Researchers create computer model that simulates anesthesia's impact on brain

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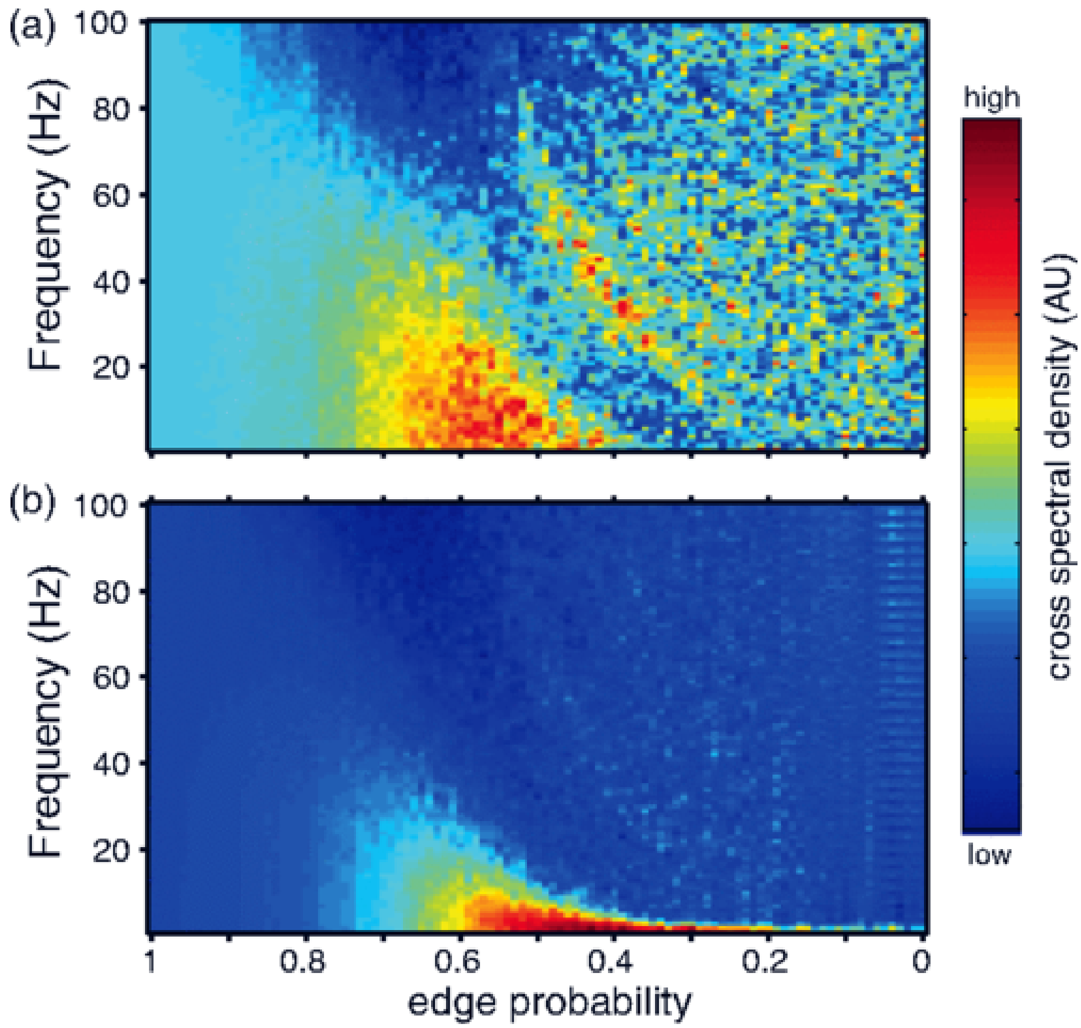

Thalamocortical and corticocortical coherence. Credit: *Phys. Rev. Lett.* 115, 108103 – Published 4 September 2015. DOI: 10.1103/PhysRevLett.115.108103

(Phys.org)—A team of researchers working at the University of Pittsburgh has created a computer model that simulates in some interesting ways, the process that occurs when anesthesia causes the human brain to essentially shut down. In their paper published in *Physical Review Letters,* the team describes how they built their model, which aspects of consciousness it represents and the ways in which it mimics human anatomy.

Despite huge advances in the development of drugs used to anesthetize people during surgery, scientists still do not know how or why it works, which is irksome because if it could be explained than we might make some inroads towards understanding the nature of consciousness itself. In this new effort, the team in Pittsburgh created a computer model framed around nodes that are meant to mimic neurons or whole parts of the brain and the signals that are sent between them. The model is based on an idea that suggests sudden changes in consciousness brought about by the introduction of an anesthetic are caused by a global change in the network responsible for carrying signals through a neural network—a sudden restoration of the network would then correspond to the sudden awakening that occurs with patients coming to after surgery.

To mimic such a situation the researchers built a network of nodes with signaling between them similar to the gamma and beta waves that can be recorded during normal human consciousness, the alpha waves that occur during times of relaxation and the delta waves that are the hallmark of deep sleep. To allow for such globalized changes, the researches assigned a variable (p) to each node that represented transmission flow—changing the value changed the ability of an individual node to read, react and transmit information that came to it. But, because it was a global variable, the researchers were able to impact the way information was processed and retransmitted for all of the nodes at the same time.

By changing the value of the variable slowly, the researchers were able to find the tipping point, where the network ceased to be able to transmit signals—mimicking a loss of consciousness. But what was truly interesting was that the signaling that occurred naturally mimicked the types of brain waves recorded on an EEG machine as a person becomes unconscious.

The researchers are not suggesting that their model actually explains what happens when an anesthetic enters the brain, but are instead offering a possible base on which to begin a way to study what does occur, perhaps leading to a better understanding of how consciousness really does work in the brain.

More information: Percolation Model of Sensory Transmission and Loss of Consciousness Under General Anesthesia, *Phys. Rev. Lett.* 115, 108103 – Published 4 September 2015.
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ABSTRACT
Neurons communicate with each other dynamically; how such communications lead to consciousness remains unclear. Here, we present a theoretical model to understand the dynamic nature of sensory activity and information integration in a hierarchical network, in which edges are stochastically defined by a single parameter p representing the percolation probability of information transmission. We validate the model by comparing the transmitted and original signal distributions, and we show that a basic version of this model can reproduce key spectral features clinically observed in electroencephalographic recordings of transitions from conscious to unconscious brain activities during general anesthesia. As p decreases, a steep divergence of the transmitted signal from the original was observed, along with a loss of signal synchrony and a sharp increase in information entropy in a critical manner; this resembles the precipitous loss of consciousness during anesthesia. The

model offers mechanistic insights into the emergence of information integration from a stochastic process, laying the foundation for understanding the origin of cognition.