EVOLUTION OF COOPERATION

V.Srinivasan

It is through cooperation rather than conflict that your greatest successes will be derived.

- Ralph Charell

Why do we Cooperate?

嫰 Humans are the champions of cooperation. From hunter-gatherer societies to nation-states, cooperation is the decisive organizing principle of human society.

嫰 Cooperation is straightforward to explain when:
  › It is beneficial to the cooperating agents.
  › The lack of it is harmful to all.

嫰 But there are several cases, where, while cooperating agents do well, any one of them can do better by not cooperating. E.g. Working in group projects.

嫰 **How did the genes of cooperation survive through so many centuries of human evolution?**

Iterated Prisoner's Dilemma(IPD)

- The classic embodiment of the tension between self-interest and cooperation is the **Prisoner's Dilemma.**

- Imagine the game being played iteratively: with an *indefinite ending* to the game.

- Axelrod studied such games by inviting strategies from various game theorists and matching them against each other.

- He also used genetic algorithmic approach to identify the best strategies over several generations.
  - Starting with a random set of initial strategies and pair them up randomly to evaluate scores.
  - Choose strategies with maximum scores to produce the next generation.
  - Allow mutations and crossovers among strategy 'genes', in the hope of getting better strategies.

Results

嬏 The winning strategy was: TIT FOR TAT , a strategy for cooperation based on reciprocity.

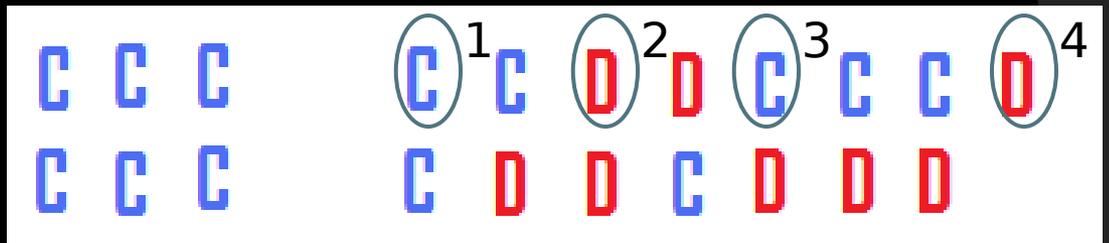嬏 *Start out with cooperation, and do what the opponent did in the last interaction.*

嬏 Other strategies which performed well, had a similar features as TFT:

Don't rock the boat:

*Be provocable:*

Accept an apology:

Accept a rut:

嬏 Disadvantage of TFT is that it cannot correct mistakes.

嬏 Better strategies found later:

› *Generous Tit for Tat* (Tit for two Tats) by Axelrod

› *Win Stay, Lose Shift* (Cooperate when players played same move in the past round) by Martin Nowak
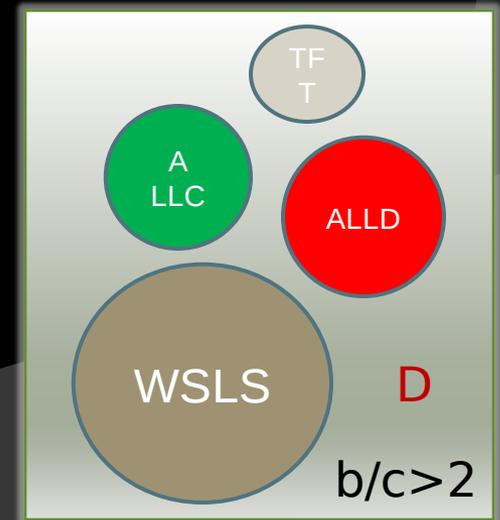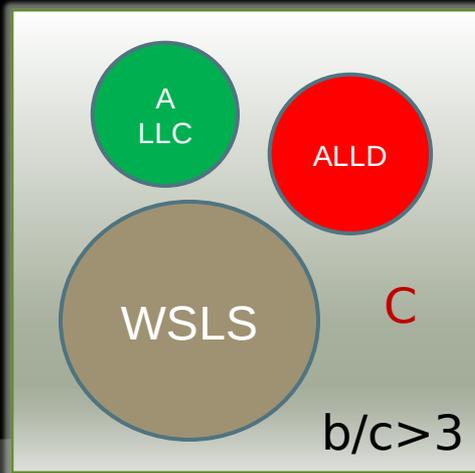
Evolutionary Stability

