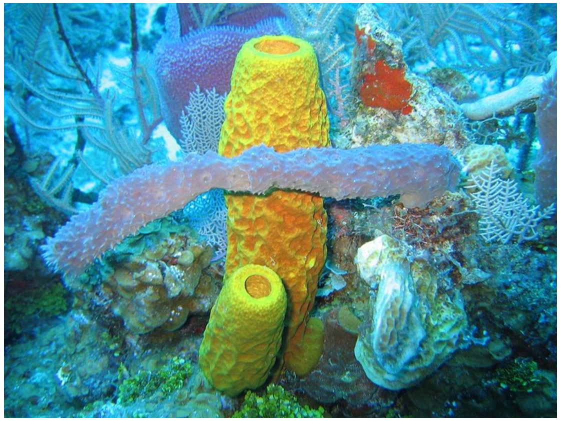
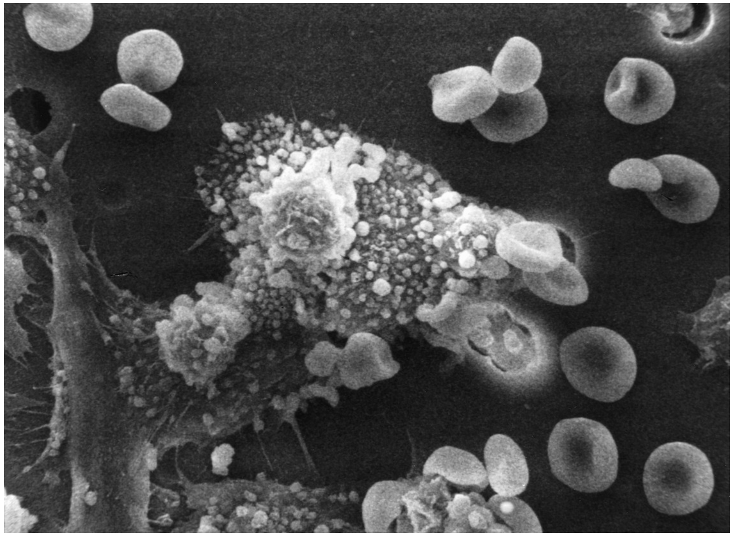
Cooperation

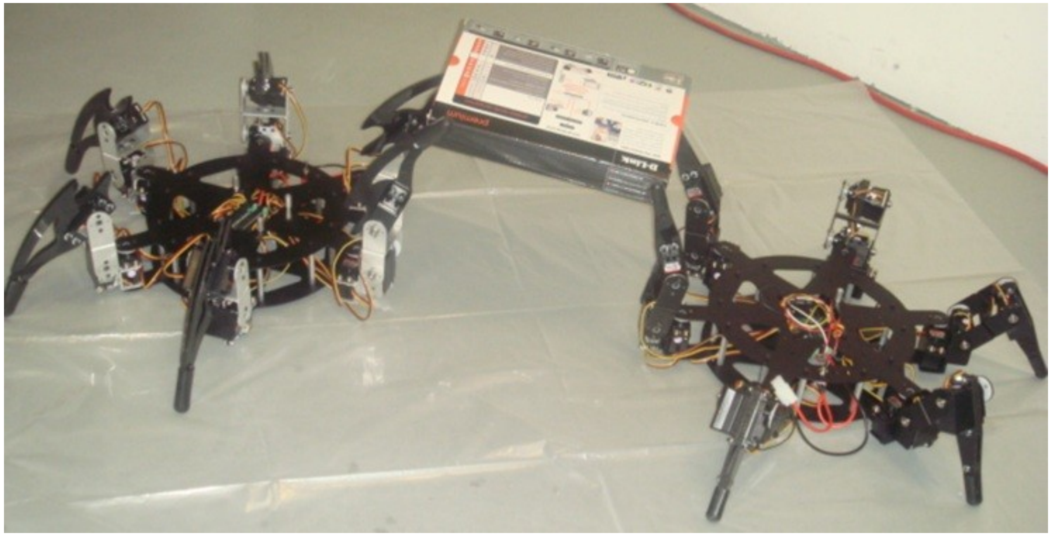
Oxford Dictionary

Cooperation: the fact of doing something together or of working together towards a shared aim.

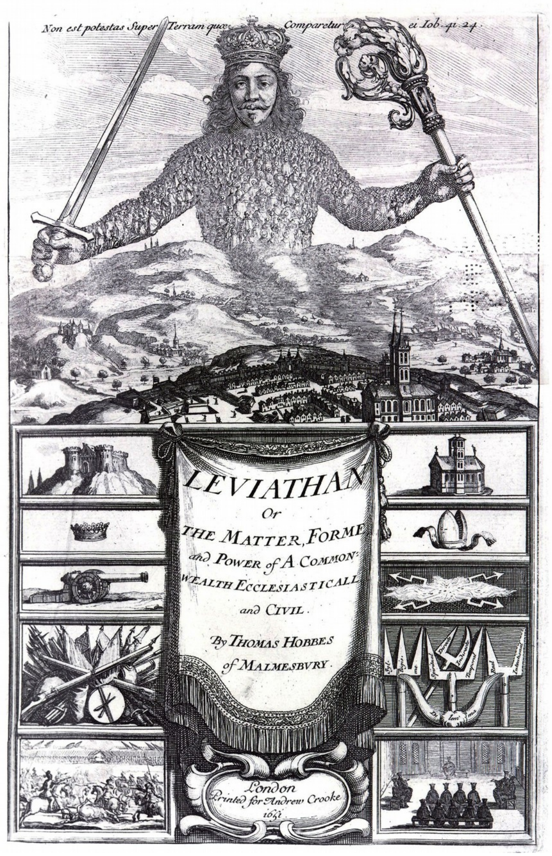
Cooperation







Cooperation



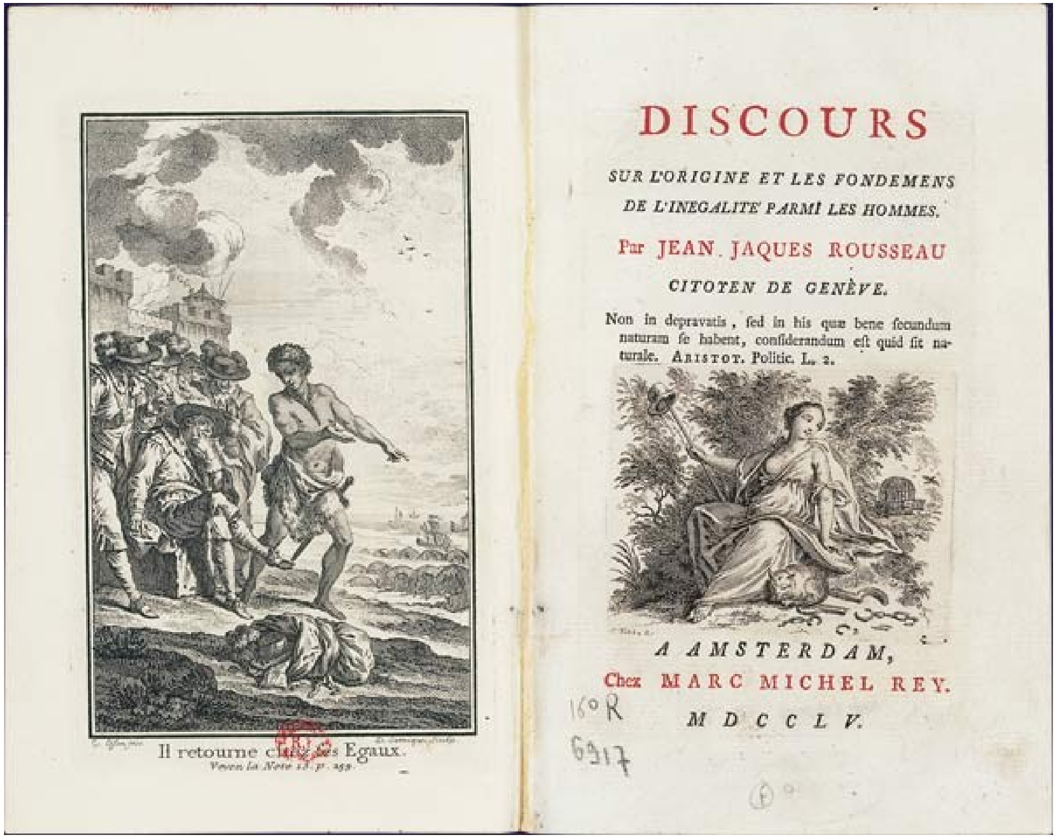
Non est potestas Super Terram quæ Comparetur ei Iob. 41. 24.

