Tides of tolerance

Karl Sigmund and Martin A. Nowak

Humans, and many other species, have a tendency to cooperate and help each other. But how does such behaviour evolve? Some new computer simulations provide a plausible answer.

When Charles Darwin published his theory of evolution in 1859, he knew that cooperation and altruistic behaviour present something of a problem for a concept that is based on competition and the struggle for existence. He did, however, anticipate a solution that was provided by William Hamilton more than a century later: cooperation can emerge as a result of ‘kin selection’ in cases where interacting individuals are genetically related. On page 441 of this issue, Riolo and colleagues discuss a new model for the evolution of cooperation, in which individuals help others that are, in some way, like themselves.

This is not the first time that the idea of ‘like helping like’ has been suggested as a route to the evolution of cooperation. Twenty-five years ago, Dawkins introduced the ‘green beard effect’ as a thought experiment in sociobiology. Consider a gene that confers on its bearer not only a green beard (or any other distinctive label), but also the instinct to provide assistance to all other owners of a green beard. Individuals with such a gene would effectively form a self-serving clique, and so the gene would spread within the population.

Today, the green beard is a cherished icon of the ‘selfish gene’ view of natural selection, and similar effects have actually been found in nature. But it still takes some effort to accept the idea of a gene producing, simultaneously, a signal and a predilection for the signaler. Such a double-effect gene seems contrived. Riolo et al. discuss a more plausible model for the evolution of cooperation: individuals just need to like their like, something that most of us can relate to.

In traditional models of how cooperation can emerge, the evolutionary development of a fictitious population of agents is simulated on a computer, over many generations, with pairs of individuals meeting randomly as potential givers and receivers of help. Giving help entails some cost to the donor, and getting help provides a larger benefit to the recipient. Cost and benefit are measured in potential givers and receivers of help. Giving help entails some cost to the donor, and getting help provides a larger benefit to the recipient.

One attractive feature of the new simulations is the evolution of tolerance — the recognition mechanism that discriminates ‘us’ from ‘them’. This tolerance does not freeze at some fixed value. Cyclically, it slowly increases over time, and then sharply declines. This drop occurs when the dominant cluster is dissolved from within as a result of mutation, by new individuals whose traits lie in the range of the dominant cluster but whose tolerance is considerably reduced. These newcomers are helped by all the residents of the established cluster but themselves help just a few, so they bear fewer costs than the established residents. A wave of intolerance then sweeps through the population, and in its wake a reduction in overall cooperation. But once a new dominant cluster is established, cooperation resumes at its former level and tolerance starts spreading again. The slow upward drift of tolerance seems to be due to a combination of mutation, pressure and kin selection. It will be important in the future to explore the robustness of this phenomenon.

These oscillations of tolerance levels are striking, and bring to mind many historical instances. We are witnessing a wave of social and religious intolerance right now. It would be foolish, of course, to reduce the complexities of political life to the vagaries of a virtual population. Yet these computer simulations do capture the imagination, and may well lead to a cottage industry of follow-up investigations, just like Axelrod’s famous computer tournaments based on the ‘prisoners’ dilemma’ game.

The new scenario applies to both genetic and cultural traits. Part of its appeal is its obvious link to reality — school ties, club memberships, tribal customs or religious creeds are all tags that induce cooperation. Some of these tags are easy to fake and might invite exploitation. Language, on the other hand, could be a reliable tag that is hard to fake: hiding one’s accent in a foreign language is nearly impossible.

Furthermore, tags can help to encourage the usual suspects behind cooperation among unrelated individuals: direct and indirect reciprocation (whereby recipients...
Catalysis frozen in time

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Modern microscopes are not just for imaging. In the right hands they can be used to follow and control catalytic reactions on a metal surface — one atom at a time.

Solid surfaces act as catalysts for a large number of reactions: it is estimated that 20–30% of the gross national product in developed countries is dependent on one way or another on this sort of catalysis. The surface acts by adsorbing the reactants and encouraging them to react until the products leave the surface. Yet despite its importance, many aspects of catalysis by solid surfaces are not understood. The use of powerful tools is now helping to change that. Writing in Physical Review Letters, Hahn and Ho show that they can manipulate individual atoms and molecules adsorbed on a metal surface to induce a catalytic reaction. By using this technique at low temperatures they can control the speed of the reaction, so they can follow important steps as they happen, atom by atom.

The catalytic oxidation of carbon monoxide (CO) is one of the simplest catalytic reactions, and is an important part of the reactions that take place in the catalytic convertor in your car. In this context, CO is transformed into carbon dioxide (CO2) by reacting with oxygen or nitrous oxide (NO) on the surface of a platinum, palladium or platinum–rhenium catalyst. The reaction involves five steps, which are summarized in Fig. 1. At low temperatures (13–45 K) used by Hahn and Ho, the two first steps (Fig. 1a) can occur on a silver surface, but the rest of the reaction requires higher temperatures to proceed spontaneously.

At these low temperatures the authors use a scanning tunnelling microscope (STM) to make the reaction happen and to image and manipulate the atoms and molecules on the surface (Fig. 1). An STM works by applying a voltage to a sharp metallic ‘tip’, which is brought into position over an adsorbed oxygen atom, and applying a new voltage pulse with the opposite sign to transfer the molecule back to the surface and to kick start the reaction.

These experiments provide atomic-scale details of a chemical reaction occurring at a surface. Intermediates that would not have a measurable lifetime at higher temperatures, and so cannot be observed during a thermal reaction, can be viewed directly. The clever part is to work at temperatures low enough for the intermediates to be frozen in time and to use electron injection rather than thermal excitation to make the reaction proceed.

The work of Hahn and Ho shows that it is possible to induce reactions that wouldn’t proceed thermally by using tunnelling electrons to activate the reaction. Using an STM tip to induce chemical reactions at a catalytic surface is not an efficient way of producing large amounts of chemicals, but it is analogous to the way natural catalysts (enzymes) manage to proceed spontaneously.

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