

PHENOMENA: ONLY HUMAN

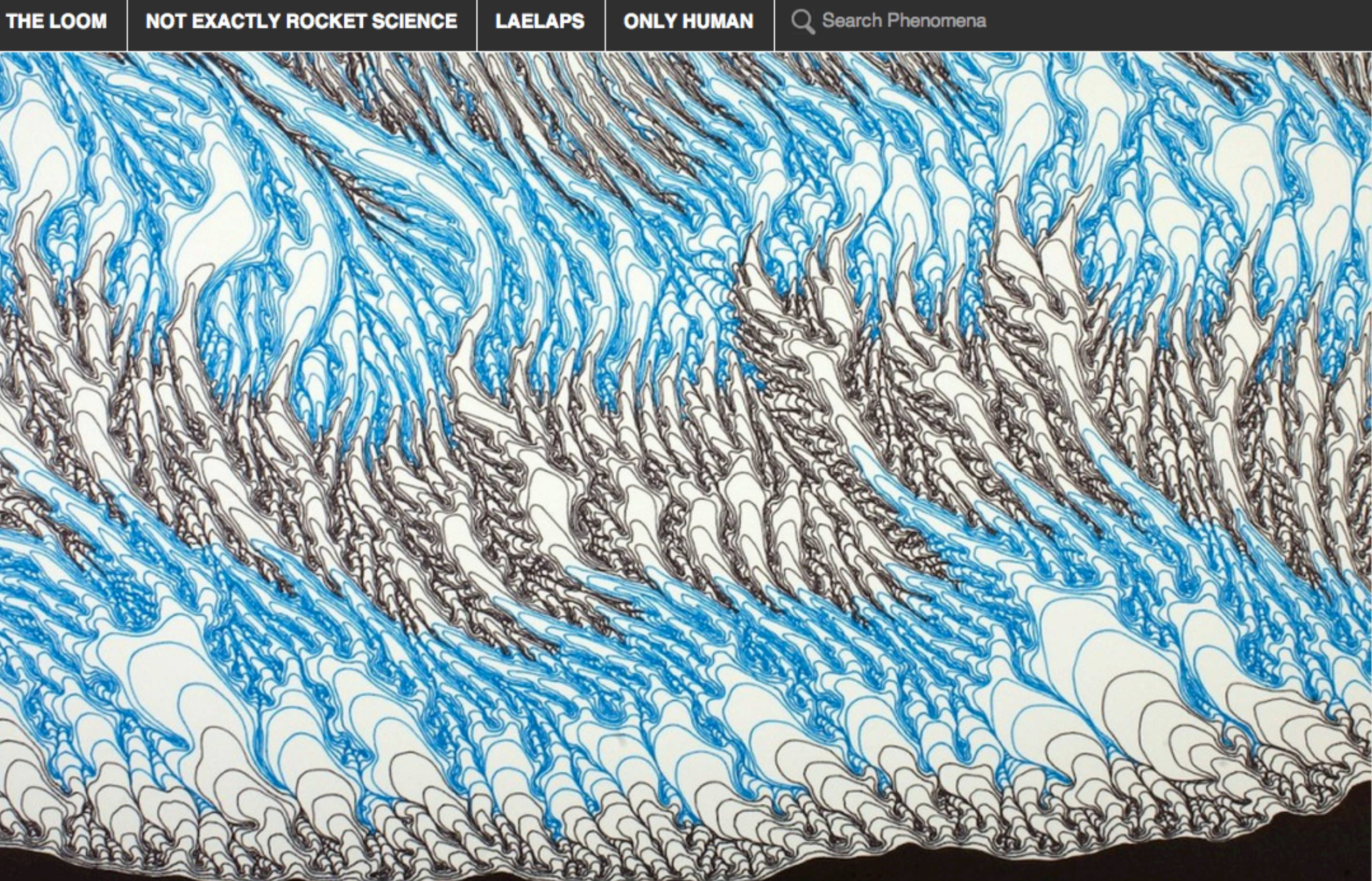


Image by [Damien James](#)

ONLY HUMAN: 4 mins ago

Consciousness is a Process

by Virginia Hughes

Last week my fellow Phenom Ed Yong wrote [a post](#) about what happens to consciousness when animals die. According to the research Ed described, a rat’s brain shows signs of consciousness for at least 30 seconds after its heart stops.

