Disrupted global brain signal during unconsciousness

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Video Abstract

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Abstract

When someone loses consciousness, one of the main things that happens is a loss of integrated activity across functionally separate brain networks. But there isn't a single way of measuring this that tracks with the degree of consciousness. That could soon change given the findings of a new article in the journal *Anesthesiology*. A group of international researchers examined functional magnetic resonance imaging, or fMRI, data and found support for the use of something called the "global brain signal". The global signal is an average of all gray-matter brain activity across each voxel in a scan, and reflects global coordination at a given time. When there's high coordination, voxels will all be mostly positive – or negative – and the sum will be positive or negative. In contrast, if there's less coordination, the voxels across the brain won't match and the values will cancel out. The standard deviation of the global signal over the course of a scan yields the global signal amplitude, which provides a measure of overall brain connectivity. The research team assessed the global signal by analyzing past fMRI scans in humans, including in people who were awake, asleep, sedated or under propofol anesthesia, and in patients who were minimally conscious or had unresponsive wakefulness syndrome. They also performed new fMRI experiments in propofol anesthetized rats. The group observed gradual reductions in brain activity coordination with reduced consciousness, such as the lighter stages of sleep, sedation and the minimally conscious state. More profound reductions occurred in truly unconscious states. The global signal amplitude was highest during wakefulness, and fell as humans and rats became more and more unconscious. There was a strong relationship between the global signal amplitude and the global signal functional connectivity. The team also compared the global-to-network functional connectivity to see which regions of the brain had less connectivity in different states. They found that in incomplete unconscious states, such as deep sleep, there was selective decoupling of sensory and attention networks. In contrast, with complete unconsciousness, most networks were uncoupled. Topography comparisons also revealed distinct differences between states that otherwise might look similar, such as general anesthesia versus a vegetative state. While more research is needed to validate the measure, the results suggest that once there is a more practical way to capture it, the global brain signal could be a good indicator of consciousness in patients.