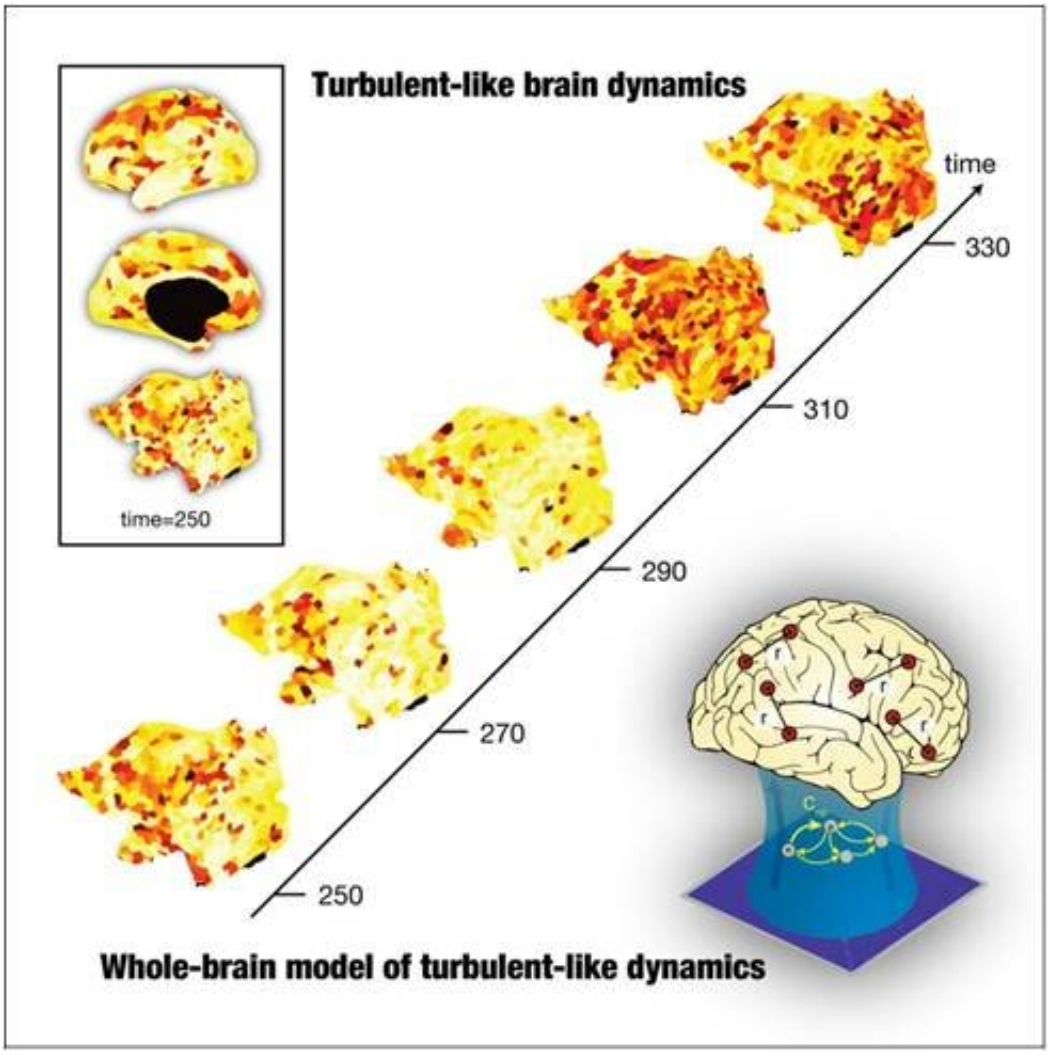
Turbulent dynamics in the human brain could revolutionize the understanding of its functionality

January 12 2021



Credit: Universitat Pompeu Fabra - Barcelona

Most people experience turbulence primarily from the experience of flying in an airplane. However, turbulence is a key feature of nature and is found everywhere, from rivers to galaxies.

Turbulent-like dynamics are difficult to capture in a still image. However, Leonardo da Vinci did everything possible to identify the underlying order of the phenomenon, which he observed in eddy currents forming randomly in water. In fact, he was fascinated by trying to understand and describe the generating principles governing such complicated dynamics. This is so much so that he coined the phrase 'turbolenza," which comes from the Latin word for crowds: 'torba." This same idea was the beginning of centuries of research into turbulence. Through the work of the giants of modern physics and mathematics like Andrey Kolmogorov, Yosihiki Kuramoto and Werner Heisenberg, some of the main organizing principles of turbulence have been established. Heisenberg said: "When I meet God, I am going to ask him two questions: Why relativity? And why turbulence? I really believe God will have an answer to the first."

The article: "Turbulent-like dynamics in the human brain" published by the main open access journal *Cell Reports* on Monday 8 December 2020, focuses on characterizing and identifying the turbulence that occurs in the human brain.

This work is the result of international collaboration between the Center for Brain and Cognition (CBC) at Pompeu Fabra University, the Department of Psychiatry at the University of Oxford (UK), and the Center for Music in the Brain at Aarhus University (Denmark), conducted by the researchers Gustavo Deco (ICREA-DTIC) and Morten L. Kringelbach, who have discovered turbulent-like dynamics in the human brain by means of functional magnetic resonance imaging (fMRI) in a sample of over 1,000 participants.

Turbulence as a fundamental organizing principle of physical systems

Gustavo Deco stated: "Previous research has shown that turbulence is the optimal way to make energy cascade through space-time on many scales, which is not just a visually pleasing phenomenon but also a fundamental organizing principle of physical systems."

The new approach suggested by this work proposes the existence of turbulent-like dynamics as the backbone of the communication of large-scale neural networks

Deco continues: "We have also shown that the physics of turbulence has important practical applications ranging, for example, from improved chemical plants to aircraft and windmills. Our results reveal a new way of analyzing and modeling whole-brain dynamics. This new approach suggests the existence of turbulent-like dynamics as the backbone of the communication of large-scale neural networks. This new knowledge could revolutionize our understanding of brain function."

Morten L. Kringelbach, co-author of the research, adds: "Our findings provide a solid, innovative framework for use as novel biomarkers for neuropsychiatric diseases. In the coming years, this theoretical framework could lead to new interventions that might improve the mental health of many people, especially after this turbulent pandemic."

More information: Gustavo Deco et al, Turbulent-like Dynamics in the Human Brain, *Cell Reports* (2020). DOI: 10.1016/j.celrep.2020.108471