LEVIATHAN
Or
THE MATTER, FORME
and POWER of A COMMON-
WEALTH ECCLESIASTICALL
and CIVIL.

By THOMAS HOBBES
of MALMESBVRY.

London
Printed for Andrew Crooke
1651

Thomas Hobbes (1651)



Il retourne chez ſes Egaux.
Voyez la Note 13. p. 259.

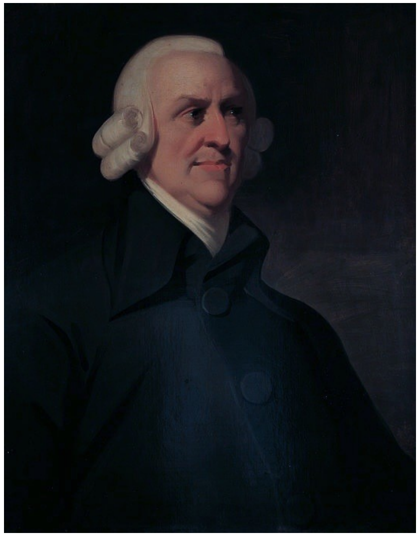
DISCOURS
SUR L'ORIGINE ET LES FONDEMENS
DE L'INEGALITE' PARMI LES HOMMES.
Par JEAN JAQUES ROUSSEAU
CITOYEN DE GENÈVE.

Non in depravatis, ſed in his quæ bene ſecundum naturam ſe habent, conſiderandum eſt quid ſit naturale. ARISTOT. Politic. L. 2.

A AMSTERDAM,
Chez MARC MICHEL REY.
MDCCLV.

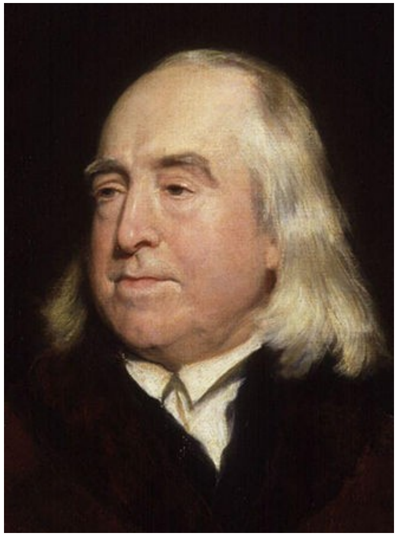
Jean-Jacques Rousseau (1755)

Cooperation



It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity but to their self-love, and never talk to them of our own necessities but of their advantages.

Adam Smith (1776)



It is the greatest happiness of the greatest number that is the measure of right and wrong.

Jeremy Bentham (1776)

Cooperation

Utility

St. Petersburg paradox

A casino offers a game of chance for a single player in which a fair coin is tossed at each stage. The pot starts at 2 dollars and is doubled every time a head appears. The first time a tail appears, the game ends and the player wins whatever is in the pot. Thus the player wins 2 dollars if a tail appears on the first toss, 4 dollars if a head appears on the first toss and a tail on the second, 8 dollars if a head appears on the first two tosses and a tail on the third, 16 dollars if a head appears on the first three tosses and a tail on the fourth, and so on. In short, the player wins 2^k dollars, where k equals number of tosses (k must be a whole number and greater than zero). What would be a fair price to pay the casino for entering the game?

Nicolaus II Bernoulli (1723)

$$E = \frac{1}{2} \cdot 2 + \frac{1}{4} \cdot 4 + \frac{1}{8} \cdot 8 + \frac{1}{16} \cdot 16 + \cdots = \infty$$

Cooperation

Utility

Daniel Bernoulli (1738)

The determination of the value of an item must not be based on the price, but rather on the utility it yields…. There is no doubt that a gain of one thousand ducats is more significant to the pauper than to a rich man though both gain the same amount.

$$E(U) = \sum_{k=1}^{\infty} \frac{1}{2^k} \left[\ln(w + 2^{k-1} - c) - \ln(w) \right] < \infty$$

Cooperation

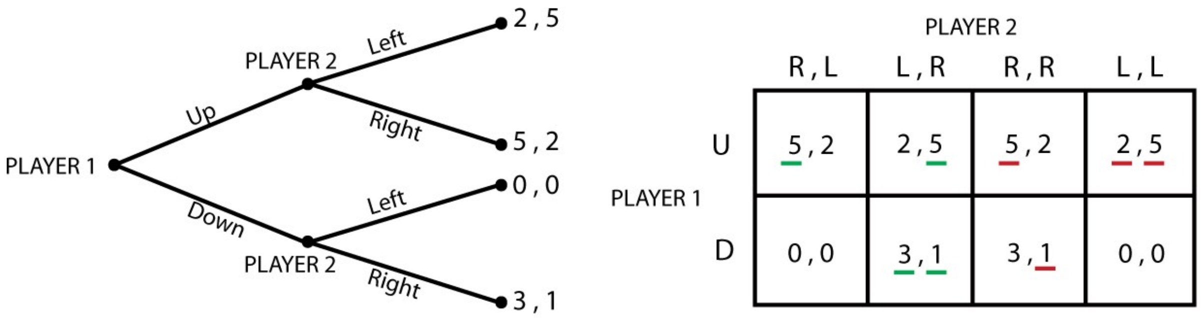
Game theory

Game theory is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers."

John von Neumann, "Zur Theorie der Gesellschaftsspiele", *Mathematische Annalen* (1928)

Cooperation

Game theory



		PLAYER 2			
		R , L	L , R	R , R	L , L
PLAYER 1	U	5 , 2	2 , 5	5 , 2	2 , 5
	D	0 , 0	3 , 1	3 , 1	0 , 0

To be fully defined, a game must specify the following elements: the players of the game, the information and actions available to each player at each decision point, and the payoffs for each outcome. (PAPI)

Nash equilibrium is a solution concept of a non-cooperative game involving two or more players, in which each player is assumed to know the equilibrium strategies of the other players, and no player has anything to gain by changing only their own strategy.

Cooperation

Game theory

Prisoner's Dilemma

	Cooperate	Defect
Cooperate	R, R	S, T
Defect	T, S	P, P

T > R > P > S

The payoff relationship R > P implies that mutual cooperation is superior to mutual defection, while the payoff relationships T > R and P > S imply that defection is the dominant strategy for both agents. That is, mutual defection is the only strong Nash equilibrium in the game

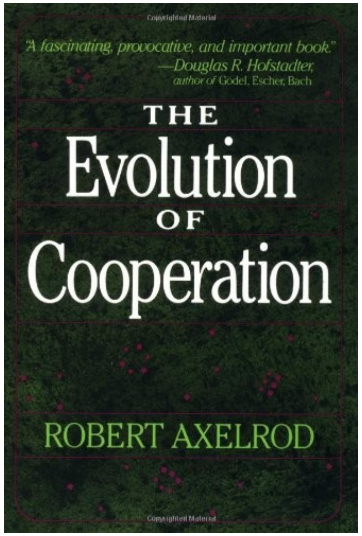
Cooperation

Game theory

Iterated Prisoner's Dilemma

Play N times (with 2R > T + S)

“Rational” strategy is still Always Defect … but humans tend to cooperate.



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"A fascinating, provocative, and important book."
—Douglas R. Hofstadter,
author of Gödel, Escher, Bach

THE
Evolution
OF
Cooperation

ROBERT AXELROD

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Robert Axelrod (1984)

IPD tournament

And the winner is...

