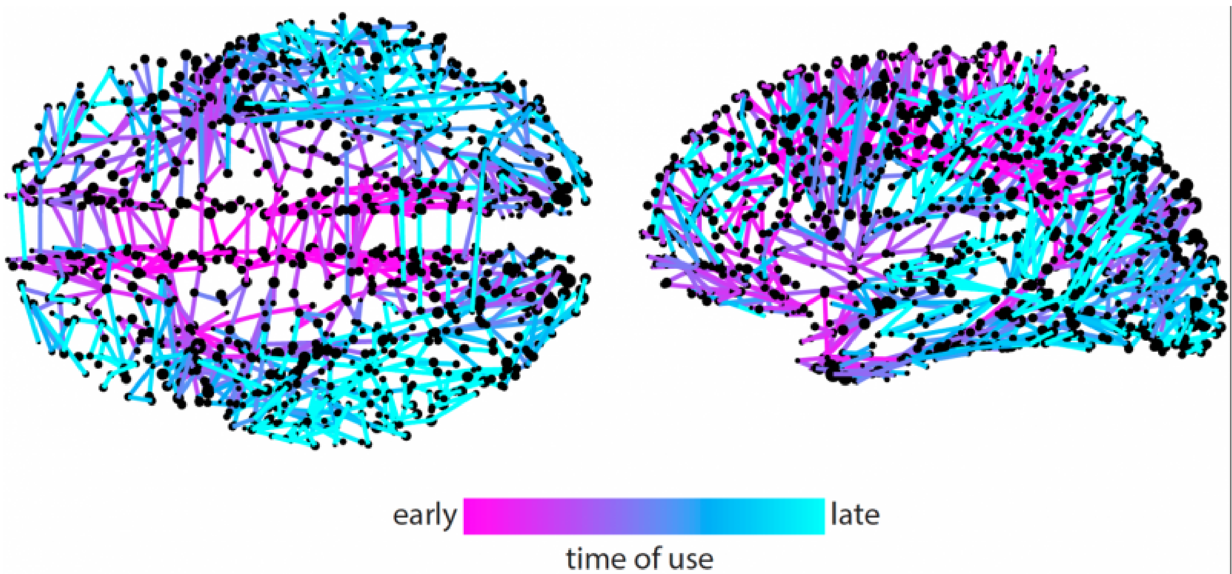
Network model for tracking Twitter memes sheds light on information spreading in the brain

June 17 2015



The times at which different connections in the brain are used to spread information. In general, information appears to rapidly spread from a compact core of central pathways. Credit: Olaf Sporns / Bratislav Misic

An international team of researchers from Indiana University and Switzerland is using data mapping methods created to track the spread of information on social networks to trace its dissemination across a surprisingly different system: the human brain.

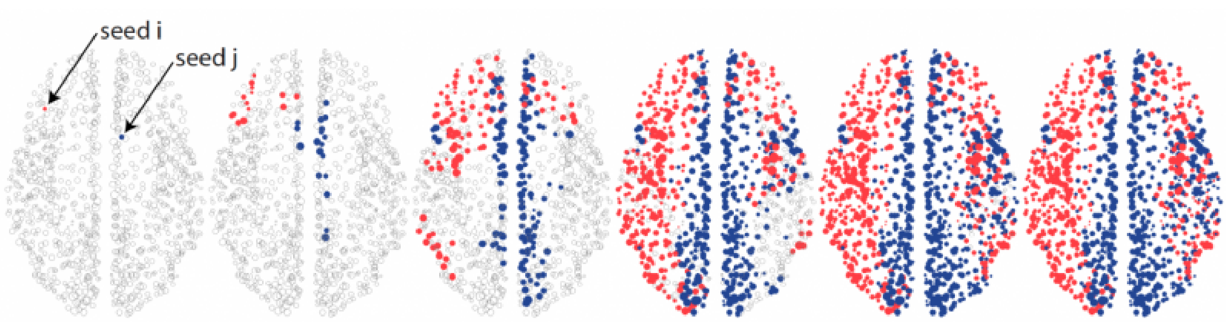
The research team from the IU Bloomington Department of Psychological and Brain Sciences and School of Informatics and Computing found that applying social network models to the brain reveals specific connections and nodes that may be responsible for higher forms of cognition.

