3. The Prisoner's Dilemma

The Prisoner's Dilemma is an example of a non-zero sum game, and it serves as an important model of strategic decision making in common 'real-life' situations. Hence it has been widely studied by researchers in game theory, political science, economics, and in the theory of evolution (it is recognised as a simple model for the evolution of cooperation, as well as other forms of non-selfish behaviour, between unrelated members of the same species).

The essence of the problem can be stated as follows:

> Suppose you are a criminal, and you and your partner (for whom you have no feelings one way or the other) have committed an crime. Unluckily, you've both been caught, and you're being held in separate cells in a jail, with no way to talk to each other.
>
> The crown attorney comes to talk to you, and says he's willing to make a deal with you. He's also o ering the same deal to your partner, and you both know that. He says, "We have some circumstantial evidence on both of you, and if neither of you tells me anything we can still get both of you a year in jail, the way things stand right now. But - if you confess, and admit your partner was with you, then we'll let you o scot free because you were helpful, and he'll get three years in jail. Of course, if he confesses and you don't, then you're the one who gets the three years and he walks free. Now, if you both confess, then we've got you both dead to rights and you both get two years in jail."
>
> The crown attorney leaves and goes back to his o ce, after telling you he'll be back in half an hour to get your answer. What do you do?
>
> You can either "co-operate" with your partner - not confess - or "defect," and confess. If you defect, you either get 0 or 2 years in jail, depending on what your partner does. If you co-operate, you get either 1 or 3. Clearly, defecting is the better strategy.
>
> Of course, the other fellow is thinking exactly the same thing. And when you both defect, you guarantee yourselves two years in jail. If only you had both co-operated, and gotten only a year! But if you co-operate and he defects, you get three while he goes free ...

This is the dilemma. Both people, by following their "best" strategy, do worse than if they had used another, apparently illogical plan.

In game theoretic notation, the situation is notated like this where R, S, T , and P represent the payo s 'Reward' (both co-operating) 'Sucker' (You co-operate, your partner defects), 'Temptation' (You defect, your partner cooperates) and Punishment (both defect).

		Your Partner	
		Co-operate	Defect
You	Co-operate	R	S
	Defect	T	P

It is always taken that

$$T > R > P > S, \text{ and } 2R > T + S,$$

so initially we can take $T = 5$, $R = 3$, $P = 1$, $S = 0$.

Things get more interesting when the game is played more than once - when it is iterated. Then players can form strategies based on the other person's previous moves. This is often more like real life, where we may face the same situation over and over and must decide afresh each time what we will do.

Basic Program

The aim of the basic program is to test di erent strategies against one another when the Prisoner's Dilemma is iterated N = 10 (say) times. Common strategies include AllD (Always defect), AllC (Always cooperate), TitforTat (Do what your oppenent did last time), and Pavlov (Change after a 'loss', stick after a 'win').

The program should calculate and write out the resulting scores when each of these strategies, plus some others of your choice, come up against one another for N = 10 iterations. Which strategy ends up with the highest average score?

Options

1. Use the internet and /or library to find out about the round-robin tournaments organised by Robert Axelrod (e.g. Axelrod (1984), The evolution of cooperation). Include in your report a review of which strategies came out best and why. Use your program to verify some of the findings.

2. Adapt the program to investigate 'asymmetric games' such as the 'battle of the sexes' see e.g. Hopfbauer and Sigmund, (1998), Evolutionary Games and Population Dynamics.

3. Adapt the program to test strategies that have a longer 'memory' than just the previous meeting with the opponent.

4. Adapt the program to examine stochastic strategies for the Prisoner's Dilemma. A stochastic strategy can be represented by the three real probabilities (y , p, q), where y is the probability of cooperating in the first round, p the conditional probability of cooperating immediately after your opponent has cooperated, and q the conditional probability of cooperating after your opponent has defected. Use the Fortran command 'call Random Number(x)' to generate the necessary random numbers.

5. Review or use the program to investigate any other related area of your choice.