Tit-for-Tat, by Anatol Rapoport!

Cooperation

Game theory

Axelrod's conditions for success:

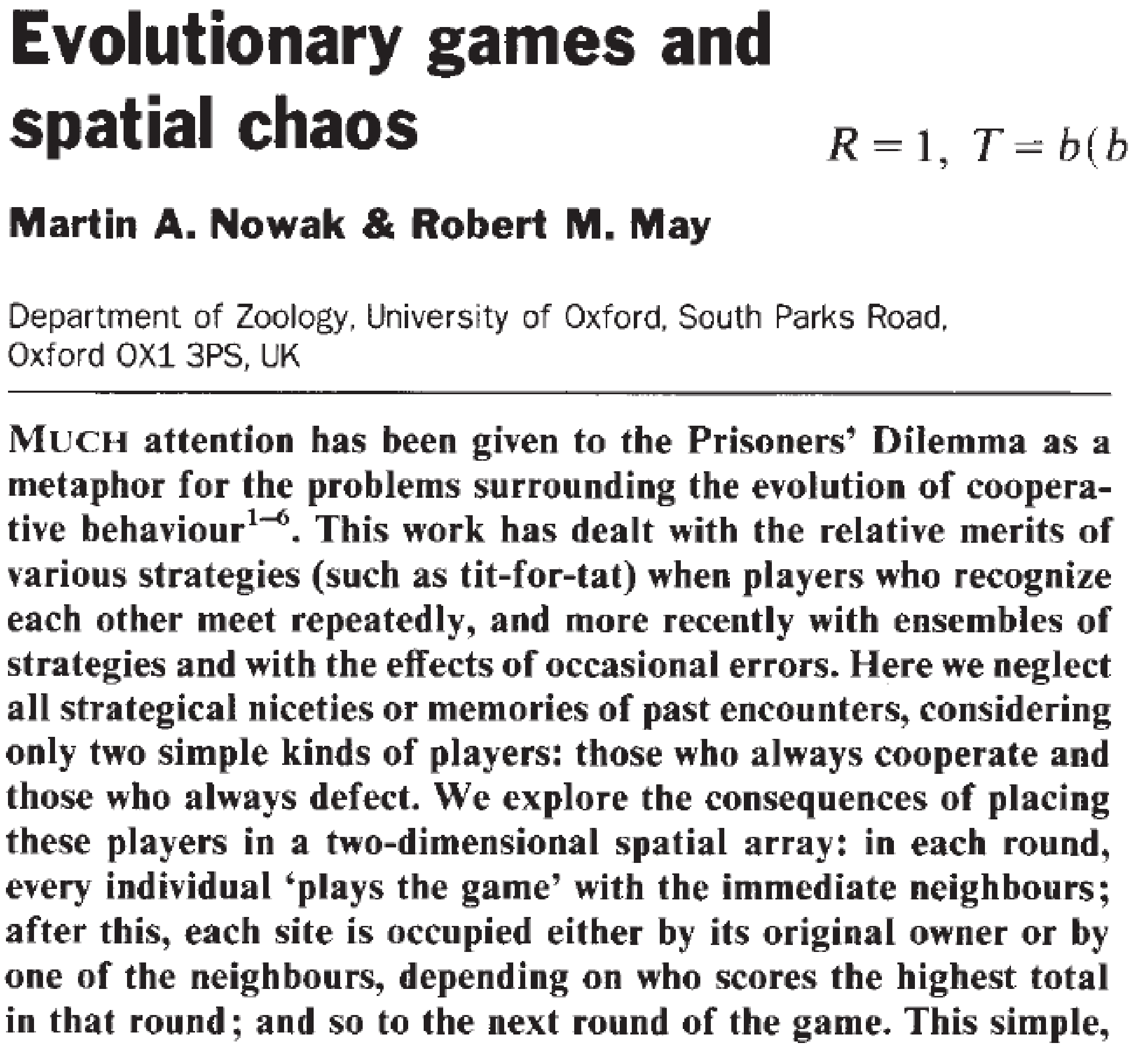
Nice: The strategy must not defect before its opponent does. Almost all of the top-scoring strategies were nice; therefore, a purely selfish strategy will not "cheat" on its opponent, for purely self-interested reasons first.

Retaliating: The successful strategy must not be a blind optimist. It must sometimes retaliate. An example of a non-retaliating strategy is Always Cooperate. This is a very bad choice, as "nasty" strategies will ruthlessly exploit such players.

Forgiving: Successful strategies must also be forgiving. Though players will retaliate, they will once again fall back to cooperating if the opponent does not continue to defect. This stops long runs of revenge and counter-revenge, maximizing points.

Non-envious: The last quality is being non-envious, that is not striving to score more than the opponent.

Cooperation



Evolutionary games and spatial chaos

Martin A. Nowak & Robert M. May

Department of Zoology, University of Oxford, South Parks Road,
Oxford OX1 3PS, UK

MUCH attention has been given to the Prisoners' Dilemma as a metaphor for the problems surrounding the evolution of cooperative behaviour[1–6]. This work has dealt with the relative merits of various strategies (such as tit-for-tat) when players who recognize each other meet repeatedly, and more recently with ensembles of strategies and with the effects of occasional errors. Here we neglect all strategical niceties or memories of past encounters, considering only two simple kinds of players: those who always cooperate and those who always defect. We explore the consequences of placing these players in a two-dimensional spatial array: in each round, every individual 'plays the game' with the immediate neighbours; after this, each site is occupied either by its original owner or by one of the neighbours, depending on who scores the highest total in that round; and so to the next round of the game. This simple,

