Prisoner's Dilemma and other Games that Animals Play

Kartik Shanker

On Robbing a Bank

Supposing you and your partner robbed a bank. Ten days later, the police arrest both of you. They suspect you, but they haven't found the money. They can put you away with the evidence that they have, but not as effectively as they would if one of you confessed. So they independently offer both of you a deal. If you confess, you get off with a really light sentence. The equation is now something like this:

If you COOPERATE with each other i.e. neither of you confess, you get a sentence of 10 years. If you DEFECT, however, to the police, you get off with 5 years only, but your partner gets 20. If both of you confess, you both get 15 years. What would you do? If you're unsure, its nothing to worry about, the problem has baffled thinkers (and perhaps bank robbers) down the ages. The game, or paradox, is called the *prisoner's dilemma*.

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Let us examine all the possible outcomes from the viewpoint of minimising your jailterm. First, let us assume your partner cooperates. If you also cooperate, you get 10 years, but if you defect, you get 5, so you had better defect. Now let us assume your partner defects. If you cooperate, you get 20 years, and if you defect as well, you get 15 years. The moral of the story: no matter what your partner does, you should defect. Now this goes for your partner as well, and so you would both end up defecting. However, there is still a twist in the story. If you both cooperated, you would get 10 years, compared to 15 for defection. So it is clearly better for both of you to cooperate than for both to defect. But we just showed that one's optimal strategy was to defect. Would you cooperate? If so, why? Do you trust your partner and why do you trust him? Theoreticians have attempted to answer these questions which have become a part of the field of study known as Game theory.

Iterated Prisoner's Dilemma

Supposing we change the rules of the game a little. Instead of prison sentences, points are awarded for each decision that you make (*Figure 1*). The object of the game is, as usual, to collect as many points as possible. The rules of the game are exactly the same as in the prisoner's dilemma. The important thing is that you have to play the game over and over again. Now, if you and partner agreed to cooperate (not overtly, but implicitly), you could both amass a lot of points. This game, known as the *iterated prisoner's dilemma*, calls for an entirely different strategy.

In this version of the game, you would have the opportunity to evaluate your partner and see if he/she were worthy of trust. Now this sounds simplistic, but many animals actually seem to play this kind of a game and the strategies they use correspond to the prisoner's dilemma model. The human animal also seems to use the game in various facets of life, be it in business or otherwise.

Figure 1. Payoffs to me from the various outcomes of the prisoner's dilemma game.

What I do \ What you do	Cooperate	Defect
Cooperate	Fairly good **REWARD** (for mutual cooperation) 3 points	Very bad **SUCKERS'S PAYOFF** 0 points
Defect	Very Good **TEMPTATION** (to defect) 5 points	Fairly bad **PUNISHMENT** (for mutual defection) 1 point

Tit for tat is a Smart Strategy

Axelrod, a political economist and Hamilton, an evolutionary biologist, evolved a theory around the prisoner's dilemma and other such games that people and animals play. Axelrod held a competition where he invited participants to submit strategies for the iterated prisoner's dilemma game. Here, each strategy (such as ALWAYS COOPERATE or ALWAYS DEFECT) would play each of the other strategies once in a series of games. ALWAYS COOPERATE would do well against another ALWAYS COOPERATE, but would do very badly against ALWAYS DEFECT. Therefore, if the population (of animals in the wild, or players in the market) comprised initially ALWAYS COOPERATE, one animal/player who ALWAYS DEFECTED would do very well. Various complex strategies were submitted, but amazingly, the strategy which won the competition was a very simple strategy called *tit for tat*. TIT FOR TAT simply copied the last move of its opponent. If it played first, it played COOPERATE. Hence, if it met another TIT for TAT, they would both end up cooperating through the game. The qualities of TIT FOR TAT which made it so successful were that it was nice, retaliatory and forgiving. TIT FOR TAT always played cooperate first, hence it was a nice strategy, and this meant it was successful against other nice strategies. It was retaliatory, and hence successful against nasty strategies; if another strategy defected, TIT FOR TAT copied its move and hence defected too. Therefore it did not get the SUCKERS PAYOFF for more than one move. Finally, it was forgiving, in that if another strategy defected by chance or intent, and then subsequently cooperated again, TIT FOR TAT did not remember the earlier defection, but also started cooperating again with its opponent.