That study got a lot of buzz, understandably, because of what it implies about near-death experiences: namely, that they’re more likely the product of a human mind than of some mystical power.

But Ed’s post also raised some more nuanced — and I think, more profound — questions about the work. For example, coma expert [Steven Laureys](#) of the University of Liège pointed out that nobody really knows yet how to determine whether an animal is conscious or unconscious by looking at its brain waves alone. “It’s terribly hard to make strong claims about what these rats actually perceived, or about possible conscious experiences,” Laureys told Ed.

But that line of research is advancing rapidly. Just two days after the rat study came out, researchers in Italy reported a new method for decoding neural signals of consciousness — in people. [Marcello Massimini](#)’s team from the University of Milan found that people in different states of consciousness will respond to a non-invasive electromagnetic pulse with [distinctive patterns of brain waves](#).

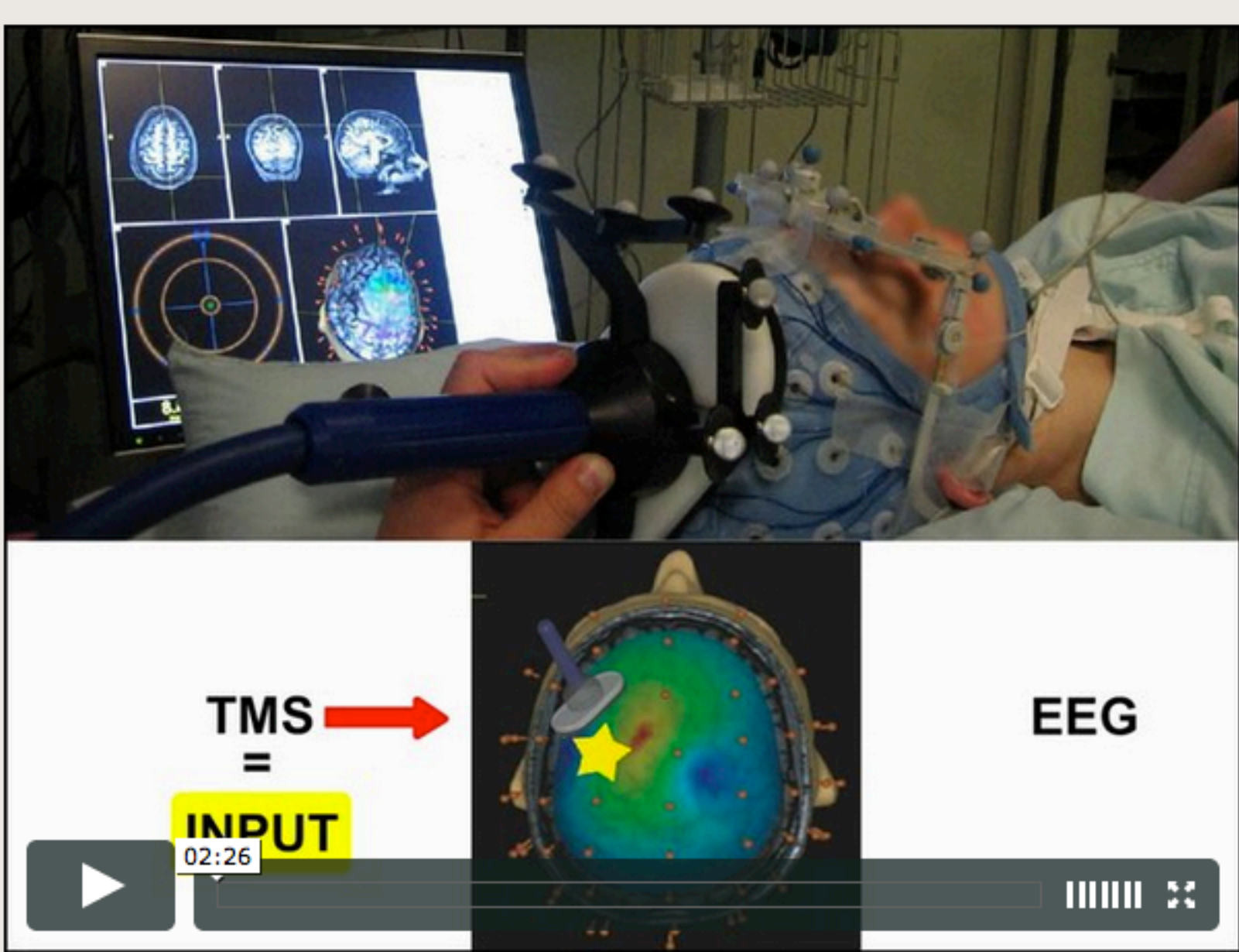
If other groups confirm that these waves are reliable markers of consciousness, it would be a huge help to doctors who treat people with brain injuries. Many of these patients look the same from the outside — they don’t respond to doctors or loved ones with words, say, or eye blinks, or hand squeezes. But they are not the same. Some 68 percent will recover consciousness within a year, and 21 percent will lead independent lives, according to one [study](#). What’s more, some people gain consciousness one, two or even five years after their injury.