$$R = 1,\ T = b(b > 1),\ S = P = 0$$

Cooperation

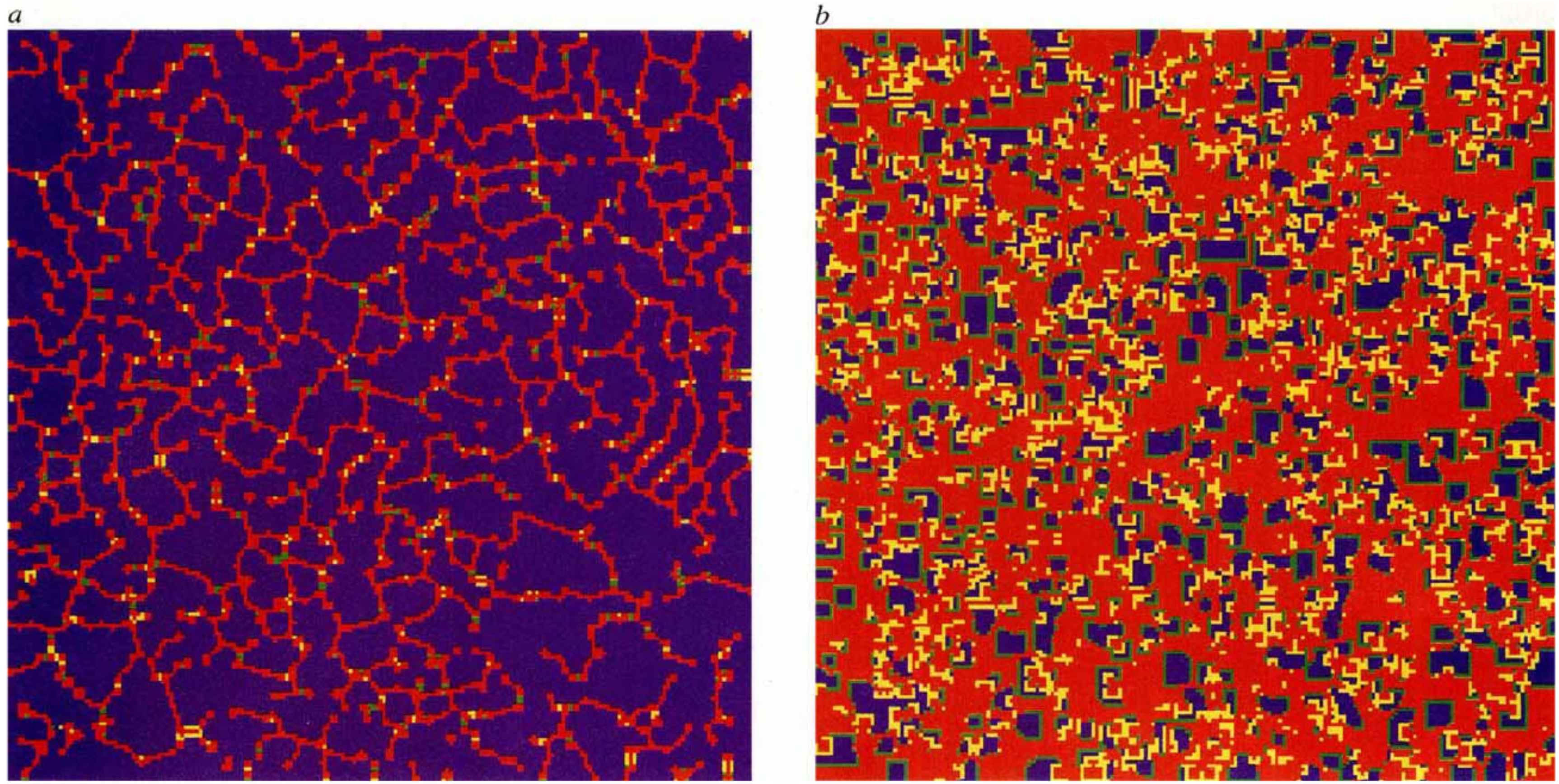
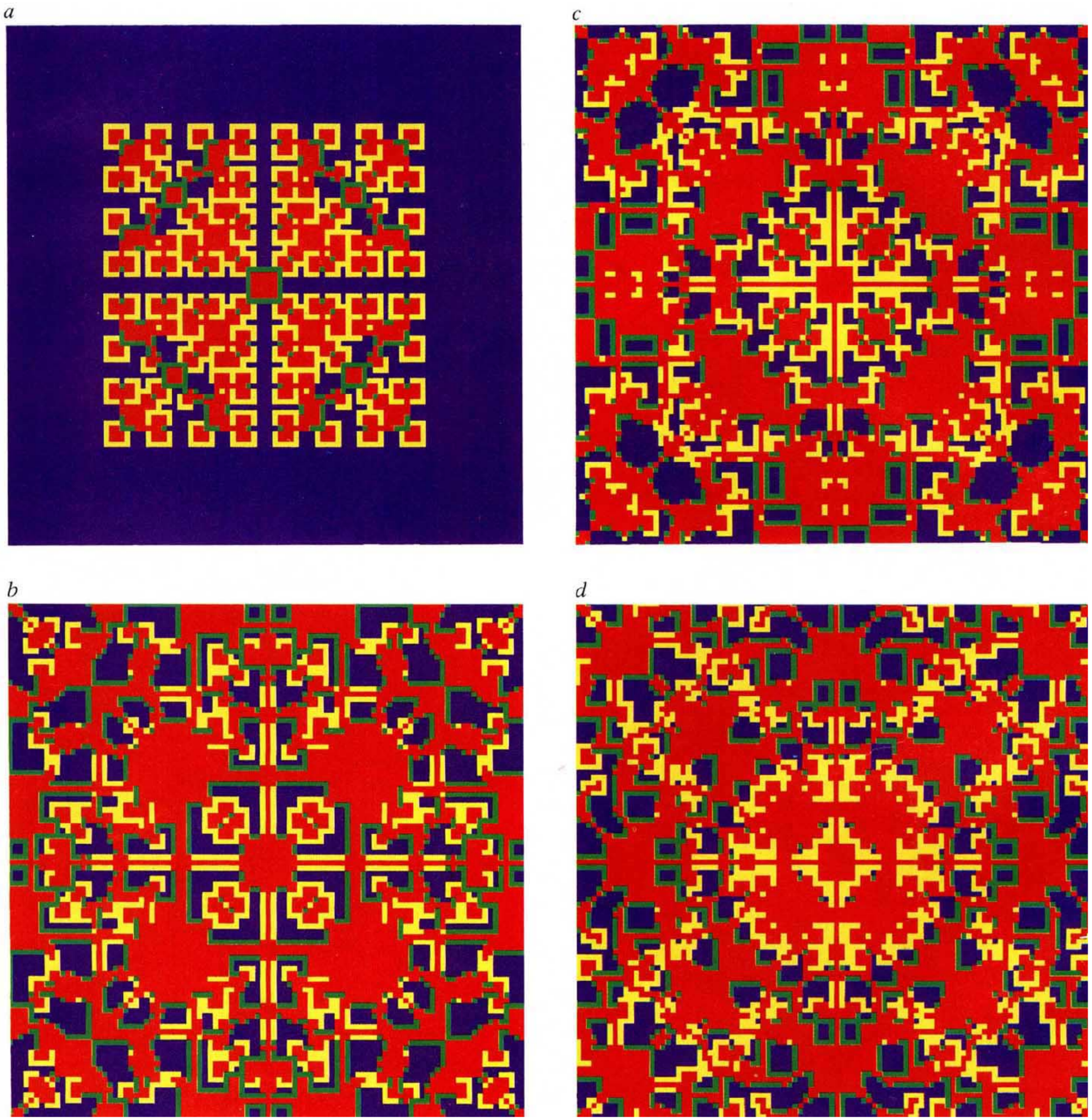


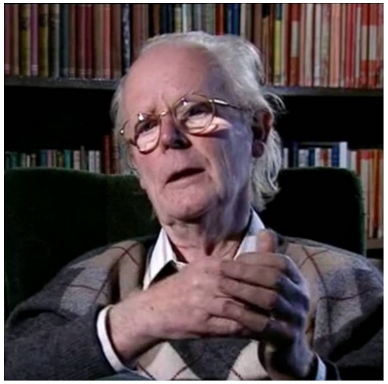
FIG. 1 The spatial Prisoners' Dilemma can generate a large variety of qualitatively different patterns, depending on the magnitude of the parameter, *b*, which represents the advantage for defectors. This figure shows two examples. Both simulations are performed on a 200 × 200 square lattice with fixed boundary conditions, and start with the same random initial configuration with 10% defectors (and 90% cooperators). The asymptotic pattern after 200 generations is shown. The colour coding is as follows: blue represents a cooperator (C) that was already a C in the preceding generation; red is a defector (D) following a D; yellow a D following a C; green a C following a D. *a*, An irregular, but static pattern (mainly of interlaced networks) emerges if $1.75 < b < 1.8$. The equilibrium frequency of C depends on the initial conditions, but is usually between 0.7 and 0.95. For lower *b* values (provided $b > \frac{9}{8}$), D persists as line fragments less connected than shown here, or as scattered small oscillators ('D-blinkers'). *b*, Spatial chaos characterizes the region $1.8 < b < 2$. The large proportion of yellow and green indicates many changes from one generation to the next. Here, as outlined in the text, 2 × 2 or bigger C clusters can invade D regions, and vice versa. C and D coexist indefinitely in a chaotically shifting balance, with the frequency of C being (almost) completely independent of the initial conditions at ~0.318.

Cooperation

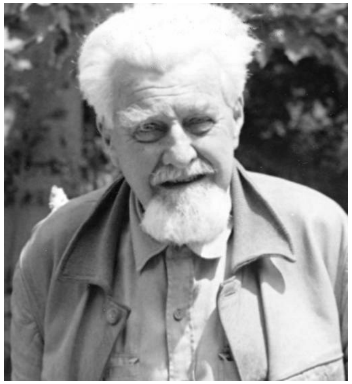


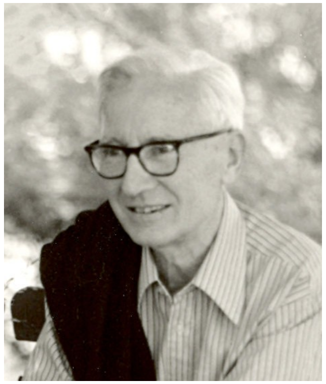
Cooperation

Why are animals so 'gentlemanly or ladylike' in contests for resources?



