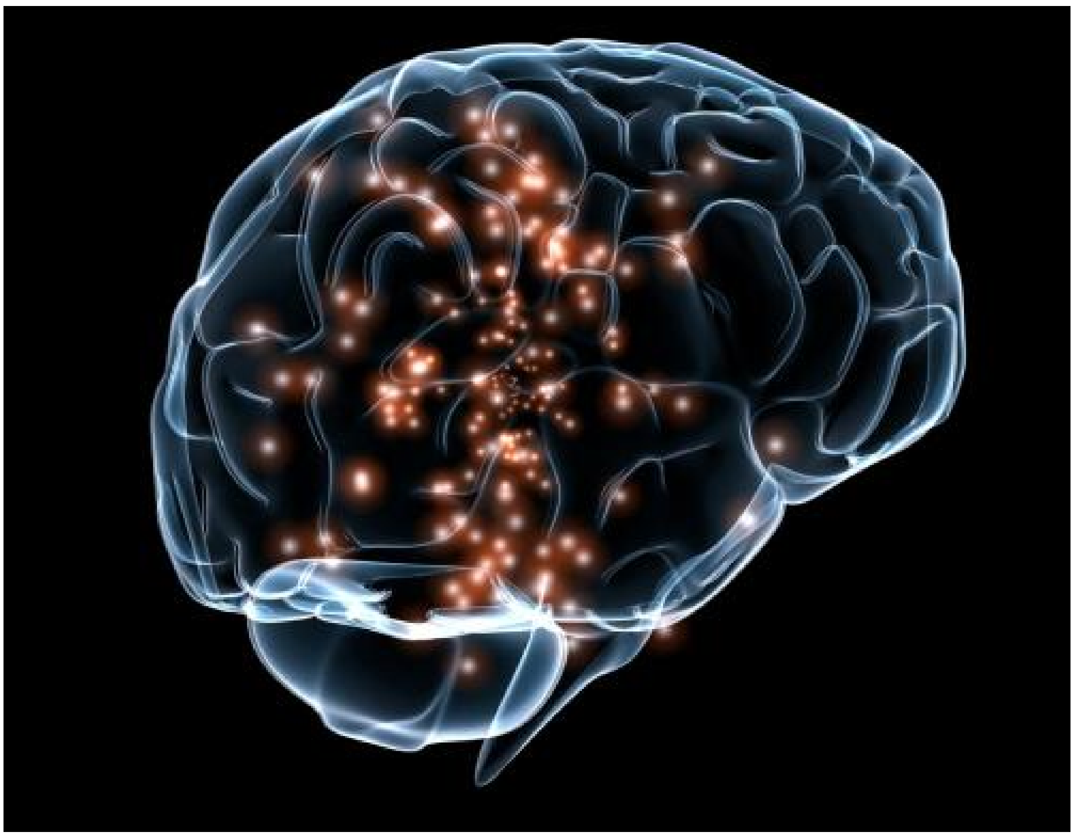
Medical Xpress

Study establishes extent of human brain excited by specific dose of electricity

December 9 2016, by Bruce Goldman



Credit: Wikimedia Commons

Until now, no quantitative relationship between the level of electricity applied to the brain and the extent of neural activity generated has been plotted in humans.

Researchers at the Stanford University School of Medicine have determined the amount of human brain tissue that is excited by a given dose of electrical stimulation.

"We have, for the first time in humans, established a dose-response curve that applies to electrical stimulation rather than to drugs," said Josef Parvizi, MD, PhD, associate professor of neurology and neurological sciences.

The findings, described in a study published online Dec. 8 in *Neuron*, may guide the therapeutic application of electrical brain stimulation via surgically implanted, current-emitting devices.

Parvizi is the senior author of the study. The lead author is former Stanford postdoctoral scholar Jonathan Winawer, PhD, now an assistant professor of psychology at New York University.

Devices delivering defined therapeutic doses of electricity to structures within the brain are now in widespread commercial use for countering the tremors of Parkinson's disease and controlling seizures in epilepsy patients, and are approved for some patients with obsessive-compulsive disorder. Similar devices are undergoing clinical testing for other conditions, including depression and Tourette's syndrome.

