Network of sounds: New research reveals the magic secret of human networks

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A group of Israeli researchers recruited 16 violinists to study the behavior of a human network and find out what sets it apart from other networks, such as animals, computers, and other objects. The results

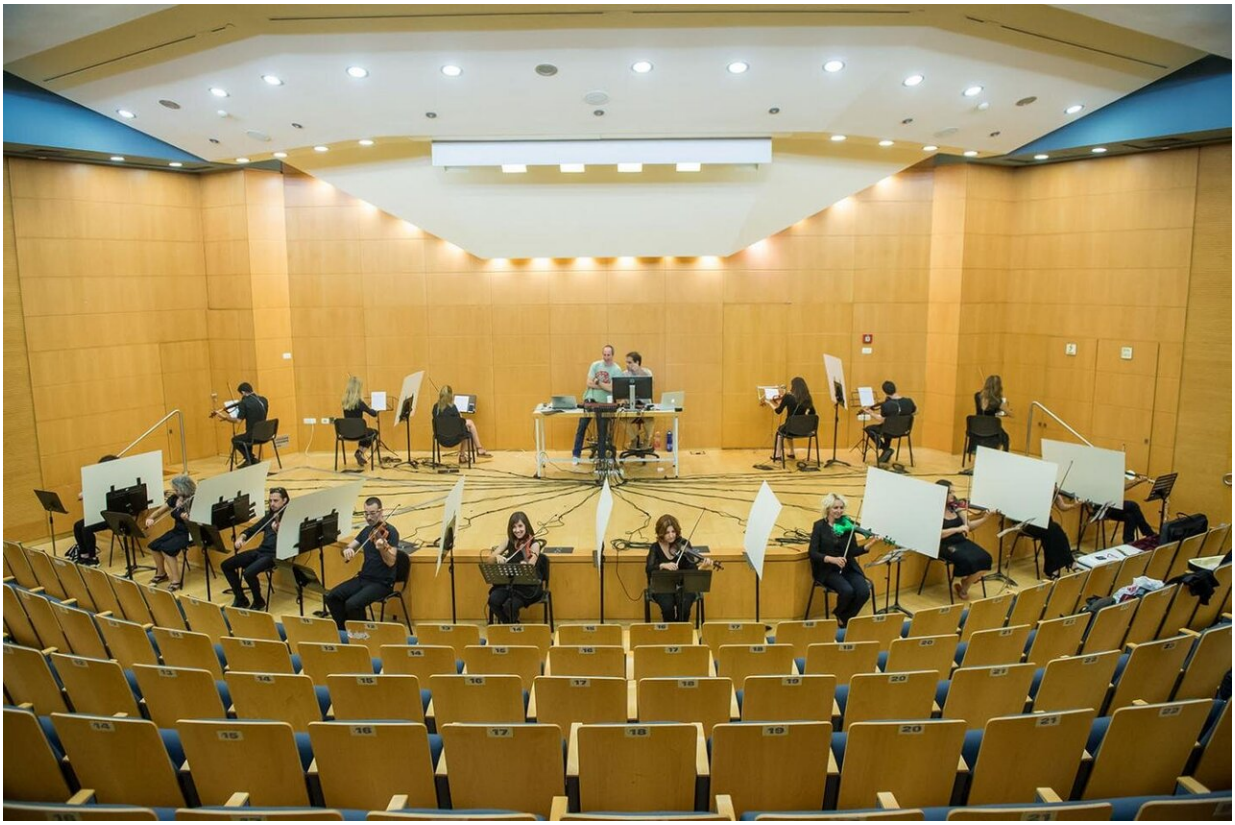
combine science and esthetics, and also evoke thoughts about the spread of the coronavirus.

