Scientists develop new theoretical model on the evolution of cooperation

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Evolution by definition is cold and merciless: it selects for success and weeds out failure. It seems only natural to expect that such a process would simply favour genes that help themselves and not others. Yet cooperative behaviour can be observed in many areas, and humans helping each other are a common phenomenon. Thus, one of the major questions in science today is how cooperative behaviour could evolve.

Scientists from the Max Planck Institute of Evolutionary Biology in Plön, Harvard University, and the University of Amsterdam have now developed a new model combining two possible explanations - direct reciprocity and population structure - and found that both repetition and structured population are essential for the evolution of cooperation. The researchers conclude that human societies can best achieve high levels of cooperative behaviour if their individuals interact repeatedly, and if populations exhibit at least a minor degree of structure.

The scientists addressed the question how cooperative behaviour could evolve using a game called the prisoner's dilemma, which considers two types of players: co-operators who pay a cost to help others; and defectors who avoid paying the cost, while reaping benefits from the co-operators they interact with. In general, everyone would be better off if they had engaged in cooperation, but from the point of view of the individual, defection is more beneficial. Selection will therefore always favour the defectors, and not cooperation. Researchers have used population structure and direct reciprocity to explain why cooperation has nevertheless evolved. In structured populations, co-operators are

more likely to interact with other co-operators and defectors with defectors. Direct reciprocity involves the repetition of interaction and is therefore based on experiences gained from prior events involving cooperation. In the past, both approaches have been regarded separately.

Using computer simulations and mathematical models, a group of scientists around Julian Garcia from the Max-Planck Institute of Evolutionary Biology in Plön have developed a new model that is taking both concepts into account. They discovered that direct reciprocity alone is not enough, and that population structure is necessary in order to reach a high level of cooperation. When there is some reciprocity, the average level of cooperation increases because alike types are more likely to interact with each other. Additionally, the researchers observed that cooperation occurs if cooperative and defective individuals are highly clustered and repetition is rare. And surprisingly, too much repetition can even harm cooperation in cases when the population structure makes cooperation between individuals very likely. This is due to the fact that reciprocity can protect defectors from invasion by defectors in a similar manner that it prevents cooperation from being invaded by defectors.

"Without population structure, cooperation based on repetition is unstable", Garcia explains one of the main findings. This is especially true for humans, where repetition occurs regularly and who live in fluid, but not totally unstructured populations. A pinch of population structure helps a lot if repetition is present. "Therefore, the recipe for human cooperation might be: a bit of structure and a lot of repetition", says Julian Garcia. This phenomenon results in a high average level of cooperation.

More information: Matthijs van Veelena,Julián Garcíac,David G. Randa and Martin A. Nowaka, Direct reciprocity in structured populations, *PNAS*,
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