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Axelrod and Hamilton held a second round of competition after publishing the results of the first round. TIT FOR TAT won again. There is something simple and powerful about the strategy. If we examined the basis on which most of us evolve personal relationships, we do something fairly similar. Those who are too trusting often get 'suckered'. Those who are too suspicious never make friends. The successful ones are those who constantly evaluate, form alliances where they can and withdraw if they see signs of 'defection'. Needless to say, the business world functions along very similar principles and is even more sensitive to cooperation and defection. In the natural world around us, every animal is trying to maximise its reproductive success and hence perpetuate the genes it carries. Here again, it would be of paramount importance, a matter of life and death really, to evolve strategies that would maximise fitness. Such strategies might therefore evolve to enable the animals to recognise other individuals and evaluate them through repeated interactions.

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Hawks, Doves and Bourgeois

Let us look at another example of game playing. Birds often defend territories during breeding. Now, there could be two extreme kinds of strategies: HAWKS, which always attack and fight intruders, and DOVES which always run away (here, the terms refer to strategies and not to different species of birds). If a HAWK meets a DOVE, HAWK always wins. However, if a HAWK meets a HAWK, there is some injury cost since both will fight. When a DOVE meets a DOVE, neither wins. Now, in a population of HAWKS, a DOVE will do very well, and will gradually increase in number, since it never incurs the cost of injury, but HAWKS are always meeting other HAWKS. However, in a population of DOVES, HAWKS do well since they are always meeting DOVES. Now they increase until there are a large number of HAWKS again. So neither strategy is stable by itself because, it can be 'invaded' by another strategy. A population will therefore comprise some HAWKS and some DOVES, or animals which use the HAWKS strategy a certain proportion of the time and the DOVE strategy a certain proportion of the time. However, there is a third strategy which may be termed BOURGEOIS which is stable and resistant to invasion by HAWK or DOVE. BOURGEOIS always fights when in its own territory and always runs away when outside its territory. This is a theoretical prediction that actually seems to be borne out in the wild. Such a strategy which is superior to all other strategies under a given set of circumstances is known as an 'evolutionarily stable strategy'. This concept was developed by Maynard–Smith.

A World of Games

If one looks around at the animal and even the plant world, it seems that everyone is in the act. Parents are in conflict with offspring because each offspring would like to get more resources (attention) from the parent, while the parent would be best served by distributing its effort amongst all the offspring. This forms the basis of parent-offspring conflict. During reproduction, both the sexes would like to put in minimal effort while getting the maximum possible reproductive output. This conflict is known as the battle of the sexes. All animals and plants compete for various kinds of resources including food, space and mates. This sets the stage for the evolution of a wide variety of strategies and counter-strategies so that each individual can maximise its fitness. Game theory gives us a framework to study these strategies and the concept of the evolutionarily stable strategy teaches us that in a given environment, a particular strategy may be superior to other strategies and resistant to cheating or invasion. On the other hand, strategies may coexist in a population in a certain proportion. The theory has also been invoked to study and explain altruism (giving up one's own benefit for the good of another) in animals. Altruism baffled early evolutionary biologists as it seemed to contradict the theory of natural selection and individual fitness, which assumes that everyone acts selfishly. However, Hamilton's theory of kin selection demonstrates that animals can gain fitness from the success of relatives (the genes of an animal can be passed on to the next generation through its offspring and also the offspring of siblings and other relatives). Hence more closely related animals are more likely to show altruistic behaviour towards each other. However, another hypothesis for altruism was suggested by Trivers, which was called reciprocal altruism and could occur between completely unrelated animals. This invoked the kind of cooperation seen in

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the prisoner's dilemma game, where the benefits of mutual cooperation outweigh the benefits of mutual defection and there are safeguards against cheating. It is interesting that many of these concepts can be applied to human societies and human behaviour as well. Game theory is an extremely interesting way of looking at animal behaviour and has created new perspectives and many insights into the field of study.

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Suggested Reading

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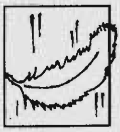
[3] **G Babu, Game theory, *Resonance*, Vol.3, No.7 &8, 1998.**

[4] **R Gadagkar, *Survival strategies – Cooperation and Conflict in Animal Societies*, Harvard University Press, Cambridge, Massachusetts, USA and Universities Press, Hyderabad, India, 1998.**



Standing on the sea shore near the baths, where the hot steam was issuing out of every crevice of the rocks and rising up out of the ground, I had the curiosity to put my hand into the water. As the waves which came in from the sea followed each other without intermission and broke over the even surface of the beach, I was not surprised, when, on running the ends of my fingers through the cold water into the sand, I found the heat so intolerable that I was obliged instantly to remove my hand. The sand was perfectly wet and yet the temperature was so very different at the distance of two or three inches. I could not reconcile this with the supposed great conducting power of water. I then, for the first time, began to doubt the conducting power of water.

Count Rumford
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