

NEUROSCIENCE

Uncovering the Magic in Magnetic Brain Stimulation

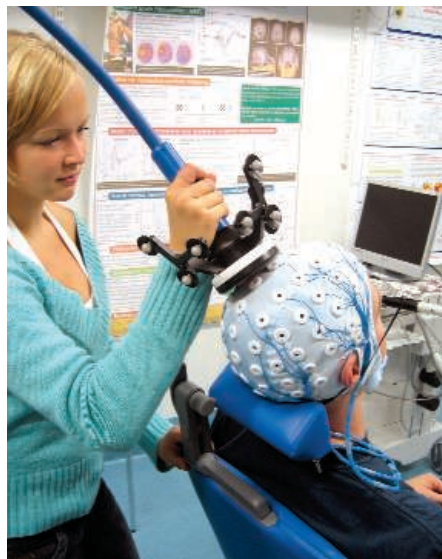
In recent years, neuroscientists and psychiatrists alike have touted the potential uses of a noninvasive brain stimulation technique called transcranial magnetic stimulation (TMS). The method has been used to disrupt neural activity experimentally in studies of human cognition, and it has shown promise in clinical trials for treating psychiatric disorders such as depression (*Science*, 18 May 2001, p. 1284). Although widely considered safe—thousands of people have received TMS—relatively little is known about how it actually works. Now, a detailed look at its effects shows that TMS can boost or dampen the firing of neurons depending on ongoing brain activity.

Neuroscientists at the University of California, Berkeley, applied TMS to the cerebral cortex of cats while monitoring neural activity and metabolism. Their findings, reported on page 1918—and future investigations of this type—will have important implications for how TMS is used in people, other researchers say.

One interesting possibility, according to Mark George, a psychiatrist at the Medical University of South Carolina in Charleston, is that it may matter what subjects think about while they're being stimulated, a factor that hasn't received much consideration to date. George, who pioneered TMS therapy for depression, says a better understanding of how TMS works will enable researchers and clinicians to apply it more effectively: "This is precisely where the field needs to go."

In a typical TMS procedure, technicians place a ring-shaped paddle near the scalp.

Electric currents swirling inside the paddle produce a magnetic field that in turn generates currents in the underlying brain tissue. These currents alter the electrical activity of neurons, but exactly how they alter it is poorly understood.



Stimulating results. New research hints at the mechanisms of magnetic brain stimulation.

Led by Ralph Freeman and graduate students Elena Allen and Brian Pasley, the Berkeley scientists applied TMS to the visual cortex of anesthetized cats and tracked the aftermath using probes developed in Freeman's lab that can simultaneously record the electrical activity of neurons and measure fluctuations in oxy-

gen concentration, an indicator of energy consumption. Using optical imaging methods, the researchers also tracked hemoglobin levels, another metabolic marker. A train of TMS pulses lasting a few seconds caused an immediate increase in neural firing that lasted for about a minute, followed by a decrease in firing for several minutes. Oxygen and hemoglobin mirrored this pattern, indicating that neurons' firing and energy demands go hand in hand.

TMS had a dramatically different effect, however, on neural activity evoked by black and white bars flashed on a computer screen. (Such responses persist even in anesthetized animals.) In this case, neural firing dipped sharply after TMS and remained suppressed for several minutes.

The findings have implications for designing TMS therapies, says George. For depression therapy, for example, "we may need people to become sad in the chair while stimulating [them]," George says. "Alternatively, we might have them engage in formal cognitive therapy, thinking positive thoughts." Such considerations are important, he adds, as the Food and Drug Administration is considering approval for daily TMS of the prefrontal cortex to treat depression.

The new findings also suggest why the effects of TMS often vary, says Alvaro Pascual-Leone, a neurologist at Harvard Medical School in Boston. Pascual-Leone suggests that TMS results could be made more consistent by monitoring the physiological state of the brain using electroencephalography or functional magnetic resonance imaging. **—GREG MILLER**

ENGINEERING

Pollution Slows China's Canal Project

The first phase of a massive project to replumb some of China's mightiest waterways has fallen far behind schedule because local authorities don't want to pay for the privilege of drinking polluted water.

The South-to-North Water Diversion Project is a three-stage effort to alleviate chronic water shortages in the country's more populous but parched northern plains (*Science*, 25 August 2006, p. 1034). The eastern route makes use of an existing network of canals, rivers, and lakes to pump and move water from the lower Yangtze River to Jiangsu and Shandong provinces. But this month, the official Xinhua news agency announced that the first phase of the route,

scheduled to begin operating this year, has been delayed at least 3 years.

Nearly half of the \$4 billion cost of the first phase is earmarked for improving the quality of the water. However, the central government is footing only about 10% of the bill, with the rest expected to come from localities that will benefit from the project. But because nobody wants to clean up somebody else's dirty water, few treatment facilities have been built along the route, and water quality continues to deteriorate. So far this year, according to Xinhua, the water is drinkable at only one of the 21 monitored cross sections in Shandong.

Some engineering experts say the entire

project itself needs to be rethought, with a greater emphasis placed on improving the ecology of the Yellow and Huai river basins. Dredging the Grand Canal north of the Yellow River to make the ancient waterway navigable, they say, would provide a greater benefit to the region and, thus, attract more investment.

Qian Ye, a climate researcher at the U.S. National Center for Atmospheric Research in Boulder, Colorado, thinks the Chinese government should do a more comprehensive feasibility study of the project that considers the impact of climate change. Global warming, he says, could make China's north wetter and allow authorities to scale back the controversial project. **—HAO XIN**