Shadows of Thoughts Revealed

By RICK WEISS

What do thoughts look like in the human brain? Does every mental sentence, every intention, every little decision explode in a telltale pattern of neurochemical activity? If so, might a brain scan someday provide a printout of a person's most intimate thoughts?

As of 1990, neither scientists nor philosophers have gained sufficient insight into the nature of cognition to peruse the private diaries nestled within the brain's convoluted folds. But researchers using new technology have now developed the first pictures of what they call "shadows of thoughts."

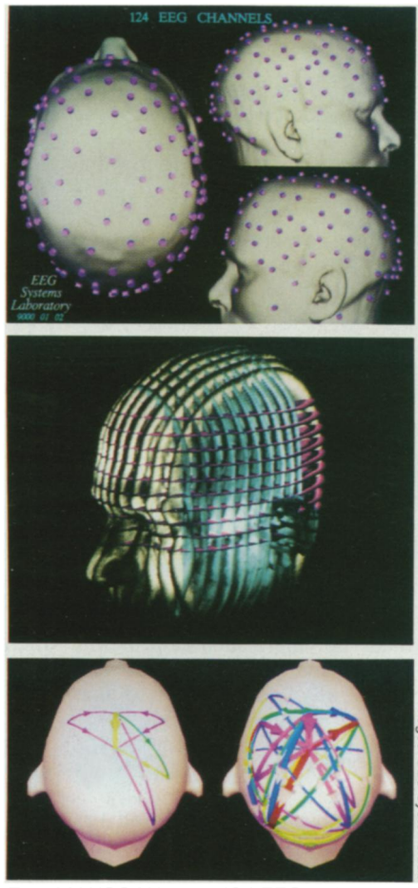
Their approach can't detect the contents of thoughts. However, it clearly differentiates among many of the electrochemical fireworks that underlie specific acts of cognition. The technique's developers say the high-resolution images they obtain may soon provide a wealth of practical benefits ranging from improved assessment of brain injury to reduced incidence of fatigue-related industrial accidents. Moreover, the work offers intriguing new clues about how the brain perceives – and constantly updates – its sense of the world and its sense of self.

"Generations of neuroscientists have dreamed about having a movie camera for observing thinking in the brain," says Alan Gevins, director of EEG Systems Laboratory, a private brain-research center in San Francisco. "Revolutionary advances in computers are now making this possible."

A space-age electroencephalography (EEG) device, worn like a soft helmet, is the heart of Gevins' mind-camera. Unlike "old-fashioned" EEG machines, which record electrical signals at 19 points on the scalp and enable clinicians to detect gross brain-wave abnormalities, Gevins' device records electrical activity at 124 points. Computers monitor the skull-bound electrical squalls we call thought and map their shifting locations within a three-dimensional image of the monitored brain, created by a magnetic resonance imager (MRI).

The EEG-MRI combo – called the mental activity network scanner, or MANSCAN – snaps a fresh picture of brain activity every 4 milliseconds, providing far more images per minute than positron emission tomography (PET), another popular brain-imaging technique (SN: 2/25/89, p.116). Together, the string of snapshots provides a movie of neuronal bursts, tracing peaks and troughs of brain activity while the monitored person performs specific mental tasks.

Speaking in St. Louis last week at the annual meeting of the Society for Neuroscience, Gevins described three brain-imaging experiments he recently performed with cognitive psychologist Brian Cutillo, psychophysiologist Paul Brickett, mathematician Jian Le and other EEG Systems scientists.



Top: MANSCAN uses 124 EEG points to trace neural activity. Middle: MRI yields a 3-D view of the head, which computers correlate with EEG data. Bottom: Analysis reveals different neural activity patterns for tasks requiring (right) and not requiring (left) immediate memory. Thicker arrows indicate greater similarity of activity between two points, and colors indicate the time delay between related activity peaks.

In one test, the researchers looked at "immediate memory" – an essential component of thought and conscious action that's easily disturbed by head injury or neural disorders such as Alzheimer's disease. MANSCAN differentiated among people with varying degrees of this very short-term memory, allowing the researchers to use brain-wave patterns to predict whether a person was about to perform a memory task correctly. This suggests the scan may prove useful for diagnosing neural diseases or in evaluating new drugs or rehabilitation therapies, Gevins says.

In another experiment, the team used MANSCAN to observe the brain as it combined letters into sounds, sounds into words and words into sentences. Gevins says preliminary results contradict theories that such processes occur in a "building block" manner, and suggest instead that language tasks involve the simultaneous use of widely distributed brain networks. He says future MANSCANs may help explain the causes of some reading disorders and guide rehabilitation approaches for stroke patients with reduced language functions.

A third experiment, in which Air Force fighter pilots performed a battery of demanding mental tasks during a 10- to 14-hour period, detected telltale signs of mental fatigue several hours before the pilots' performance actually deteriorated. Gevins says the results hint that brain monitors may one day provide early warnings of mental fatigue in workers operating complex equipment.

The new findings, appearing soon in BRAIN TOPOGRAPHY, invite speculation about the nature of cognition, Gevins says. "Our brains are not mere stimulus-response devices," he says. "Rather, our brains seem to devote a very large portion of their activity to continuously forming, maintaining and revising detailed simulations, or models, of what we imagine our self- and world-states to be."

In experiments by his team and others, Gevins finds evidence that the mind is remarkably dynamic, constantly updating its sense of reality. Using sensory organs, he says, the brain extracts information from the environment, then compares that information with mental models based on past experience. What we experience as "thought" may actually be the brain revising its models to accommodate new information, Gevins says. In a fraction of a second, he adds, these revised models become preconceptions for the next moment's cognition.

MANSCAN, while impressive, probably doesn't represent the final say in cognitive mapping. Steven Petersen, a neuroscientist at Washington University in St. Louis, notes that PET still provides superior spatial resolution in the brain, even if it can't compete with MANSCAN's millisecond "shutter speed." He predicts that the two approaches, in combination with other technologies, may provide "spectacular" motion pictures of cognition within the next five to 10 years. □