With current technologies, however, it’s extremely difficult for doctors to predict which patients will have positive outcomes and which will [never break through](#). In 2009, Laureys’s group estimated that 41 percent of people diagnosed as being in a vegetative state (a murky state of biological arousal without any conscious awareness) were later found to have [some level of consciousness](#).

Massimini’s solution relies on a technology called transcranial magnetic stimulation, or TMS, in which researchers place a wand on the person’s head. The wand contains a magnetic coil, which produces an electromagnetic pulse that passes through the person’s skull and tickles the neurons underneath. The neurons respond to that pulse, and the researchers then measure that neuronal response via EEG electrodes places all over the scalp.

The researchers created algorithms that analyze the patterns of EEG response and spit out a number — the “perturbational complexity index”, or PCI — between 0 and 1. PCI is based on the idea that consciousness arises when groups of neurons show responses that are *both* unique and coordinated. As Nicholas Schiff, a neuroscientist at Cornell University, explained it in a related [commentary](#): “High PCI values are obtained only if the initial TMS perturbation alters activity in a large set of integrated brain regions that each then react differently over time.”

It’s complicated stuff. This video, created by the researchers, describes the technique visually, which helped me understand it:



Video by [Adenauer G. Casali](#)

Once they had refined their methods for calculating PCI, the researchers tested its validity on 32 healthy people while they were either: awake, in dreaming sleep, in deep (unconscious) sleep, or under various kinds of anesthesia. The lowest PCI recorded during a conscious state was .44, and the highest PCI recorded in an unconscious state was .31, suggesting that a score somewhere in between could serve as an objective threshold of consciousness.

The team then showed that PCI could also accurately identify consciousness in 20 people with brain injuries. Six people in a vegetative state, for example, had PCI scores between .19 and .31 — in the same range as healthy people who were in deep sleep or drugged. In contrast, two patients with locked-in syndrome — a condition in which people are aware and have normal thinking abilities, but cannot communicate because of total body paralysis — had PCI scores ranging from .51 to .62, no different from awake healthy people.

There’s still much to be done before this new technology can be tested in the clinic. The sample size was pretty small. And it’s not clear yet whether PCI can reliably distinguish between patients who have a minimum level of consciousness and those who have none — the distinction that’s arguably the most difficult and important in a clinical setting.

I like the study, though, because it emphasizes an essential point that also came out of [the rat study](#).

“Doctors assume that after clinical death, the brain is dead and inactive,” the rat study’s lead investigator, [Jimo Borjigin](#), told Ed. “They use the term ‘unconscious’ again and again. But death is a process. It’s not a black-or-white line.”

Right, death is a process. But consciousness, too, is a process — a very slippery one.

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ABOUT VIRGINIA



I’m a freelance journalist who writes about neuroscience, genetics, behavior, and medicine for the likes of *Nature*, *Popular Science*, and *Slate*. Before coming to Phenomena, I contributed to the delightfully quirky science blog *The Last Word on Nothing*. I live in Brooklyn, New York, land of artisanal basketball stadiums and rich dog walkers, with my husband and whip-smart puppy.

