

Brain imaging provides window into consciousness

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Using a sophisticated imaging test to probe for higher-level cognitive functioning in severely brain-injured patients provides a window into consciousness -- but the view it presents is one that is blurred in fascinating ways, say researchers at Weill Cornell Medical College in the Feb. 25 online edition of the journal *Brain*.

In a novel study of six patients ranging in their function from minimally conscious state to the locked-in syndrome (normal cognitive function with severe motor impairment), the researchers looked at how the brains of these patients respond to a set of commands and questions while being scanned with [functional magnetic resonance imaging](#) (fMRI).

They found there was a wide, and largely unpredictable, variation in the ability of patients to respond to a simple command (such as "imagine swimming -- now stop") and then using that same command to answer simple yes/no or multiple-choice questions. This variation was apparent when compared with their ability to interact at the bedside using voice or gesture.

Some patients unable to communicate by [gestures](#) or voice were unable to do the mental tests, while others unable to communicate by gestures or voice were intermittently able to answer the researchers' questions using mental imagery. And, intriguingly, some patients with the ability to communicate through gestures or voice were unable to do the mental tasks.

The researchers say these findings suggest that no exam yet exists that can accurately assess the higher-level functioning that may be, and certainly seems to be, occurring in a number of severely brain-injured patients -- but that progress is being made.

"We have to abandon the idea that we can rely on a bedside exam in our assessment of some severe

brain injuries. These results demonstrate that patients who show very limited responses at the bedside may have higher cognitive function revealed through fMRI," says the study's corresponding author, Dr. Nicholas D. Schiff, professor of neurology and neuroscience and professor of public health at Weill Cornell Medical College and a neurologist at NewYork-Presbyterian Hospital/Weill Cornell Medical Center.

While progress has been made in elucidating the range of brain function in those who are severely injured, Dr. Schiff urges caution. "Although everyone wants to use a tool like this, fMRI is not yet capable of making clear measurements of cognitive performance. There will be a range of possible responses reflecting different capabilities in these patients that we have to further explore and understand," he says.

The new study tested three levels of communication in steps that required increasing cognitive capacity, says Dr. Henning Voss, who is the study's senior investigator and associate professor of physics in radiology at Weill Cornell Medical College. "While we could not unambiguously establish communication in these brain-injured patients, our research is helping us identify problems specific to this patient population," Dr. Voss says. "We got a clear picture about where and how to look for this kind of brain activity in response to certain commands."

Ethical Imperative

"Thousands of people suffer debilitating brain injuries every year, and there is a clear ethical imperative to learn as much as possible about their ability to communicate," says the study's lead author, Jonathan Bardin, a third-year neuroscience graduate student at Weill Cornell Medical College.

"These findings caution us against giving too much weight to negative results and open our eyes to the

diversity of responses one might expect from the wide-ranging group of severely brain-injured people," he says.

The potential implications of these kinds of consciousness studies are significant, says co-author Dr. Joseph Fins, the E. William Davis, Jr., M.D. Professor of Medical Ethics, chief of the Division of Medical Ethics, and professor of medicine, professor of public health, and professor of medicine in psychiatry at Weill Cornell Medical College. "Beyond facilitating communication with these patients, these studies should communicate to society at large this population is worthy of our collective attention.

"A vast majority of severely brain injured patients around the country are receiving substandard care because they are improperly diagnosed, not given adequate rehabilitation, and often end up in nursing homes. We all want this to change," adds Dr. Fins, who is also director of medical ethics and chairman of the ethics committee at NewYork-Presbyterian Hospital/Weill Cornell Medical Center.

fMRI Reveals Consciousness's Complexity

The Weill Cornell study is a continuation of research into how fMRI can establish a line of communication with brain-injured patients in order to understand if they can benefit from rehabilitation, and to gauge their level of pain and other clinical parameters that would improve care and quality of life.

Research collaborators in Cambridge, England, and Liege, Belgium, published earlier demonstrations in 2006 and 2010 that severely brain-injured patients could respond to commands or questions. The present studies extend the earlier findings and represent an important confirmation of such measurements by independent scientists.

In the current study, the dissociations observed and the wide range of communication capacities in the patient subjects studied provide unique insights. In the first step, the six patients, as well as 14 control participants, were asked a command that formed the basis for further communication. The control volunteers were asked to imagine performing their

favorite sports, the patients to imagine themselves swimming.

Then, in the three patients who could do this, and in all of the controls, the researchers asked them to use the same imagined activity to respond to one or two options in a simple two-part question. In the third multiple-choice task, they were shown a face card from a deck of playing cards, then asked to respond when either the face or suit of the card was named.

The scans showed a number of "dissociations" in these patients -- "surprising instances in which patients' imaging responses diverged from their behavior," Bardin says.

One patient could generate the mental imagery but not use it to answer questions -- although he could communicate accurately with gestures. Another patient, who can speak, could not carry out the mental imagery task. A third patient who could imagine swimming on command showed dramatically varied brain response patterns when tested over time.

"The patients participating in this study often have multiple or widespread brain injuries affecting not only local brain areas but the whole brain network on a wide scale," Dr. Voss says. "Even if we knew precisely all the injuries involved in a subject, our still-limited understanding of the [brain](#) networks involved in communication makes it impossible to accurately predict remaining cognitive and communicative skills in many cases. If there is no normal communication possible, fMRI can reveal cognitive capacities on several levels."

"This is a reality check, in essence, because there is a wide range of cognitive abilities in these patients, and the implications on the extreme ends of the spectrum are important," Dr. Schiff says.

"There are people whose personal autonomy is abridged because they don't have a good motor channel to express themselves despite their clear mind and opinions and desires about themselves and the world. And there are people who are without cognitive capacity, but because there is a misinterpretation of what is possible, there is a willingness to hold out hope.

"Not all minimally conscious patients are the same, and not all patients with locked-in syndrome are the same," Dr. Schiff says.

Going forward, the research group, along with others in the field, is planning a major multicenter trial of fMRI along with European and Canadian colleagues supported by The James S. McDonnell Foundation to better understand both its promise and limitation in gauging cognitive abilities in severely brain-injured patients.

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