Such behaviour exists for the benefit of the species





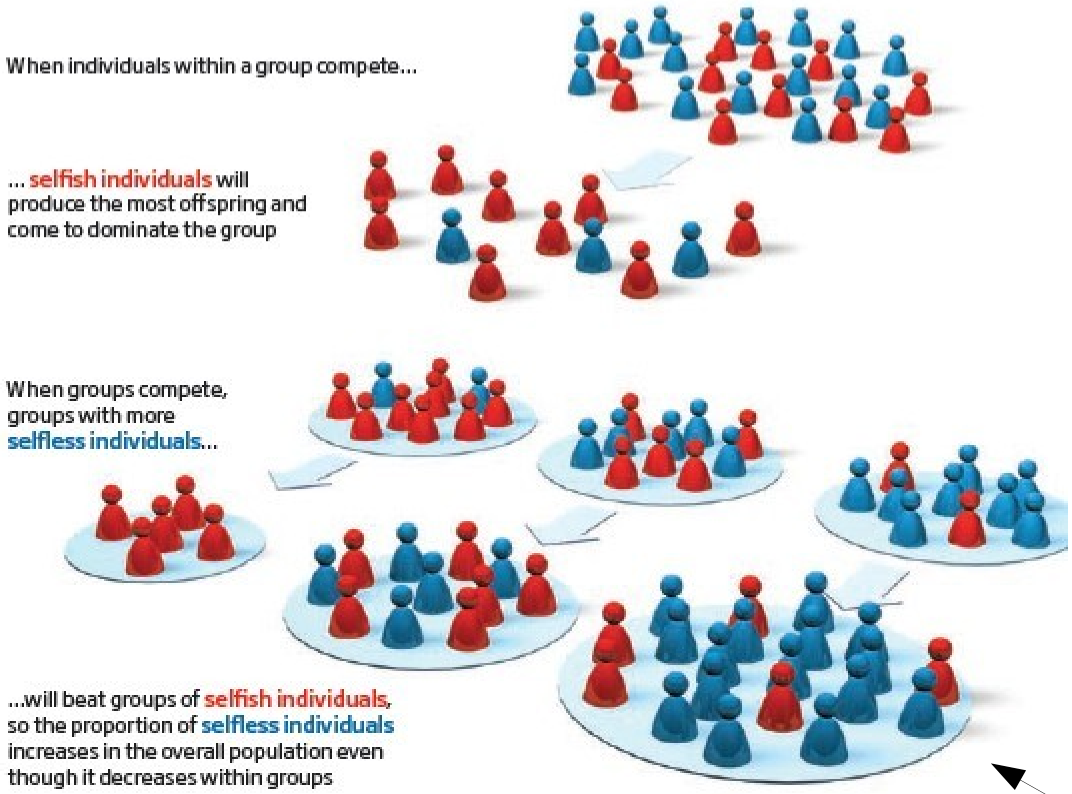
Konrad Lorenz
(1966)

Niko Tinbergen
(1978)

John Maynard Smith

Cooperation

Group selection



When individuals within a group compete...

... selfish individuals will produce the most offspring and come to dominate the group

When groups compete, groups with more selfless individuals...

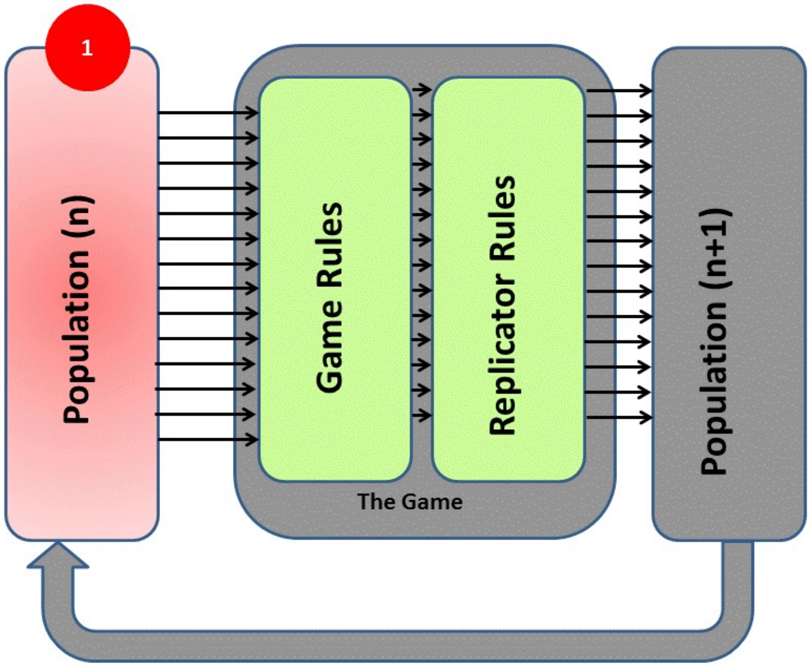
...will beat groups of selfish individuals, so the proportion of selfless individuals increases in the overall population even though it decreases within groups

But why don't the bad guys win in here too?

Cooperation

Evolutionary Game Theory

~~Rationality~~ → Reproductive success



Replicator equation:

$$\dot{x}_i = x_i[f_i(x) - \phi(x)]$$

Proportion of type *i*

Fitness of type *i*

Average population fitness

$$\phi(x) = \sum_{j=1}^{n} x_j f_j(x)$$

Cooperation

Stanford Encyclopedia of Philosophy:

In the preface to Evolution and the Theory of Games, Maynard Smith notes that “[p]aradoxically, it has turned out that game theory is more readily applied to biology than to the field of economic behaviour for which it was originally designed.” It is perhaps doubly paradoxical, then, that the subsequent development of evolutionary game theory has produced a theory which holds great promise for social scientists, and is as readily applied to the field of economic behaviour as that for which it was originally designed.

Cooperation

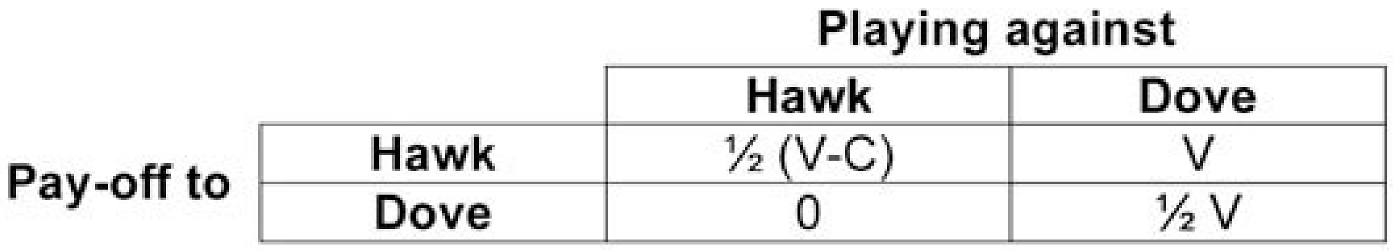
Hawk Dove

- If a Hawk meets a Dove he gets the full resource V to himself

- If a Hawk meets a Hawk – half the time he wins, half the time he loses…so his average outcome is then V/2 minus C/2

