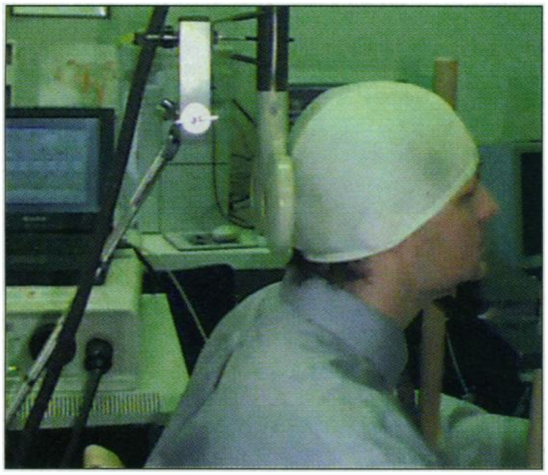
NEUROBIOLOGY

Shedding Light on Visual Imagination

In the past decade, two little acronyms, PET and fMRI, for positron emission tomography and functional magnetic resonance imaging, have permeated the literature of cognitive neuroscience. That's because these powerful techniques allow researchers to see activity in the living human brain. But both have a drawback: Although they can show a correlation between brain activity and a given function, they can't show a causal connection. Now a relatively new, little-known technique called transcranial magnetic stimulation (TMS) may provide that missing link.



Brain zapper. This TMS device focuses a magnetic field that disrupts specific brain areas.

On page 167, Stephen Kosslyn and his colleagues at Harvard Medical School report that they have used TMS, which directs a magnetic field to temporarily disrupt the functions of specific brain areas, to address a decades-old question in cognitive psychology: Does the visual imagery that occurs when the brain imagines an image work the same way as when the brain processes a real image from the retinas? Their results support the hypothesis that it does, because they indicate that the primary visual cortex, the first part of the cerebral cortex to receive retinal information, is necessary for at least some visual imagery as well.

"This is a very exciting finding," says cognitive neuroscientist Randy Buckner of Washington University in St. Louis—and not just for its contribution to the imagery debate. If TMS works as it seems to, he adds, it is "exactly what the field needs, an ability to safely manipulate cognitive processing in humans," partially inactivating brain areas to help pin down their functions.

Kosslyn began exploring the brain's strategies for imagining—as opposed to viewing—a scene more than 20 years ago. In his early experiments, he measured the time it took people to shift their attention from one feature in an imagined scene to another. That time grew with the distance between the features, suggesting, but not proving, that the brain was panning across an imagined scene, depicted in the brain with the same spatial topography as a retinal image.

When brain imaging techniques became available, they provided further support for that idea. V1, the primary visual cortex, is "retinotopically organized," which means that it encodes images in a way that preserves the same spatial arrangement that falls on the retinas. In 1995, Kosslyn and Nathaniel Alpert at Massachusetts General Hospital in Boston used PET to show that visual imagery activates V1. They also showed that changing the size of the imagined image changes the area of activation in V1, further evidence that the image is represented retinotopically.

But the possibility remained that V1 activation was merely a side effect and that some other brain area actually produces visual imagery. To address that issue, Kosslyn teamed up with Alvaro Pascual-Leone of Boston's Beth Israel Deaconess Medical Center to try TMS, which works by focusing a magnetic field on targeted brain areas, inducing electrical currents that temporarily disrupt their functions.

The technique has been used for years for mapping brain areas responsible for movement, and in 1997, Pascual-Leone, working with Leonardo Cohen and Mark Hallett of the National Institute of Neurological Disorders and Stroke (NINDS), used TMS to show that V1 plays a role in Braille reading. In that study, TMS was delivered as a rapid barrage, and the subjects were tested during the stimulation. But high-frequency TMS has on rare occasions caused seizures, and Pascual-Leone also worried that magnetic stimulation during testing may generally disrupt attention, casting doubt on the role of brain areas such as V1. A recent study showed, however, that the effects of safer low-frequency TMS on the motor cortex linger for up to 10 minutes. So Pascual-Leone and Kosslyn applied low-frequency TMS to V1, turned it off, and then tested the subjects.

After treating eight subjects, they had them compare the lengths of pictured bars, either while looking at the picture or while holding its image in memory. TMS impaired the subjects' abilities at both perception and imagery when compared to a sham treatment that focused the magnetic field outside the brain, creating the same scalp sensations as real TMS without affecting any brain areas.

"Their effect looks very strong," says neurologist Eric Wassermann of NINDS. He cautions, however, that the effects of low-frequency TMS are even less well understood than those of the high-frequency form used in the Braille study, and warns that the team has not ruled out the same concern Pascual-Leone had for high-frequency TMS—that it may cause a general disruption of brain function.

Others, including cognitive neuroscientist Nancy Kanwisher of the Massachusetts Institute of Technology, question the technique's ability to uniquely pinpoint V1. It is likely to be affecting adjacent visual areas as well, says Kanwisher. But she adds, "I don't think that matters," as those areas are also retinotopically organized. "The point is being able to say 'There is the image, and it is in the retinotopic cortex.'"

Some skeptics don't agree. Zenon Pylyshyn of Rutgers University in New Brunswick, New Jersey, has maintained for decades that visual imagery is encoded not spatially but in what he calls "the language of thought, a symbolic language." Even if disrupting V1 reduces performance, he argues, "that still doesn't show that the retinotopic aspect of V1 is being used." Instead, he says, V1 may encode information in nonretinotopic ways as well. But even if this result doesn't finally settle the imagery debate, it may foreshadow a time when TMS—if its safe form proves reliable—will be as familiar a tool for cognitive neuroscientists as PET and fMRI.

–MARCIA BARINAGA

ZOOLOGY

Dispute Over a Legendary Fish

It must have been like spotting a koala in New York's Central Park. Strolling in a fish market on the island of Sulawesi, Indonesia, in September 1997, Mark Erdmann, a biologist at the University of California (UC), Berkeley, and his wife Arnaz caught a glimpse of what appeared to be a coelacanth, just before the hefty lobe-finned fish was whisked away by a buyer. Almost 60 years had passed since the stunning news that a coelacanth—a species believed to have gone extinct 80 million years ago—had turned up off South Africa, 10,000 kilometers from Indonesia. No one thought the living fossil survived anywhere else in the world until Erdmann, almost a year after the initial sighting, at last laid his hands on a live specimen. Now it turns out that Erdmann's find may be not just another coelacanth but a second coelacanth species.

Erdmann, however, isn't celebrating the announcement, because the report in the April issue of *Contes Rendus de L'Académie*

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