Nice organisms finish first: Why cooperators always win in the long run

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"We found evolution will punish you if you're selfish and mean," said lead author Christoph Adami, MSU professor of microbiology and molecular genetics. Credit: G.L. Kohuth

Leading physicists last year turned game theory on its head by giving selfish players a sure bet to beat cooperative players. Now two evolutionary biologists at Michigan State University offer new evidence that the selfish will die out in the long run.

"We found evolution will punish you if you're selfish and mean," said lead author Christoph Adami, MSU professor of microbiology and molecular genetics. "For a short time and against a specific set of opponents, some selfish organisms may come out ahead. But selfishness isn't evolutionarily sustainable."

The paper "Evolutionary instability of Zero Determinant strategies demonstrates that winning isn't everything," is co-authored by Arend Hintze, molecular and microbiology research associate, and published in the Aug. 1, 2013 issue of *Nature Communications*.

Game theory is used in biology, economics, political science and other disciplines. Much of the last 30 years of research has focused on how cooperation came to be, since it's found in many forms of life, from single-cell organisms to people.

Researchers use the prisoner's dilemma game as a model to study cooperation. In it, two people have committed a crime and are arrested. Police offer each person a deal: snitch on your friend and go free while the friend spends six months in jail. If both prisoners snitch, they both get three months in jail. If they both stay silent, they both get one month in jail for a lesser offense. If the two prisoners get a chance to talk to each other, they can establish trust and are usually more likely to cooperate because then both of them only spend one month in jail. But if they're not allowed to communicate, the best strategy is to snitch because it guarantees the snitcher doesn't get the longer jail term.

The game allows scientists to study a basic question faced by individuals competing for limited resources: do I act selfishly or do I cooperate? Cooperating would do the most good for the most individuals, but it might be tempting to be selfish and freeload, letting others do the work and take the risks.

In May 2012, two leading physicists published a paper showing their newly discovered strategy – called zero-determinant—gave selfish players a guaranteed way to beat cooperative players.

"The paper caused quite a stir," said Adami. "The main result appeared to be completely new, despite 30 years of intense research in this area."

Adami and Hintze had their doubts about whether following a zero determinant strategy (ZD) would essentially eliminate cooperation and create a world full of selfish beings. So they used high-powered computing to run hundreds of thousands of games and found ZD strategies can never be the product of evolution. While ZD strategies offer advantages when they're used against non-ZD opponents, they don't work well against other ZD opponents.

"In an evolutionary setting, with populations of strategies, you need extra information to distinguish each other," Adami explained.

So ZD strategies only worked if players knew who their opponents were and adapted their strategies accordingly. A ZD player would play one way against another ZD player and a different way against a cooperative player.

"The only way ZD strategists could survive would be if they could recognize their opponents," Hintze added. "And even if ZD strategists kept winning so that only ZD strategists were left, in the long run they would have to evolve away from being ZD and become more cooperative. So they wouldn't be ZD strategists anymore."

Both Adami and Hintze are members of the BEACON Center for the

Study of Evolution in Action, a National Science Foundation Center that brings together biologists, computer scientists, engineers and researchers from other disciplines to study evolution as it happens.

The research also makes that case that communication and information are necessary for cooperation to take place.

"Standard game theory doesn't take communication into account because it's so complicated to do the math for the expected payoffs," Adami explained. "But just because the math doesn't exist and the general formula may never be solved, it doesn't mean we can't explore the idea using agent-based modeling. Communication is critical for cooperation; we think communication is the reason cooperation occurs. It's generally believed that there are five independent mechanisms that foster cooperation. But these mechanisms are really just ways to ensure that cooperators play mostly with other cooperators and avoid all others. Communication is a universal way to achieve that. We plan to test the idea directly in yeast cells."

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