嫡 Consider the following variant of Prisoner's Dilemma

- c - cost of cooperation

b - benefit of cooperation
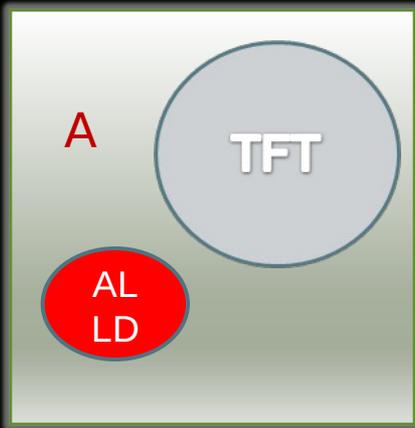
$$\begin{array}{cc} & \begin{array}{cc} C & D \end{array} \\ \begin{array}{c} C \\ D \end{array} & \begin{pmatrix} b-c & -c \\ b & 0 \end{pmatrix} \cdot \end{array}$$

A

TFT

ALLD

B

TFT

ALLC

ALLD

WSLS   C   b/c>3

TFT

ALLC

ALLD

WSLS   D   b/c>2
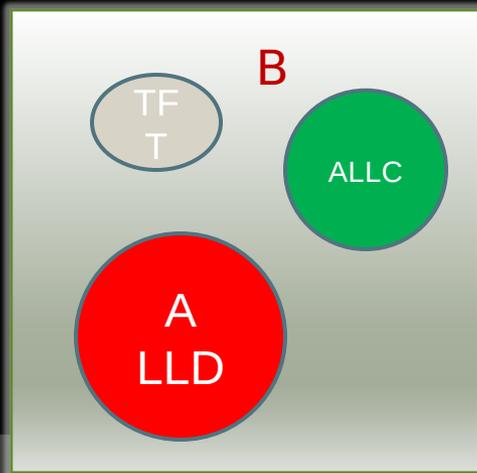
Inferences

ALLD against TFT is a coordination game, where TFT is always selected as long as the benefit, *b, is larger than* the cost, *c.*

If unconditional co-operators are added, they can invade and take over a TFT population, but an ALLC population is quickly taken over by ALLD players. ALLD is the selected strategy.

If instead of TFT, WSLS competes with ALLC and ALLD, then WSLS is selected, provided the benefit-to-cost ratio, *b/c, is sufficiently large. The critical value is 3.*

Similar behaviour as in c) is observed if TFT is added, but the critical value is now lowered to 2 for any intensity of selection.

IPD with Punishment

巤 Anna Dreber et. al. studied the case when "costly punishment" was introduced as an option into Prisoner's Dilemma.

Option	You will get	The other person will get
A:	−1	+2
B:	+1	−1
C:	−1	−4

• A study was done by them with 104 students (45 women, 59 men)
• An average of 79 total rounds per subject.
• Income for Each Subjects—— $ 15 show up fee+ $ 5 extra at the end of the session +(final score* $ 0.10)

C1

	C	D
C	1	-2
D	3	0

T1

	C	D	P
C	1	-2	-5
D	3	0	-3
P	1	-2	-5

C2

	C	D
C	2	-2
D	4	0

T2

	C	D	P
C	2	-2	-5
D	4	0	-3
P	2	-2	-5

And the results were...

