How a simple mathematic formula is starting to explain the bizarre prevalence of altruism in society

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Why do humans cooperate in things as diverse as environment conservation or the creation of fairer societies, even when they don't receive anything in exchange or, worst, they might even be penalized?

This is a question that has puzzled academics for centuries, especially since in evolution the basis for the "survival of the fittest" is, after all, selfishness. But in an article just published in the journal *Nature*, three Portuguese theoretical physicists develop a mathematical model capable of providing a way out from this conundrum through the introduction of social diversity - a ubiquitous characteristic of modern social networks - and suggesting that that the act of cooperation is dependent on one's social context/ranking.

And in fact, when social diversity was taken into account the numbers of those cooperating increased in direct relation to the system diversity. Furthermore, cooperation, according to this model, spreads even faster when the act of cooperation is considered more important than the amount given, with these societies presenting also a much fairer distribution of wealth. This new mathematic model for society's evolution is particularly interesting because not only it reveals a logic behind the large numbers of cooperators that we know exist in all human societies, but also it gives us a glimpse of the principles that can help "pushing" them into a better, fairer, path.

Evolutionary game theory is a mathematical approach used to study (and predict) the evolution of social interactions, in which the study of conflict and decision-making is treated – like its name indicates – as a game. One such example are public good games (or PGG), which are frequently used to study cooperation as they look into social behaviour towards public goods - such as education, free health or even street lightning – those that every one can benefit from, regardless of how much they contribute (or not) to create it.

Here because the individual's benefits are independent of he/she contribution the most rational and selfish strategy (both in the games and real life) is to chose no-cooperation, what we know does not happen in real life. This is a good example of how difficult it has been to understand and create a theoretical model capable of explaining the emergence and prevalence of cooperation not only among humans but many other species.

What Jorge M. Pacheco and Marta D. Santos (University of Lisbon, Portugal) did - together with Francisco C. Santos (Free University of Brussels, Belgium) - in order to overcome this apparent paradox, was to introduce into PGG, for the first time, a new variant – social diversity – in contrast to the models previously used in which all individuals were equivalent. Social diversity here refers to the characteristics typical of most social networks: the existence of individuals with different numbers and types of social connections, with few very highly connected and most with very few connections.

Since PGG are represented as a mathematical formula, diversity was introduced as a new variable in the equation. Then Santos, Santos and Pacheco used this new altered formula to calculate the percentage of collaborators in the community, in function of population diversity (in PGG this would refer to the number and type of games each individual participated or, in other words, his/her "popularity"). And in fact, it was found, that in populations with high diversity, as diversity increased also did collaboration levels.

The way PGG work is that each individual pays a certain amount to play (defectors play but do not pay/cooperate) and in the end profit, which is the total amount gathered in a game, is divided by all players. The reason why diversity increased cooperation had to with the fact that those few individuals with more connections and playing more games (the cooperators) would also have much higher "profits" and their impressive success would lead the other players to imitate their behaviour (even when the behaviour per se did not seem to improve directly their own life) resulting in an exponential increase of cooperation. In the same way, in real life the more connected/popular individuals are emulated, becoming role models and opinion makers.

Equally the model also predicted that even when no-cooperators lead to new no-cooperators (as it happens many times in real life where this kind of behaviour can spread within groups) this will result in less profit, less success and eventually their own self-extinction with only a few sporadic ones left to parasite cooperators.

Furthermore, it was also shown that the increase in cooperation was particularly accelerated when all individuals contributed to the games with the same total contribution, independently of the number of games played. This corresponds, in real life, to saying that if the act of contributing to the public good was seen as more important than the amount contributed, the percentage of collaborators in a community would grew much faster.

Interestingly, the model, when applied in a more economical perspective, also suggests that these communities, with high diversity and where the act of cooperation is what matters, will also have a much fairer wealth distribution.

In conclusion, social relations, in this case differences in "popularity", tested when introduced into PGG , are suggested to be crucial for the spread of cooperation throughout society.

Although this is obviously a very simple mathematical model and reality will never be as linear, Santos, Santos and Pacheco's results gives us a total new perspective on how to look at ways of increasing cooperation/altruism and, consequently, also on how to create more successful societies, concerning issues as crucial to our survival as the protection of the environment or fairer social relationships, contributing in this way to the construction of a more peaceful world with less conflict and destruction.

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