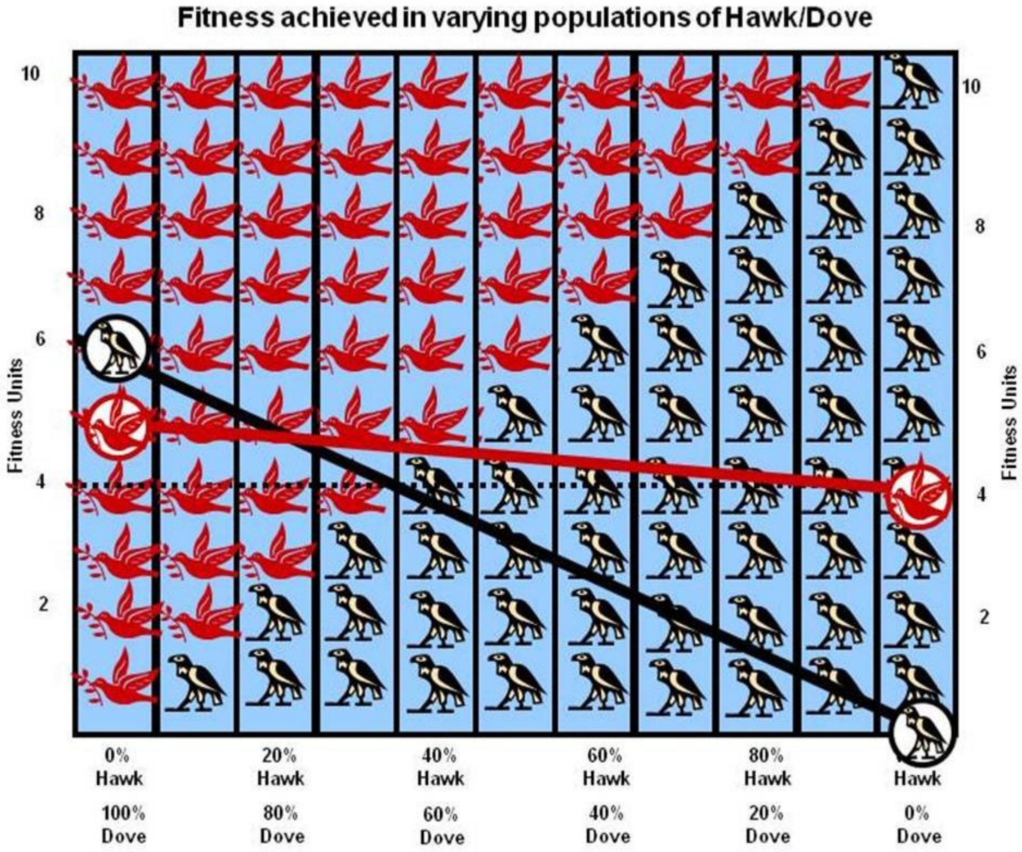
- If a Dove meets a Hawk he will back off and get nothing - 0

- If a Dove meets a Dove both share the resource and get V/2



		Playing against	
		Hawk	Dove
Pay-off to	Hawk	½ (V-C)	V
	Dove	0	½ V

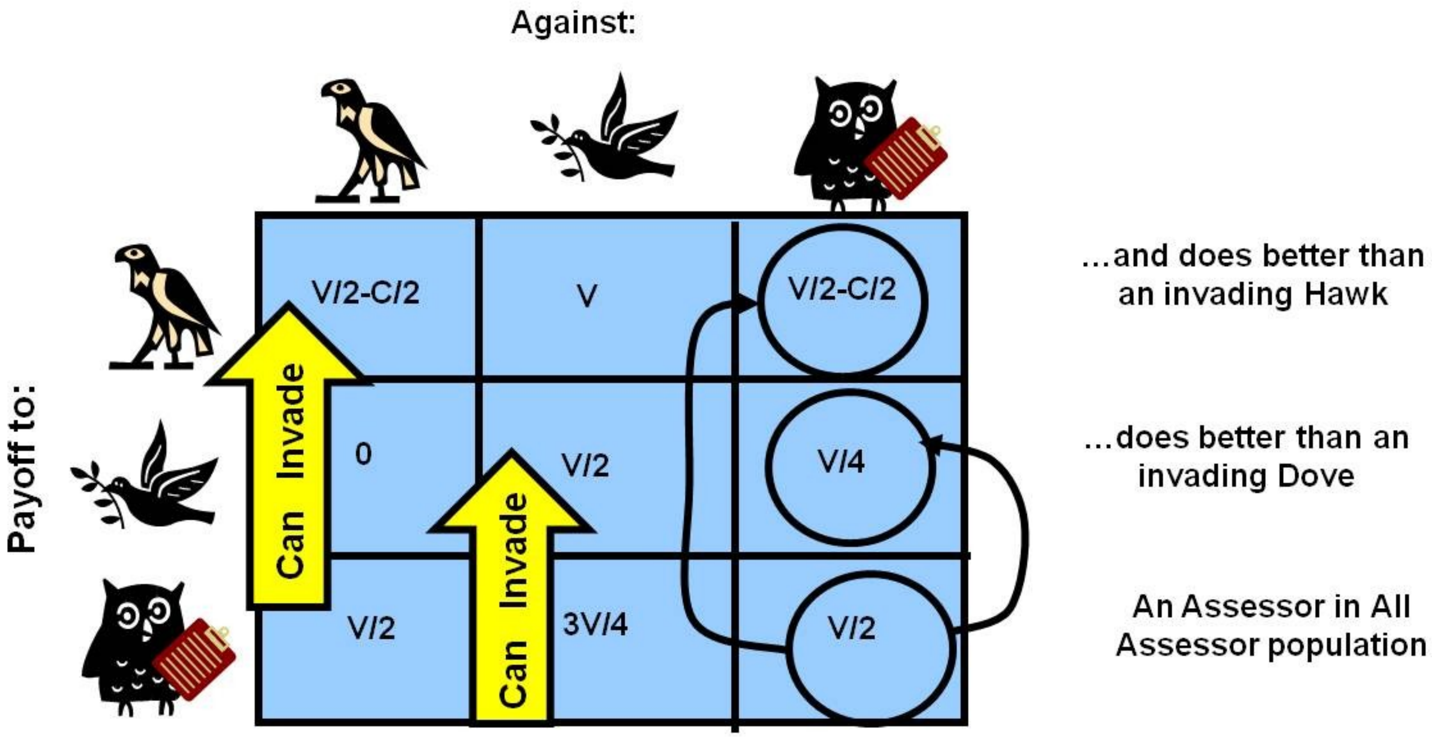
Cooperation



Stationary proportion of Hawks = V/C

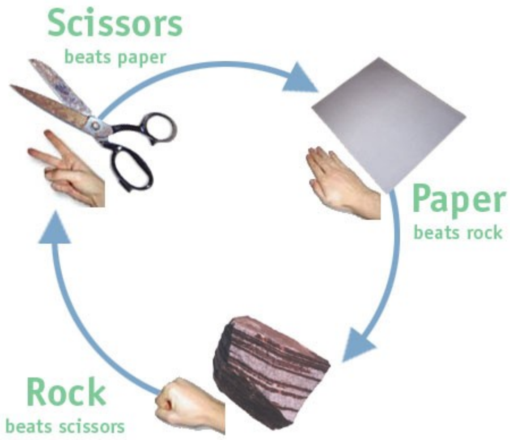
Cooperation

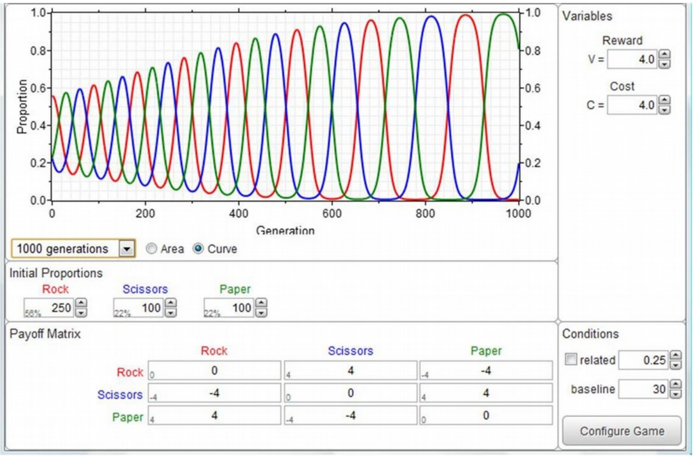
Evolutionarily Stable Strategy: a state of game dynamics where, in a very large (or infinite) population of competitors, another mutant strategy cannot successfully enter the population to disturb the existing dynamic.