"We often try to correct a problem occurring in some tiny part of the brain's complicated circuitry by administering a drug," said Parvizi. "However, instead of reaching the cells you want to target, much or most of the drug may wind up in the skin, bone, muscle, liver and elsewhere, not to mention brain cells you don't want to target." That can cause all kinds of side effects.

'Immense potential'

"Electrical brain stimulation, targeting only a specific malfunctioning brain circuit, has immense potential to change medical practice," Parvizi said. "But figuring out just how much current will be effective without recruiting unwanted brain circuitry and inducing side effects has been largely guesswork."

To get a more accurate picture, the new study focused on part of the brain's surface called the primary visual cortex, one of the most well-studied regions of the human brain. Located in the back of the brain on the facing inner surfaces of that organ's two hemispheres, the primary visual cortex is the first docking station for visual information from the retina.

Each nerve cell in the primary visual cortex receives its information from a fixed location in the retina and responds to an object observed at a given position in a person's visual field. The precision with which this correspondence has already been mapped out makes the primary visual cortex an ideal place to examine just how far the effects of a given electrical input propagate along the brain's surface.

Parvizi, who directs Stanford's Human Intracranial Cognitive Electrophysiology Program, was taking care of four adult patients under his evaluation at Stanford Health Care to determine the point of origin of their recurring, drug-refractory epileptic seizures. In this procedure, a portion of the skull is temporarily removed and a grid of electrodes is placed on the brain's surface in order to record seizure activity and pinpoint the spot in the brain where it begins.

Each of these four patients' primary visual cortex, while perfectly healthy, was partially covered by the electrode grids.

Mapping phosphenes

Investigators showed them geometric forms moving across a computer screen while they stared at the center of the screen. Using brain-imaging techniques, the researchers mapped which areas of the participants' primary visual cortex these displays activated.

Once electrode grids were in place, the team used them to stimulate and to record activity in the participants' primary visual cortex. After each stimulation, they asked the participants to chart the location and size of the hallucinatory phenomena, or phosphenes, they experienced in their visual field in response to electrical stimulation.

A phosphene is a visual sensation in the absence of light. Some phosphenes look like a flickering, fractured formation composed of small zigzagging lines of color dancing at a specific location in the field of vision. (For people prone to migraines, such apparitions often herald the onset of a painful headache.) Others may just be a burst of light or color. (People often "see" phosphenes when they rub their closed eyes.) It's long been known that activating the primary visual cortex by direct electrical stimulation can produce phosphenes, which persist for the duration of the stimulation and then vanish.

The investigators, always taking care to adhere to strict safety limits, pulsed electrical current from one or another electrode at varying frequencies, pulse widths, amplitudes and durations while the participants stared at the center of the computer screen. After each instance of stimulation, they were asked to draw on the computer screen, using its trackpad, the outline of the phosphene they saw in its perceived location. Then, using the imaging-derived maps of the individuals' primary visual cortexes they'd constructed earlier, the researchers were able to connect points on the observed phosphenes to corresponding points on participants' primary visual cortex, and to infer from phosphenes' sizes and locations just how much brain-surface area in that brain region had been excited by each electrode-delivered stimulation.

"The resulting dose-response relationship can be used now in clinical trials of electrical brain stimulation," Parvizi said.

Scientists have tried to establish this relationship in rodents, said Winawer. "But you can't easily extrapolate from rodent studies, both because our brains are quite different from theirs and because the recording and stimulating instruments used in rodent experiments are 1,000-fold different from those used in humans."

Nor have connections between the physiologically measureable outcome and perceptual outcome been previously mapped to any extent. (Animals can't report what they see.)

"Notably, we observed a clear correspondence between the amount of electricity applied and the size and intensity of the ensuing visual phenomena subjects reported experiencing," said Parvizi, who has long been fascinated by the question of how manipulating the brain's strictly material components alters subjective consciousness.

How well the dose-response relationship as measured at the cortical surface holds up in deep-brain structures remains to be further tested, he added.

More information: Jonathan Winawer et al. Linking Electrical Stimulation of Human Primary Visual Cortex, Size of Affected Cortical Area, Neuronal Responses, and Subjective Experience, *Neuron* (2016). DOI: 10.1016/j.neuron.2016.11.008

Provided by Stanford University Medical Center

December 9) retrieved 7 May 2024 from https://medicalxpress.com/news/2016-12-extent-human-brain-specific-dose.html