Scientists identify a mathematical 'crystal ball' that may predict calamities

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Bank run: Neuroscientists identify a mathematical equation that could predict financial crises of the sort that brought about the banking collapse of 2008.

Neuroscientists have come up with a mathematical equation that may help predict calamities such as financial crashes in economic systems and epileptic seizures in the brain.

The University of Sussex-led study, published this week (24 October 2013) in *Physical Review Letters*, could have far-reaching implications. If the principle is generalised in other real-world complex systems, such as climate change or disease control, it could open up the possibility of

catastrophes being averted before they happen.

In a collaboration between the University's Sackler Centre for Consciousness Science and the Centre for Research in Complex Systems at Charles Sturt University in Australia, researchers used mathematics and detailed computer simulations to show that a measure of 'information flow' reaches a peak just before a system moves from a healthy state to an unhealthy state.

Such 'phase transitions' are common in many real systems, and are often highly significant: epileptic seizures and financial market crashes are just two examples of transitions. Until now, though, ways to predict these transitions in advance have been lacking. Previous measures, which peak at the transition itself, have been of no use for purposes of prediction.

Lead researcher Dr Lionel Barnett says: "The key insight in the paper is that the dynamics of complex systems – like the brain and the economy – depend on how their elements causally influence each other; in other words, how information flows between them. And that this information flow needs to be measured for the system as a whole, and not just locally between its various parts."

Essentially this means finding a way to characterize, mathematically, the extent to which the parts of a complex system are simultaneously segregated (they all behave differently) and integrated (they all depend on each other). In the present study the research team managed to do just this, and to show for the first time that their measure reliably predicts phase transitions in standard systems studied by physicists now for many decades (the so-called 'Ising' model).

Professor Anil Seth, Co-Director of the Sackler Centre, says: "The implications of the work are far-reaching. If the results generalise to

other real-world systems, we might have ways of predicting calamitous events before they happen, which would open the possibility for intervention to prevent the transition from occurring.

"For example, the ability to predict the imminent onset of an epileptic seizure could allow a rapid medical intervention (perhaps via brain stimulation) which would change the course of the dynamics and prevent the seizure. And if similar principles apply to financial markets, climate systems, and even immune systems, similar interventions might be possible. Further research is needed to explore these exciting possibilities."

More information: prl.aps.org/abstract/PRL/v111/i17/e177203

Provided by University of Sussex