V/2-C/2	V	V/2-C/2
0	V/2	V/4
V/2	3V/4	V/2

Cooperation





Variables

Reward
V = 4.0

Cost
C = 4.0

1000 generations ○ Area ● Curve

Initial Proportions

Rock 56% 250

Scissors 22% 100

Paper 22% 100

Payoff Matrix

	Rock	Scissors	Paper
Rock	0	4	-4
Scissors	-4	0	4
Paper	4	-4	0

Conditions

☐ related 0.25

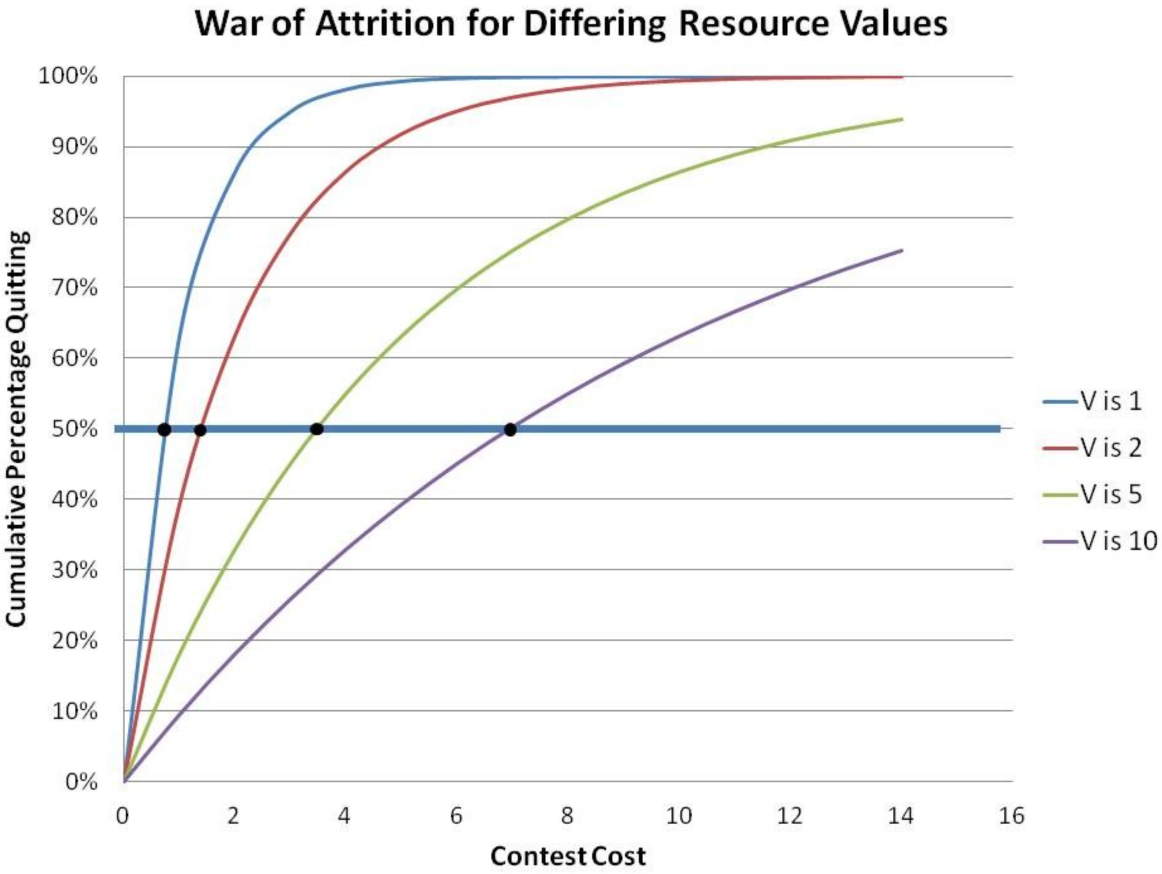
baseline 30

Configure Game

Uta stansburiana (the side-blotched lizard)

1) The orange throat is very aggressive and operates over a large territory - attempting to mate with numerous females within this larger area
2) The unaggressive yellow throat (called “sneakers”) mimic the markings/behavior of female lizards and sneakily slip into the orange throat's territory to mate with the females there (thereby overtaking the population), and
3) The blue throat who mates with and carefully guards ONE female - making it impossible for the sneakers to succeed and therefore overtakes their place in a population…
However the blue throats cannot overcome the more aggressive orange throats…

Cooperation



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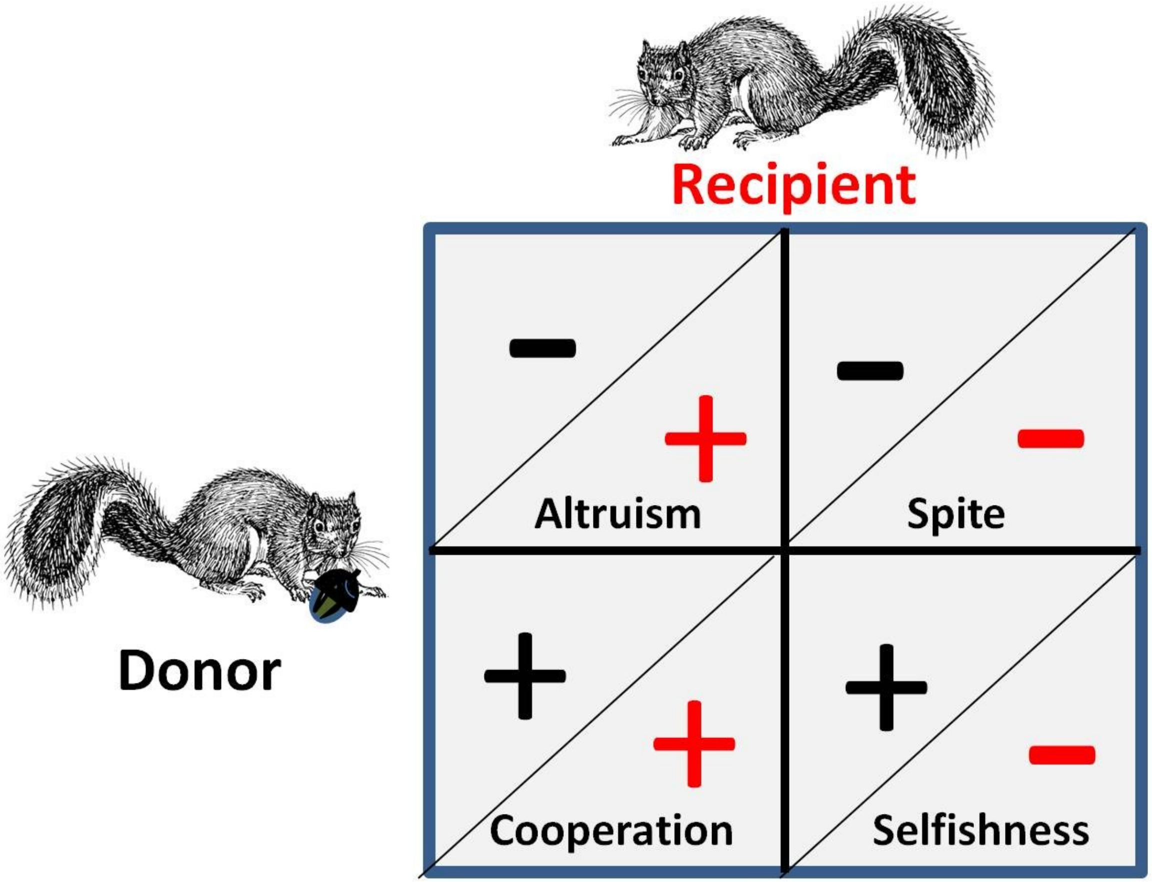
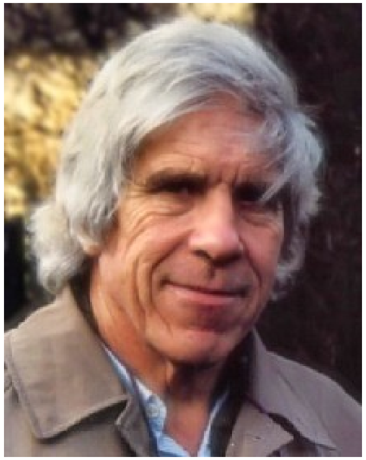


