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Researchers provide new framework for studying brain organization

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UCLA researchers and colleagues at Emory University and other research centers have combined data simulation and experimental observation to bridge a gap between two major properties of large-scale organization of the human brain—stationary and traveling waves of activity.

"Functional magnetic resonance imaging suggests the brain has a globally coherent spatial structure, but there is not yet consensus among scientists on the proper way to catalog this structure. We show that a small number of spatiotemporal patterns can do the job," said Lucina Uddin, professor of psychiatry and biobehavioral sciences and director of the Brain Connectivity and Cognition Laboratory at the UCLA Semel Institute for Neuroscience and Human Behavior.

Taylor Bolt, the lab's statistician and the study's first author, said, "We showed that a wide range of previously observed empirical phenomena are manifestations of three main spatiotemporal patterns."

The study centers on spontaneous low-frequency blood-oxygenation-level dependent (BOLD) fluctuations, a phenomenon discovered in the 1990s. Spontaneous fluctuations have been subjected to increasingly complex analytic techniques, leading to a large landscape of competing descriptions of large-scale functional brain organization. Some researchers have highlighted the simultaneous synchrony of brain regions across the cortex—what the authors refer to as "standing" or "stationary" wave structure. Other researchers have highlighted the time-lag synchrony of brain regions across the cortex—what the authors refer to as "propagatory" or "traveling" wave structure. There has been "little attempt to synthesize findings across different approaches," the researchers said.

Uddin likened the lack of consensus to the Indian parable of the blind men and the elephant, where each man encounters one part of the animal and comes up with a description that is different from all the others.

"The parable teaches us the perils of missing the 'big picture' due to our own limited observations," she said.

Hypothesizing that stationary and traveling wave representations "of intrinsic functional brain organization are capturing different aspects of a small number of spatiotemporal patterns," the authors found that a range of previous observations could be unified in a framework modeling both standing and traveling wave structure. The investigators said their findings provide a "description of global functional brain organization that can inspire new hypotheses about the mechanisms underlying coordination of activity across the brain."

The study was published in July 28, 2022 issue of *Nature Neuroscience.*

Uddin and Jason Nomi, an assistant researcher at the UCLA Semel Institute for Neuroscience and Human Behavior, collaborated on the study with an international team including senior author Shella Keilholz, of Emory University in the United States; Dr. Danilo Bzdok, of McGill University in Canada; Jorge Salas and Catie Chang, of Vanderbilt University in the U.S.; and Thomas Yeo, of the National University of Singapore.

More information: Taylor Bolt, A parsimonious description of global functional brain organization in three spatiotemporal patterns, *Nature Neuroscience* (2022). DOI: 10.1038/s41593-022-01118-1. www.nature.com/articles/s41593-022-01118-1

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