Everyone can have an impact on the dynamics of a group, particularly if they join forces with others

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How do we as individuals prompt our fellow humans to behave socially? This is one of the central questions relating to social dilemmas in game theory. Previous studies assumed that it is almost impossible to control cooperation in large groups. Nonetheless, scientists from the Max Planck Institute for Evolutionary Biology have now demonstrated that each of

us can exert an influence on the cooperative behaviour of others. However, the possibilities available to the individual are limited in this regard, particularly in the context of large groups. The researchers therefore also examined how group success is influenced when several like-minded members join forces. The mathematically calculated result corroborates experience: we can achieve more when we act together.

When game theorists test cooperative behaviour, they often use the prisoner's dilemma as a model, whereby two players decide separately to act either socially or egoistically. If both act egoistically, they derive little benefit. The greatest benefit is obtained by the person who acts egoistically while his (or her) counterpart acts socially. When this situation is iterated several times in succession with both participants, cooperation may arise.

Based on this dilemma, for a long time, game theory considered it impossible for one player to control the outcome irrespective of the approach adopted by the other. But two years ago an American research team demonstrated mathematically that, based on zero-determinant (ZD) strategies, it is actually possible for an individual player to enforce a correlation between own payoff and that of the opponent. Thus, a player can determine whether he or she will benefit to the same or even greater extent as the other by playing generously, fairly or extortionately. In particular, the possibility of extortion was previously unknown and its discovery caused quite a stir among experts.

In practice, however, as scientists working with Manfred Milinski from the Max Planck Institute for Evolutionary Biology in Plön discovered based on an experiment involving test subjects, many people do not allow themselves to be exploited in the long term. (See "Extortioners are only temporarily successful"). Working in cooperation with researchers from Harvard University, two of their colleagues from Plön have now tested this approach in a different way. They extended the ZD strategies

mathematically to situations involving multiple players; after all, in real life, cooperation usually involves more than two participants. "Using game theory, pressing problems of our time, such as the avoidance of climate change, can be understood as social dilemmas involving multiple players," explains Arne Traulsen, Director of the Department for Evolutionary Theory at the Plön-based Max Planck Institute. "Many people have the feeling that they cannot achieve anything as individuals. However, they underestimate the possibilities available to them."

With the help of mathematical calculations, Christian Hilbe, a former post-doc in Plön, and his colleagues showed that the ZD strategies that are successful in games involving two participants are also effective in situations involving any number of players. Therefore, an individual can also control within a group how he or she will gain from a situation compared to the other players. If the person plays fairly, i.e. cooperates if the others cooperate but punishes egoistic behaviour proportionally through a refusal to cooperate, his or her payoff will reflect the mean value of that of the other players. If a player behaves generously, that is acts socially more often than the other players, the player can ensure that these players obtain a better result. One player also has the possibility of extorting the others, however. The tactic adopted in this case is that he or she cooperates sufficiently often for it to be beneficial for the other players to adopt a cooperative strategy in the long term. At the same time, however, the extortioner aims to act egoistically more often than the others. In this way, the extortioner succeeds in exploiting the others and obtaining greater benefit.

"What interested us most, however, was how the individual can contribute to the development of stable cooperation within the group," says Hilbe. The researchers were actually able to calculate mathematically which strategies promote cooperation. According to their findings, individual players should act generously in principle to avoid ending up in a spiral of refusal when another has acted egoistically once

– possibly due to a misunderstanding. On the other hand, individual players should not be too generous either and should consistently punish egoistic behaviour.

However, the strategic opportunities available to the individual always decline the more people there are involved in the game. Hence, to ensure the success of a joint strategy in large groups, it makes sense to form an alliance. According to the calculations, whether or not this tactic must be re-negotiated for each individual round or is agreed from the outset is of secondary importance. What is crucial to the shared objective is how many players join forces.

But an alliance does not necessarily have to commit itself to a social approach. On the contrary, it can form an extortioner group. "There are no limits to extortion when sufficient numbers cooperate," notes Traulsen, explaining the result of the model. Yet even this phenomenon can have a positive effect, as this group prompts the others to behave socially. As a result – according to the model – it can generate a positive group dynamic among the outsiders and promote cooperation to some extent.

More information: "Cooperation and control in multiplayer social dilemmas." *PNAS* 2014 ; published ahead of print October 27, 2014, DOI: 10.1073/pnas.1407887111

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