Synchronization, in which a complex system operates as one body, is an important phenomenon that takes place in an enormous range of scales—from subatomic particles to galaxies. In biology, fish, birds, and even cells synchronize in order to survive. Group synchronization is essential to human beings, and critical to our physical and mental health. Examples of synchronization can be seen in drivers on the road or in a crowd of people clapping hands together. Today, in order for a group of people to make a decision, they don't have to meet. Rather, there is a complex network of connections that enables them to make decisions. The phenomenon of synchronization between humans in a complex network is necessary for understanding decision-making, understanding the spread of fake news, political science, economics, and the spread of diseases, yet it hasn't been studied to date.

To contribute to existing knowledge about human synchronization, and to investigate it for the first time in a measurable and accurate way, Dr. Moti Fridman of the Kofkin Faculty of Engineering at Bar-Ilan University, Prof. Nir Davidson of the Weizmann Institute, and Elad Shniderman from Stony Brook University in New York, created a musical ensemble that acted like a network. Their findings were published in the journal *Nature Communications*.

The ensemble was composed of 16 violinists wearing headphones. Each of the violinists repeatedly played an identical short musical phrase, and heard his/her own performance, along with the performance of two or more violinists, through the headphones. Visual information was also neutralized by separating the musicians with partitions. All they were asked to do was to synchronize with each other, or in other words, to play along with what they heard in the headphones.

The experimental setup created by the researchers allowed them to control the connectivity of the network, such as how many of the members of the ensemble each musician was connected to and the intensity in which each musician heard the other musicians. What the musicians heard in the headphones was one or two violinists or more playing with them in real time while an increasing delay was imposed on the system. "Here we have a different phenomenon than a regular musical piece. There is no global clock, but many people within a certain network of communication responding independently. In fact, it's an esthetic object that reveals the behavior of people in a group personally, or as an ensemble," says Fridman.



Sixteen violinists participating in the networking experiment in which they are connected to a computer system hearing only the sound received from the computer. Credit: Chen Damari

"By introducing a delay between the coupled violinists so that each violinist heard what his/her neighbors played a few seconds ago, we prevent the network from reaching a synchronized state," says Fridman. This is called a frustrated situation and is well studied in different types of networks. According to current network theory models, in a frustrated state each node will try to compromise between all its inputs.

"Humans behave differently," Dr. Fridman explains. "In a state of frustration they don't look for a 'middle', but ignore one of the inputs. This is a critical phenomenon that is changing the dynamics of the network. It has not been addressed to date because the measurements weren't clean and couldn't be shown."

The research conducted by Dr. Fridman and his colleagues, which actually began as a scientific-artistic project for the Fetter Museum of Nanoscience & Art at Bar-Ilan University, offers two innovations: the first is methodological—a platform that measures human network dynamics accurately and cleanly. The second is evidence that a human network has two unique characteristics: the flexibility to change pace, and the ability to filter, and even ignore, inputs that create frustration. These capabilities fundamentally change the dynamics of human networks relative to other networks and necessitate the use of a new model to predict human behavior.

"If you take humans and you study how they clap together, you have no control over who hears what. While working on this project we discovered that human networks behave differently than any other network we've ever measured. Human networks are able to change their inner structure in order to reach a better solution than what's possible in existing models. This concept is the core of our scientific and esthetic discovery," says Fridman.

The research has led to a new model for simulating human networks, which is important for several applications. The dynamics of human networks are essential for understanding decision making in groups which is a wide subject related to economics, politics, human sciences, and more. Since the experiment is the first to measure the dynamics of complex networks, this can be beneficial to understanding how and when a group of people in a social network, which is exposed to false information, arrives at wrong conclusions. It can prevent what is known as "fake news" from spreading without control. In addition, the research is related to epidemic control and understanding how many connections we can preserve and still prevent an epidemic from spreading.

The results are also related to any network where each node in the network has decision-making ability, such as autonomous cars, or introducing AI into our highly-connected world. This model can predict with high accuracy the dynamic of such systems, beyond what was possible before.

More information: Synchronization of complex human networks, *Nature Communications* (2020). DOI: 10.1038/s41467-020-17540-7, www.nature.com/articles/s41467-020-17540-7

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