|	Decisions	Payoff in this interaction	Final rank
a	Nice people finish first		
	C C C C	8	1
	C C C C	8	2
b	Punish and perish		
	C P P P P	−10	25
	D D D D D	−9	22
c	Defection restores cooperation		
	C D D C D C	10	15
	D D C C C C	4	9
d	Turning the other cheek		
	C C C C C	2	6
	D D C C C	14	19
e	Mutually assured destruction		
	C P P P D D	−20	30
	D D P P P P	−14	25
f	Revenge is not so sweet		
	C C C P D D P P P	−6	24
	C C D D D D D D D	−4	22
g	A 'pre-emptive strike'		
	C P D	2	29
	C C D	−4	24

Data analysis

Punishment does lead to increased cooperation, as seen in the corresponding Control and Treatment experiments.
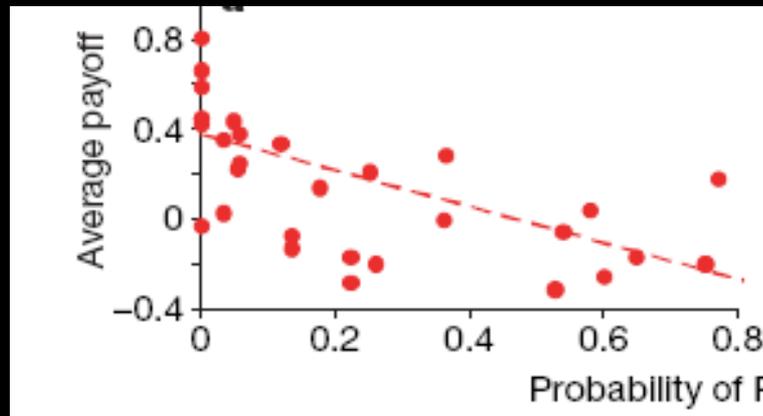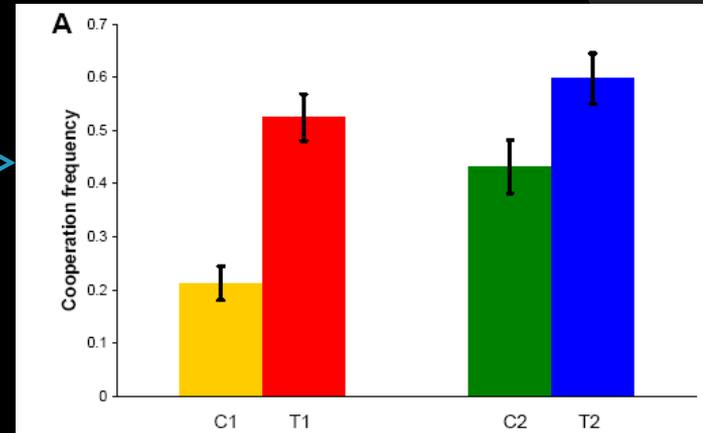
Significant negative correlation between usage of punishment and average payoff.

Players with lower rank (higher payoffs) punish less than players with higher rank (lower payoff).
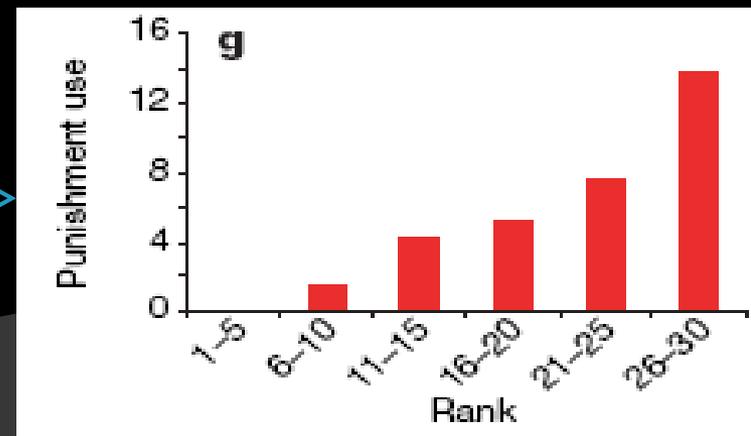
Winners don't punish!!!

Shadow of the Future - Reputation

- Another concept that is used to explain the evolution of cooperation, is the shadow of the future, under the model of direct reciprocity.