Cooperation

Kin Selection

inclusive fitness = own contribution to fitness + contribution of all relatives



W. D. Hamilton (1996)

$$w_i = b_i + \sum_j r_{ij} b_j$$

$$1 < (1 - C) + RB$$

↓

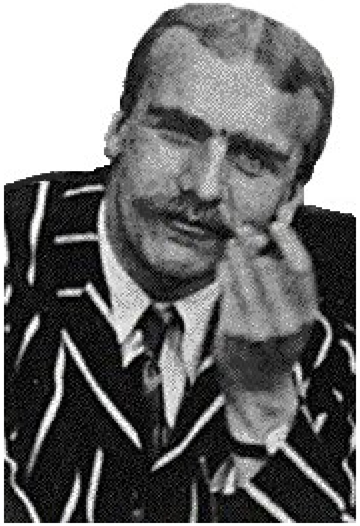
$$R > C/B$$

Cooperation

Would you give your life to save a drowning brother?

No, but I would to save two brothers or eight cousins.

An ounce of algebra is worth a ton of verbal argument.



J. B. S. Haldane (1932)

Cooperation

The Belding's ground squirrel lives in communities of closely related females and their young and male “immigrants”. This is so because males leave the colony on reaching maturity and find other colonies to join. When predators are in the vicinity of a colony certain squirrels emit a loud piercing alarm call, allowing other colony members to take cover. This call substantially endangers the caller as it easily locates it for the predator. However as female squirrels are so closely related evolutionary game theory utilising measures of Inclusive Fitness shows that this behaviour is superior to not calling for them. Field studies confirm this is exactly how the females behave. The males, however, having no such level of inclusive fitness, in general do not call.

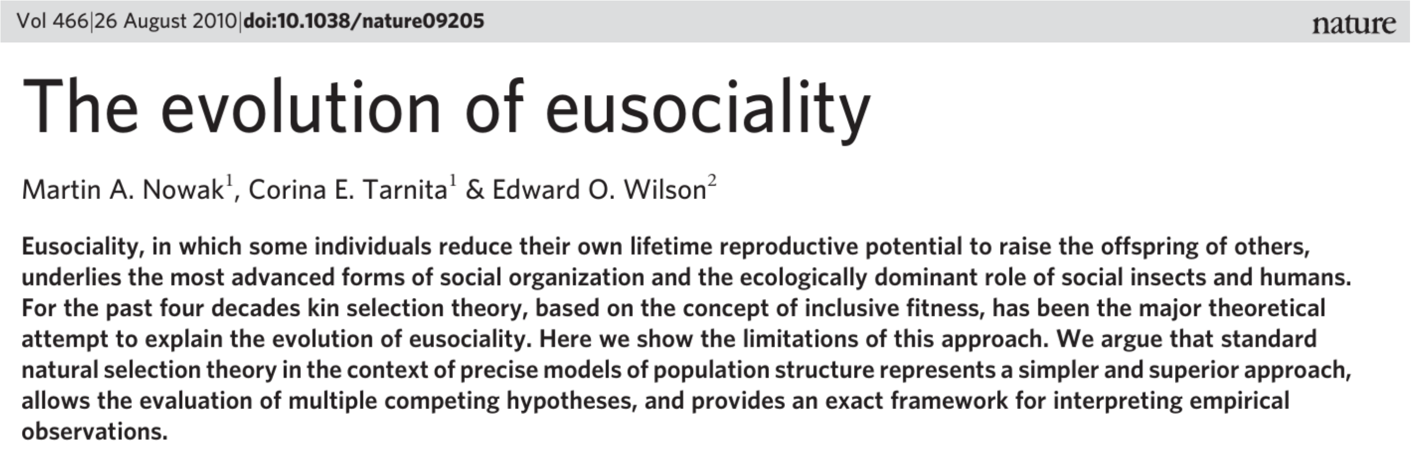
Belding's ground squirrel (2004)

Cooperation

Leaf cutter ants (2013)

Most eusocial insect societies have haplo-diplod sexual determination, which in essence means that males develop from unfertilised eggs, females from fertilised. This leads to the situation in these Haplodiploid species, that sisters share 75% of their genes in common…. in effect more than they genetically share with their mother.

Cooperation



Vol 466|26 August 2010|**doi:10.1038/nature09205** nature

The evolution of eusociality

Martin A. Nowak[1], Corina E. Tarnita[1] & Edward O. Wilson[2]

Eusociality, in which some individuals reduce their own lifetime reproductive potential to raise the offspring of others, underlies the most advanced forms of social organization and the ecologically dominant role of social insects and humans. For the past four decades kin selection theory, based on the concept of inclusive fitness, has been the major theoretical attempt to explain the evolution of eusociality. Here we show the limitations of this approach. We argue that standard natural selection theory in the context of precise models of population structure represents a simpler and superior approach, allows the evaluation of multiple competing hypotheses, and provides an exact framework for interpreting empirical observations.

BRIEF COMMUNICATIONS ARISING

Inclusive fitness theory and eusociality

ARISING FROM M. A. Nowak, C. E. Tarnita & E. O. Wilson *Nature* **466,** 1057–1062 (2010)

The descent of Edward Wilson

by **Richard Dawkins** / MAY 24, 2012 / **149 COMMENTS**

A new book on evolution by a great biologist makes a slew of mistakes

Cooperation

Routes to altruism

Kin Selection

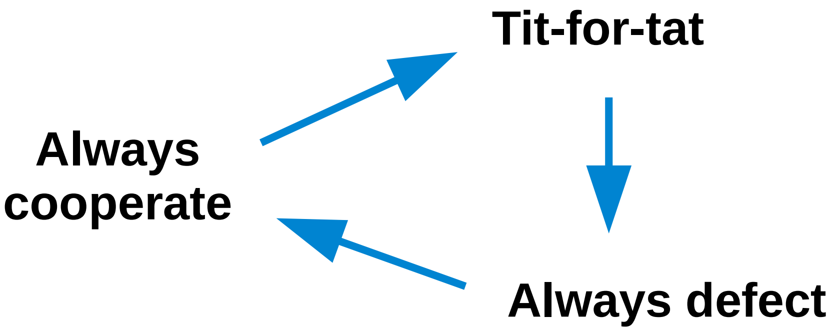
Direct reciprocity: "I'll scratch your back if you scratch mine"

Indirect Reciprocity: "I'll scratch your back, you scratch someone elses back, another someone else will scratch mine (probably)"

David Haig (2015)

For direct reciprocity you need a face;
for indirect reciprocity you need a name.

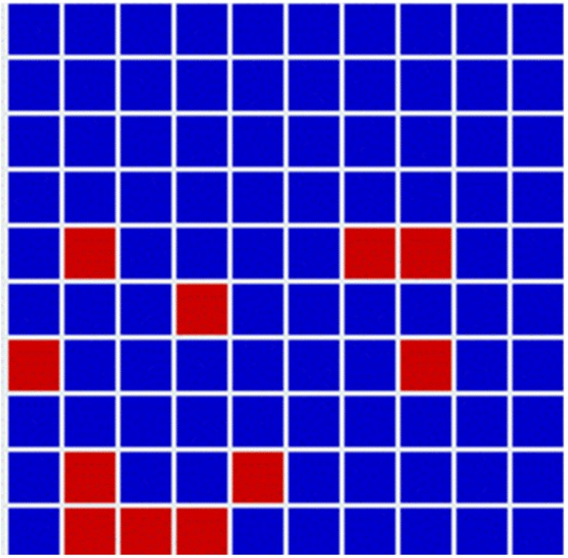
Cooperation



Tit-for-tat

Always cooperate

Always defect



See evolutionary graph theory!

Hannibal Lecter (1991)

Does evolutionary game theory predict psychopaths – and their victims?