Photo by [Brian Friedman](#)

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[Science Seeker Award Winner 2012](#)

Re-Awakenings, a story about a strange sleeping sickness published on *The Last Word on Nothing*, was deemed best post of 2012 by *Science Seeker*.

Our *Body the Ecosystem*, published in *Popular Science*, was included in the 2012 *Best American Science and Nature Writing* anthology.

How Damaged Are NFL Players’ Brains?, published in the *New Yorker* (online).

The Big Fat Truth, published in *Nature*. More and more studies show that being overweight does not always shorten life — but some public-health researchers would rather not talk about them.

The Roots of Resilience, published in *Nature*. In 1986, Elizabeth Ebaugh was abducted, raped and thrown over a bridge. How did she manage to bounce back? How does anybody?

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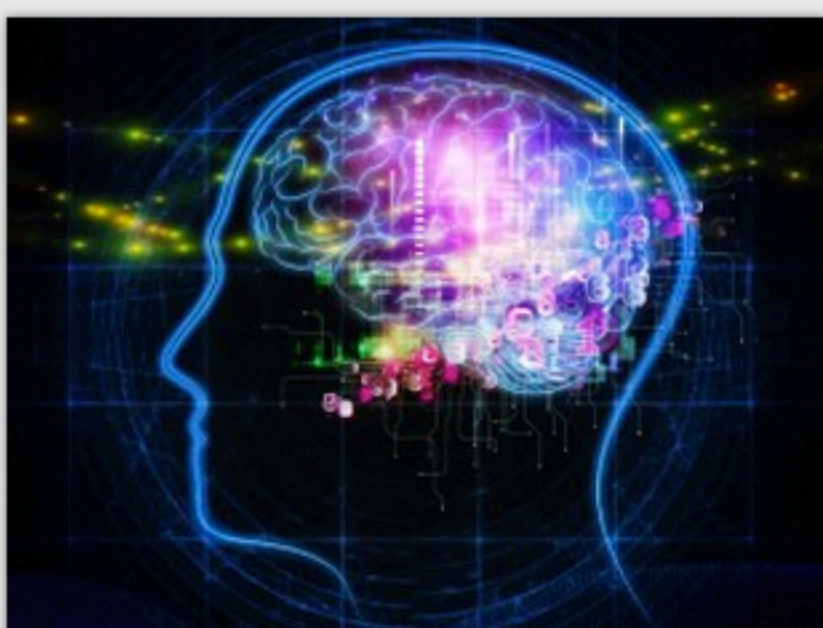
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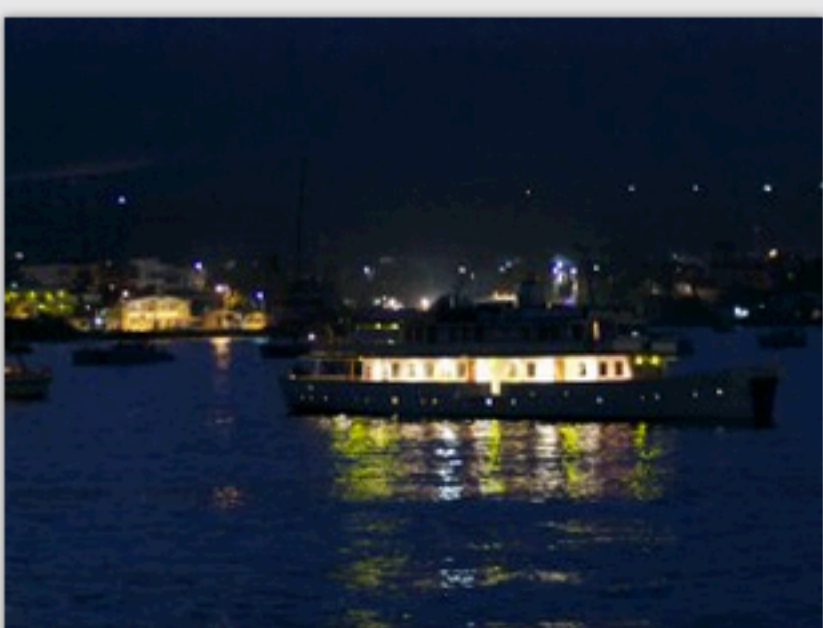
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