New game theory model describes how people make decisions in changing environments

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Does staying informed help us cooperate? Not always, as ignorance can lead to cooperation too. Credit: Hebi B. (422737)/Pixabay

In the face of existential dilemmas that are shared by all of humanity, including the consequences of inequality or climate change, it is crucial to understand the conditions leading to cooperation. A new game theory model developed at the Institute of Science and Technology Austria (ISTA) based on 192 stochastic games and on some elegant algebra finds that both cases—available information and the lack thereof—can lead to cooperative outcomes.

The journal *Nature Communications* has published a new open-access paper on the role information plays in reaching a cooperative outcome. Working at ISTA with the Chatterjee group, research scholar Maria Kleshnina developed a framework of stochastic games, a tool to describe how people make decisions in changing environments. The new model finds that availability of information is intricately linked to cooperative outcomes.

"In this paper, we present a new model of games where a group's environment changes, based on actions of group members who do not necessarily have all relevant information about their environment. We find that there are rich interactions between the availability of information and cooperative behavior.

"Counter-intuitively there are instances where there is a benefit of ignorance, and we characterize when information helps in cooperation," says Professor Krishnendu Chatterjee who leads the "Computer-Aided Verification, Game Theory" group at the Institute of Science and Technology Austria, where this work was done.

Ignorance can be beneficial for cooperation too

In 2016, Štěpán Šimsa, one of the authors of the new paper was working with the Chatterjee group, when he ran some preliminary simulations to find that ignorance about the state of the game may benefit cooperation.

This is counter-intuitive since the availability of information is generally thought to be universally beneficial. Christian Hilbe, then a postdoc with the Chatterjee group, along with Kleshnina, thought this to be a worthy research direction. The group then took on the task of investigating how information or the lack thereof affects the evolution of cooperation.

"We quantified in which games it is useful to have precise information about the environmental state. And we find that in most cases, around 80 to 90% it is indeed really good if players are aware of the environment's state and which game they are playing right now. Yet, we also find some very interesting exceptional cases, where it's actually optimal for cooperation if everyone is ignorant about the game they are playing," says co-author Christian Hilbe, who now leads the research group Dynamics of Social Behavior at the Max Planck Institute for Evolutionary Biology in Germany.

The researchers' framework represents an idealized model for cooperation in changing environments. Therefore, the results cannot be directly transferred to real-world applications like solving climate change. For this, they say, a more extensive model would be required. Although, from the basic science model that she has built, Kleshnina is able to offer a qualitative direction.

"In a changing system, a benefit of ignorance is more likely to occur in systems that naturally punish non-cooperation. This could happen, for example, if the group's environment quickly deteriorates if players no longer cooperate mutually. In such a system, individuals have strong incentives to cooperate today, if they want to avoid playing an unprofitable game tomorrow," she says.

To illustrate the benefit of ignorance, Kleshnina says, "For example, we found that in informed populations, individuals can use their knowledge to employ more nuanced strategies. These nuanced strategies, however,

can be less effective in sustaining cooperation. In such a case, there is indeed a small benefit of ignorance towards cooperation."

A brilliant method

Game theory is, in its essence, a study of mathematical models set up within the framework of games or exchange of logical decisions being played between rational players. Its applications in understanding social and biological evolution have been welcomed by interdisciplinary researchers given its game-changing approach.

Within the context of evolutionary game theory, many models investigate cooperation but most assume that the same game is played over and over again, and also that the players are always perfectly aware of the game that they are playing and its state at any given moment. The new study weakens these general assumptions, first by allowing the simulated players to play different games over time. And second, by accounting for the impact of information.

"The beauty of this approach is that one can combine some elegant linear algebra with extensive computer simulations," says Kleshnina.

The new framework opens up many new research directions. For instance, what is the role of asymmetric information? One player might know the exact game being played, but another may not. This is not something that the model currently covers. "In that sense, our paper has quite [a few] future applications within theory itself," Hilbe adds.

More information: Maria Kleshnina et al, The effect of environmental information on evolution of cooperation in stochastic games, *Nature Communications* (2023). DOI: 10.1038/s41467-023-39625-9

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