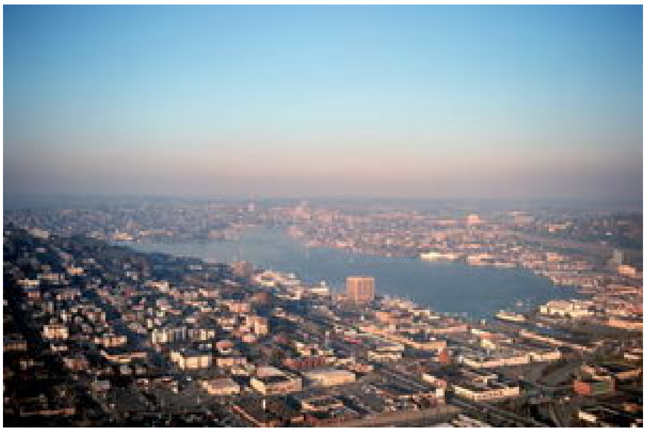
A 'prisoner's dilemma' for real-life situations

20 September 2006



The creation and growth of communities requires a degree of cooperation among citizens. Photo Credit: US National Oceanic and Atmospheric Administration

What's best for the individual and what's best for society are often not the same thing--this predicament is the premise for the famous "prisoner's dilemma" game. However, healthy societies depend on individuals cooperating for the common good, even at the risk of personal loss. In theory, individuals should choose what's in their own best self-interest, but the reality is that many people--and even animals--instead choose to cooperate, to the puzzlement of many professionals who study sociology, game theory and other disciplines.

Physicist Matjaž Perc of the University of Maribor in Slovenia has recently developed a model for the evolution of cooperation that provides a more realistic description for the altruistic behavior of individuals than previous explanations do. In a recent issue of the *New Journal of Physics*, Perc explained how selfish individuals are more likely to cooperate in a prisoner's dilemma game version which accounts for certain extrinsic factors. For instance, individuals often change their connections, engage in long-distance interaction that bridges gaps, and sometimes experience lesser risk and greater benefit for cooperating than those of the average outcome.

"External influences are omnipresent in everyday life," Perc explained to *PhysOrg.com*. "So far, the framework of evolutionary game theory, in which the evolution of cooperation is often studied, has not yet been supplemented by external factors. Thus, the payoffs of players (for example, humans, animals, firms, etc.) were considered as being fully deterministic (known in advance). In reality, however, unpredictable expenses, originating, for example, from accidents, fines, small violations of law we didn't really intend to do can hardly be discarded as being irrelevant. It is interesting to see that under such real-life motivated conditions, cooperation thrives best."

The basic premise of the prisoner's dilemma is that two suspects are placed in two different rooms, and each is asked separately whether or not his partner is guilty. Prison sentences depend on how each suspect responds: if both remain true to each other, they each serve only six months. If both betray each other, they both serve two years. If one betrays and one stays silent, the silent/cooperative partner serves 10 years while his betrayer goes scot-free. As one of the suspects, if you choose to betray, you will have better results, either serving two years or going free. If you choose to cooperate, you're in the cooler for either six months or 10 years. With those odds, most people should betray, even though the best result for everyone would be full cooperation.

As others have done, Perc studied a version of the prisoner's dilemma that includes many individuals and repeats the game numerous times, called an iterative prisoner's dilemma. In contrast with earlier models, however, he did not impose certain restrictions on the players, allowing them to commence or terminate connections, as often happens in real life. Perc also recognized that although outcomes average out "fairly" (e.g. the set prison sentences), sometimes individuals may reap better or worse results at any instance of the game, which he calls random payoff variation. For example, the risk of cooperation is not always equivalent to 10 years behind bars—sometimes, it might be eight, or six, or four. Also, sometimes the single betrayer doesn't go free, but actually serves more than six months, meaning that two cooperators will benefit more individually as well as overall. Depending on the scale of fluctuations of pre-determined “average payoffs,” it can be rarer for the risk of cooperation to increase, or for the benefits of mutual cooperation to decrease, Perc found. So overall, a certain degree of payoff variations encourages cooperative strategies.

Perc determined critical values for the variable payoffs, as well as for changing and long-term connections, and found that accounting for these two factors—what he calls the "double resonance" phenomenon—results in greater cooperation between individuals. In particular, cooperators survive by forming clusters so as to protect themselves against being exploited by defectors. Cooperators located in the interior of such clusters enjoy the benefits of mutual cooperation and are therefore able to survive despite the constant exploitation by defectors along the cluster boundaries. However, as the temptation to defect exceeds a threshold value, cooperators die out.

"In reality, humans often form alliances not just with their immediate neighbours, but also with others that are physically far away," said Perc. "On the other hand, however, the introduction of shortcuts hinders cluster formation and enables defectors to exploit clustered cooperators not just along the cluster boundaries but also from within. Thus there exists an optimal fraction of shortcuts among players that still enables at least some long-range connections among distant cooperators, but at the same time does not hinder large cluster formation in the spatial domain. In simpler terms, it is good if firms expand, and form alliances with foreign partners, but at the same time they must always maintain a healthy and solid core—a central facility, the Fort Knox, if you will—upon which everything is based and which holds everything together."

Another real-life situation involving the benefits of cooperation is an arms race between two countries that spend billions of dollars on making weapons for fear that their enemy may be investing in the same defensive strategy. Both lose, considering that the money could have been spent on more productive means. According to Perc's results, countries who can take the risk of forming and trusting allies will aid one another through cooperation. They can more readily cooperate, according to the double resonance phenomenon, by beginning to cooperate during instances of decreased risk, as well as by taking advantage of currently existing long-distance bonds that provide a mechanism for cooperative alliances across the globe.

Citation: Perc, Matjaž. "Double resonance in cooperation induced by noise and network variation for an evolutionary prisoner's dilemma." *New Journal of Physics*. 8 (2006) 183.