Models of Social Dynamics
An Introductory Module

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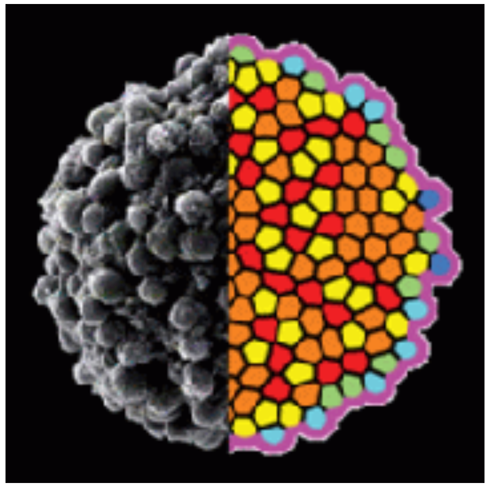
Unit 4:
Cooperation

The problem of cooperation



Individual organisms helping others at a cost

How does **cooperation** emerge in a population?

Once present, how do **cooperators** maintain an advantage over **non-cooperators**?

What factors facilitate more or less cooperation?

The prisoner's dilemma

Player 2

Player 1	Cooperate	Defect
Cooperate	$b - c$	$-c$
Defect	b	0

$b > c$

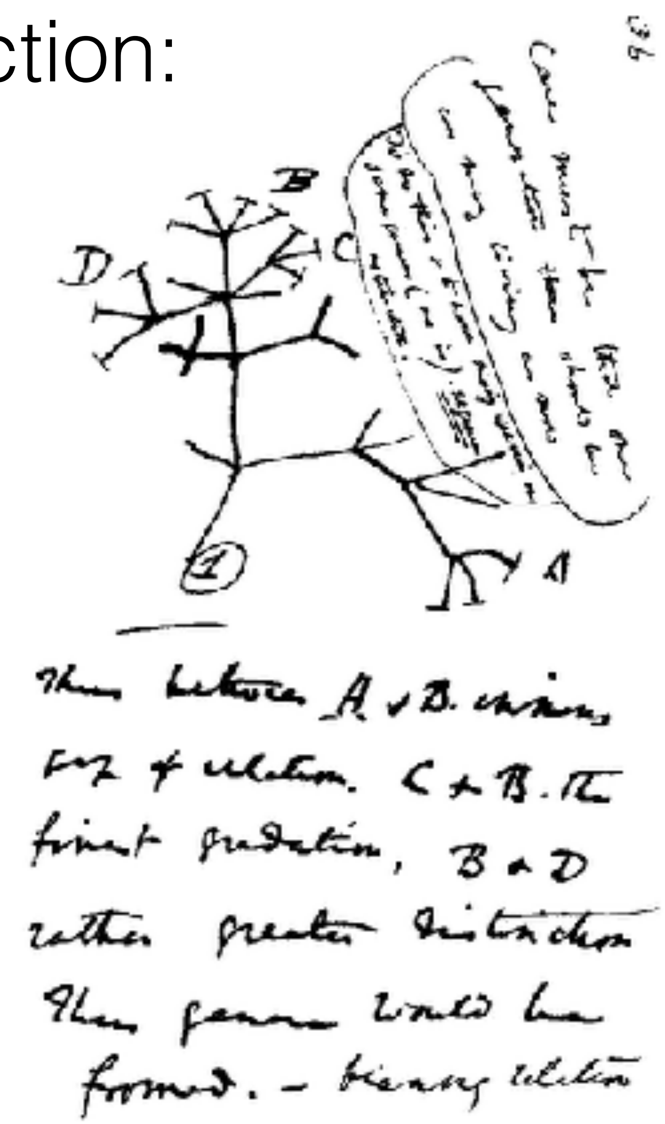
b: benefit of receiving aid
c: cost of giving aid

payoff is to Player 1

Evolutionary Dynamics

<u>3 requirements</u> for evolution by natural selection:

- There must be **variation**
- That variation must have consequences for survival or reproduction (**selection**)
- Variation must be **heritable**



Selection and Heritability

- Genetic transmission: The most successful individuals transmit their genetically encoded strategies
- Social transmission
  - <u>Vertical transmission</u>: successful individuals have more offspring, to whom they teach their strategies
  - <u>Success-biased transmission</u>: individuals preferentially learn from successful individuals

Evolutionary dynamics are similar in all three cases!

A simple PD game model

- **Variation**: Individuals play *pure strategies* of **cooperate** or **defect**
- **Selection** and **heritability**: Individuals play their neighbors and accumulate payoffs, which are observable. Individuals then imitate the strategy of their most successful neighbor.
- **Structure**: assume a simple lattice structure.

Reminder about simplicity

- This model reflects an extremely simplistic view of social behavior, structure, and evolution (cultural or genetic).
- This a good thing.
- Simple models often provide insight, including insight into the sort of additional complexity we may or may not need to make sense of our systems.