- Results show that the shadow of the future matters, and that it significantly reduces opportunistic behaviour. i.e., subjects cooperate more the greater the probability of future interaction.

- Reputation allows evolution of cooperation by indirect reciprocity. Helping someone establishes a good reputation, which will be rewarded by others. When deciding how to act, we take into account the possible consequences for our reputation.

Direct reciprocity

Indirect reciprocity
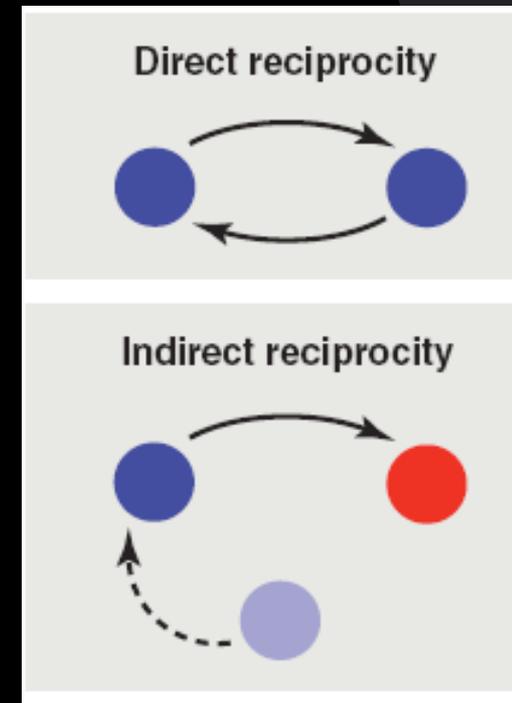
Combination of Punishment and Reputation

- Direct punishment incurs salient costs for both the punisher and the punished, whereas reputation mechanisms discipline by withholding action, immediately saving costs for the 'punisher'.

- Recent results show that punishment is maintained when a combination with reputation building is available, however, at a low level.

- Costly punishment acts are markedly reduced although not simply substituted by appreciating reputation. Indeed, the remaining punishment acts are concentrated on the worst free-riders, who are most severely punished in the combination.

- When given a choice, subjects even prefer a combination of reputation building with costly punishment. The interaction between punishment and reputation building boosts cooperative efficiency.

Summary

- We have seen that the surviving strategies in IPD are those which are very similar to Tit for Tat and aim for cooperation.

- Introduction of punishment though enabling more cooperation results in lower average payoffs and the winners are those who use punishments rarely.

- Punishment and Reputation building being the omnipresent interacting forces in human societies provide a good platform for evolution of cooperation.

Summary

Past

- Evolution (by Imitation of winning strategies.)

Present

- Fear of punishment for defection.

Future

- Shadow of the future
- Reputation at stake.

Thank you!!!

* For your kind "cooperation".

References

- Axelrod – "Evolution of Strategies in Iterated Prisoner's Dilemma", 1987.

- Axelrod, Doughlas Dion – "Further Evolution of Cooperation", 1988.

- Martin A. Nowak, Akira Sasaki, Christine Taylor & Drew Fudenberg- "Emergence of cooperation and evolutionary stability in finite populations", Nature, vol 428, April 2004.

- Lorens A. Imhof, Drew Fudenberg, and Martin A. Nowak – "Tit-for-tat or Win-stay, Lose-shift?", Journal of Theoretical Biology, August 2007.

- Eric Maskin, Drew Fudenberg – "Evolution, Cooperation and Repeated Games", 2008.

References

- Anna Dreber, David G. Rand, Drew Fudenberg & Martin A. Nowak - "Winners don't punish", Nature, vol 452, March 2008.

- *Pedro Dal Bo* – *"*Cooperation under the Shadow of the Future: Experimental Evidence from Infinitely Repeated Games", The American Economic Review, October 2005.

- Robert Boyd, Herbert Gintis, Samuel Bowles, and Peter J. Richerson – "The evolution of altruistic punishment", PNAS March 2005.

- Martin A. Nowak – "Five Rules for the Evolution of Cooperation"