iowa, they contend. Like Gage, these individuals display pervasive irresponsible behaviors, as well as difficulty in expressing and interpreting emotions.

Brain circuits that mediate emotion may participate in various types of social decision making, Damasio and her coworkers theorize. This collaborative effort may depend on the cerebral terrain Phineas Gage unintentionally blasted away, they assert. *— B. Bower*

Is this the way Bobby Fischer does it?


P. Nichelli et al./NATURE

These computer-generated images of the brain illustrate how — or actually, where — chess players think. The brightly colored regions reveal that the various mental tasks of chess require the activation of different neural pathways, says Jordan Grafman, a neuropsychologist at the National Institute of Neurological Disorders and Stroke in Bethesda, Md.

He and his colleagues imaged the brains of 10 experienced, active chess players using positron emission tomography (PET). During the PET scans, these right-handed men answered questions about a chessboard displayed on a computer monitor.

The researchers designed the questions to examine increasingly complex problem solving. With each new task, they ignored areas activated by earlier, simpler tasks. In this way, they sought to identify parts of the brain used uniquely for a particular type of thinking.

Players first had to decide whether black or white pieces lay on the board. Then they noted the color of the piece closest to their own, which was marked with an X — a test of spatial discrimination.

Next, they answered whether a particular piece, such as a pawn, could capture a nearby piece. The players had to both recognize the piece and remember how it moves. This so-called rule retrieval involved additional parts of the brain, including the hippocampus and other areas of the left temporal lobe, the researchers report in the May 19 NATURE.

Finally, the players decided whether one move remained to checkmate, based on the configuration of pieces on the computer screen. Only in that last task did they tap the prefrontal cortex, located in the front of the brain, Grafman notes. "We think that's because of its role in planning," he says.

This scheming also tapped an area toward the back of the brain not activated by the earlier tasks. The region seems to draw mental pictures of the chess-piece configurations being thought out by the prefrontal cortex, Grafman says.

These results bolster his contention that the prefrontal cortex is where the brain does its planning and processing of events or thoughts that must be considered as a unit instead of individually. — E. Pennisi

Seeing quantum leaps at room temperature

Scientists usually observe quantum effects only at temperatures close to absolute zero. But by looking at materials on a sufficiently small scale, some quantum effects can be detected even at room temperature, say researchers at the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y.

By and large, the energy levels of electrons in a solid are closely spaced. However, quantum mechanics predicts that these energy levels will become widely separated in certain regions where electron movement is restricted.

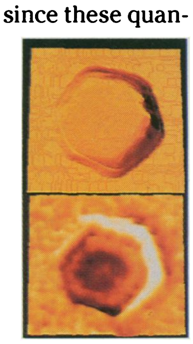
Researchers Phaedon Avouris and In-Whan Lyo report in the May 13 SCIENCE that tiny, naturally formed terraces on metal surfaces trap electrons and that these electrons exhibit quantum size effects. The researchers used a scanning tunneling microscope to map the surfaces of both gold and silver sheets on an atomic scale and simultaneously to observe the distribution and energy levels of electrons.

The movement of electrons on some metal surfaces is restricted to two dimensions. Like light, electrons can act as both particles and waves. When surface electrons get stuck on a terrace, they bounce back and forth between the edges in a standing wave; these electrons can still travel parallel to the edges, however. Electrons on the surface of an island, or isolated terrace, also are trapped in standing waves, just as the head of a drum vibrates in an enclosed area when struck.

To see quantum size effects, says Avouris, scientists must look at materials on approximately the same scale as the electron wavelengths. The smaller the terrace, the shorter the wavelengths and the greater the energy and frequency of the electrons trapped there.

If the terraces are small enough — as they are on these metal surfaces — the energy levels of the trapped electrons are so far apart that even the jiggling effects of thermal radiation can't prevent the quantum size effects from being detected at room temperature.

"We are going to have to be more careful when thinking that surfaces are smooth," says Avouris, since these quantum size effects may affect diffusion and surface chemistry. Understanding these effects may eventually lead to new devices and technologies, he adds. *— D. Christensen*


IBM Research

Topograph of 4.5-nanometer-wide silver island (top); image of standing (trapped) electron waves (bottom).