The results are reported in today's issue of the journal *Neuron*.

"This study suggests that answers about where in the brain higher cognition occurs may lie in the way that these areas are embedded in the network," said IU Distinguished Professor Olaf Sporns, who is senior author on the study. "You can't see this just by looking at a static network. You need to look at dynamic patterns.

"Each thought or action involves multiple signals, cascading through the brain, turning on other nodes as they spread. Where these cascades come together, that's where integration of multiple signals can occur. We think that this sort of integration is a hallmark of higher cognition."

Other lead researchers on the paper are Yong-Yeol Ahn and Alessandro Flammini, both of the IU Bloomington School of Informatics and Computing. An expert on complex networks, Ahn had previously used data from Twitter to track information spreading through social networks, including constructing analyses that predict which memes will go viral.



Two competing information "cascades" in the brain, one red and one blue. The nodes where the cascades meet create the potential for integration, a hallmark of higher forms of cognition. Credit: Olaf Sporns / Bratislav Misic

To conduct the brain study, the team performed diffusion spectrum imaging on the brains of 40 research volunteers at University Hospital Lausanne in Switzerland. The team then created a composite map of regions and long-range connections in the brain and applied a dynamic model for information spreading based in part upon Ahn's model for tracking viral memes.

"Like information in social networks, information in the brain is traveling along connections that form complex networks," said Sporns, who is a co-founder of the emerging field of connectomics, which aims to produce comprehensive network maps of the neural elements in the brain and their interconnections. "It was not too far a stretch for us to think of the brain this way."

Despite the team's playful nickname for the project, "twitterbrain," Ahn said the social network models they applied to the brain represent only non-viral forms of information spreading.

"The viral distribution of information may be considered good online, but it does not accurately describe the normal functioning of the brain," he said. "The model we used for networks in the brain reflects a decidedly non-viral form of information spreading."

Yet the resulting model still revealed an insightful global view of the brain's information architecture, delivering detailed data on how the brain's network structures support the spread of information.

"The model allows us to track those signals and see how they travel through the brain's network and where they meet up, with these meeting points appearing to represent 'higher-level' areas in the brain's hierarchy," said co-first-author Bratislav Miši?, a postdoctoral fellow in the Department of Psychological and Brain Sciences, who uses the example of a person speaking, an action that generates both an auditory and visual signal in the brain.

The model also highlighted the pattern of this information's spread. The researchers could trace a signal from a specific point and observe how quickly it spread through the brain. They could also use the model to infer what connections were used in the brain or identify the connections used at the start of a signal to provide an initial foothold or a fastest path through the network.

"We found these connections are not randomly distributed; they have a fairly conspicuous structure," Sporns said. "Certain pathways, for example, form a compact, highly organized pattern, which supports early spreading. There's also a prominent central component, which gives the signal an initial boost. These are all things we didn't know until now."

The work also offers an alternative to a trend in modern neuroscience, in which the brain is described in increasingly smaller biophysical units and micro-processes, according to Richard Betzel, a graduate student in the Department of Psychological and Brain Sciences and co-first-author on the study.

"To get a global understanding of how the brain works as a complex networked system is a major goal in our field," Sporns said. "We've hit upon something that is both promising and relatively simple, a model that may help us get better insight into why certain things happen in certain parts of the brain and not others. Much remains to be done; we've only scratched the surface."

Next, the IU team plans to explore the role of individual differences in brain networks, and how brain lesions may affect the brain's ability to distribute information.

Provided by Indiana University