Payoffs

- An agent considers N neighbors (N = 4), of which n_C are cooperators and n_D are defectors ($n_D = N - n_C$).

- The payoff to a cooperator is:

$$\begin{aligned} V_C &= n_C(b - c) - n_D c \\ &= n_C b - Nc \end{aligned}$$

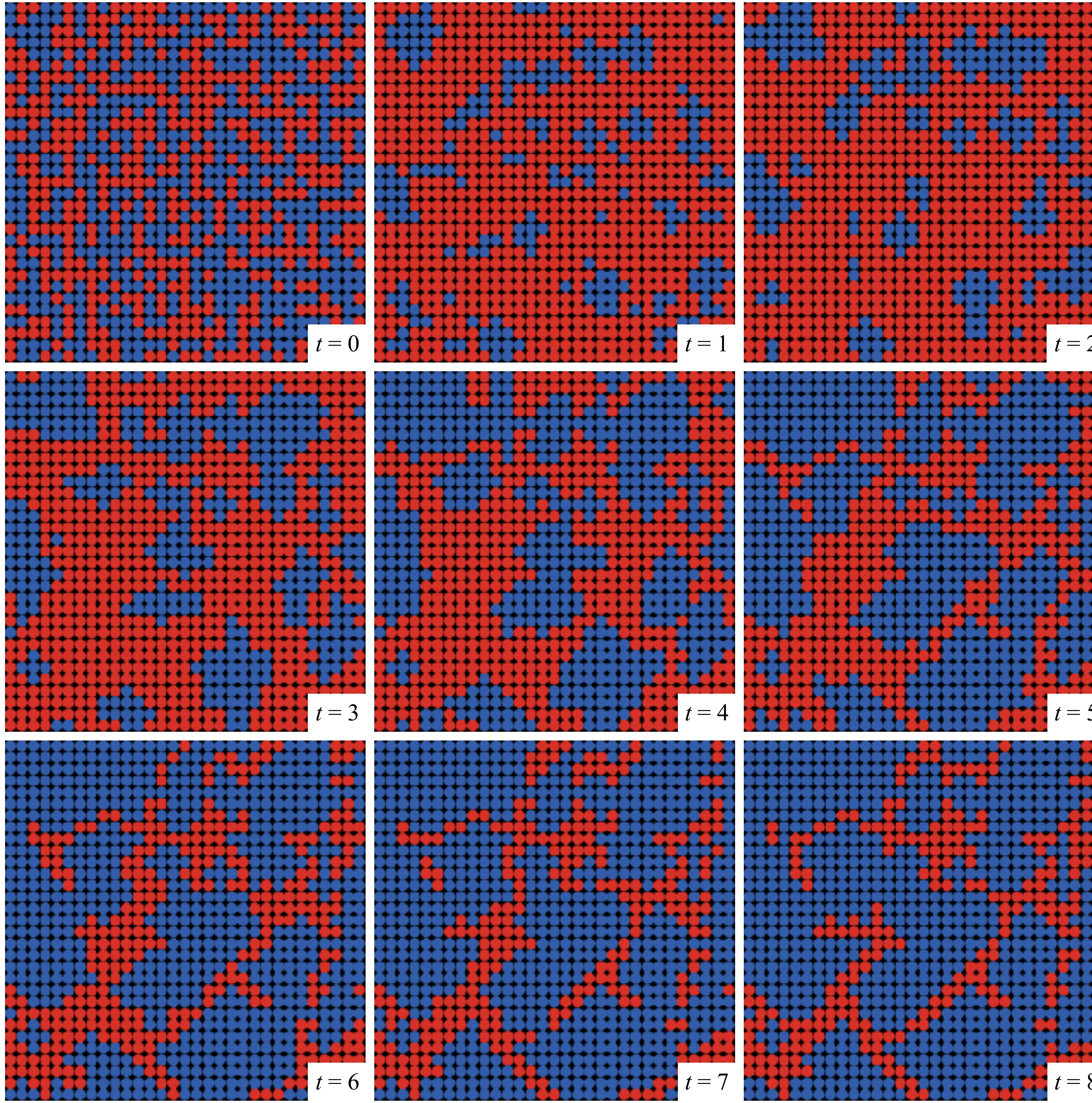
- The payoff to a defector is:

$$V_D = n_C b$$

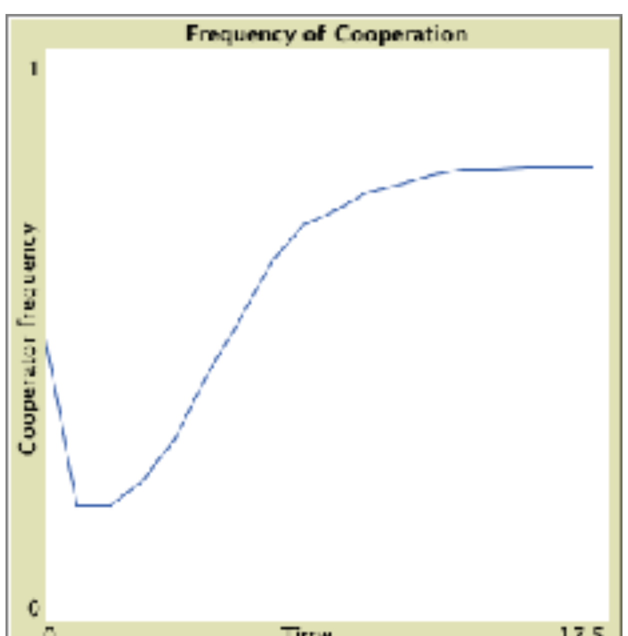
Cooperators only do better when they can interact with more cooperators than defectors can!

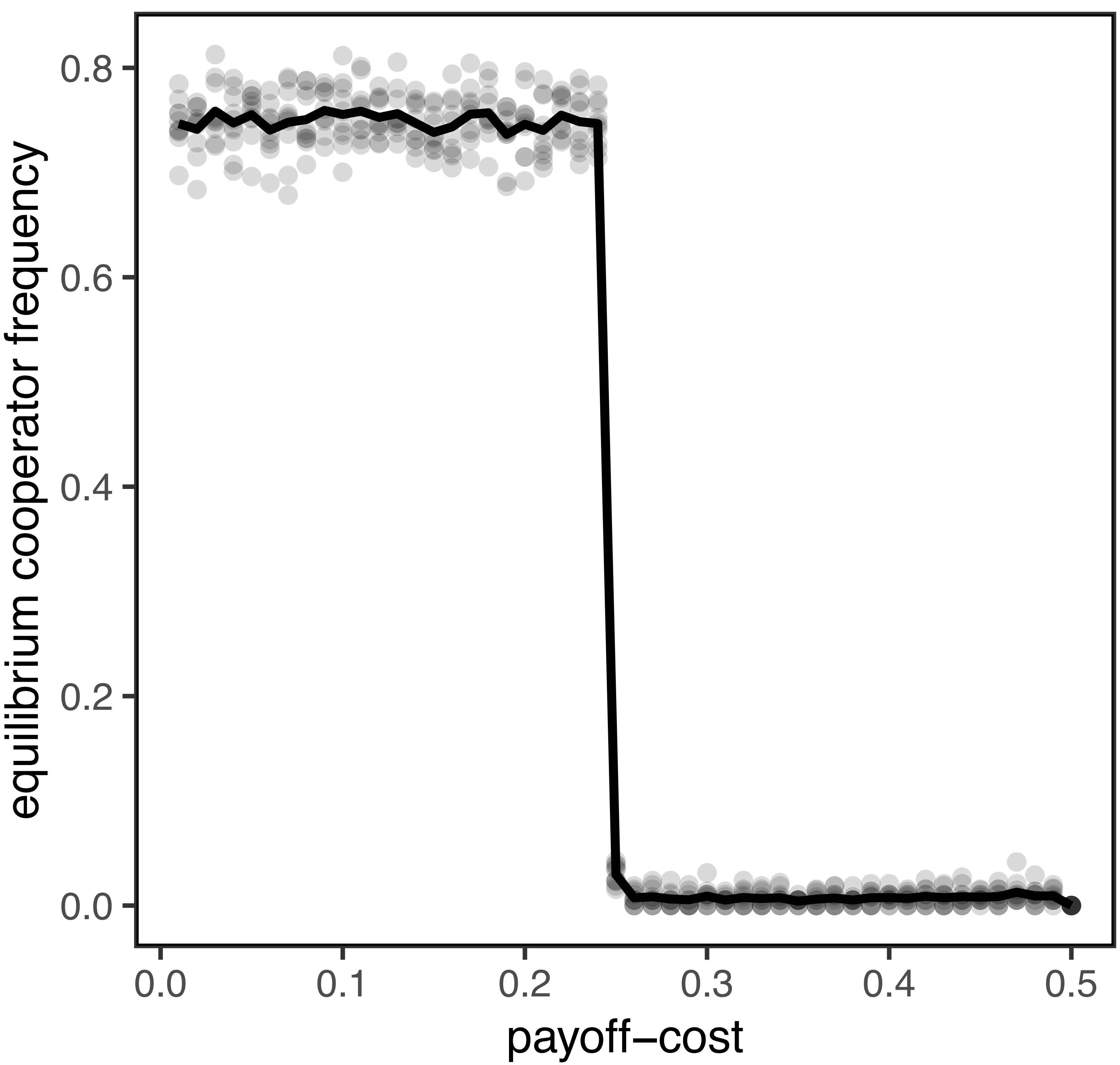
a simple model with assortment

CODE: PD_simple.nlogo



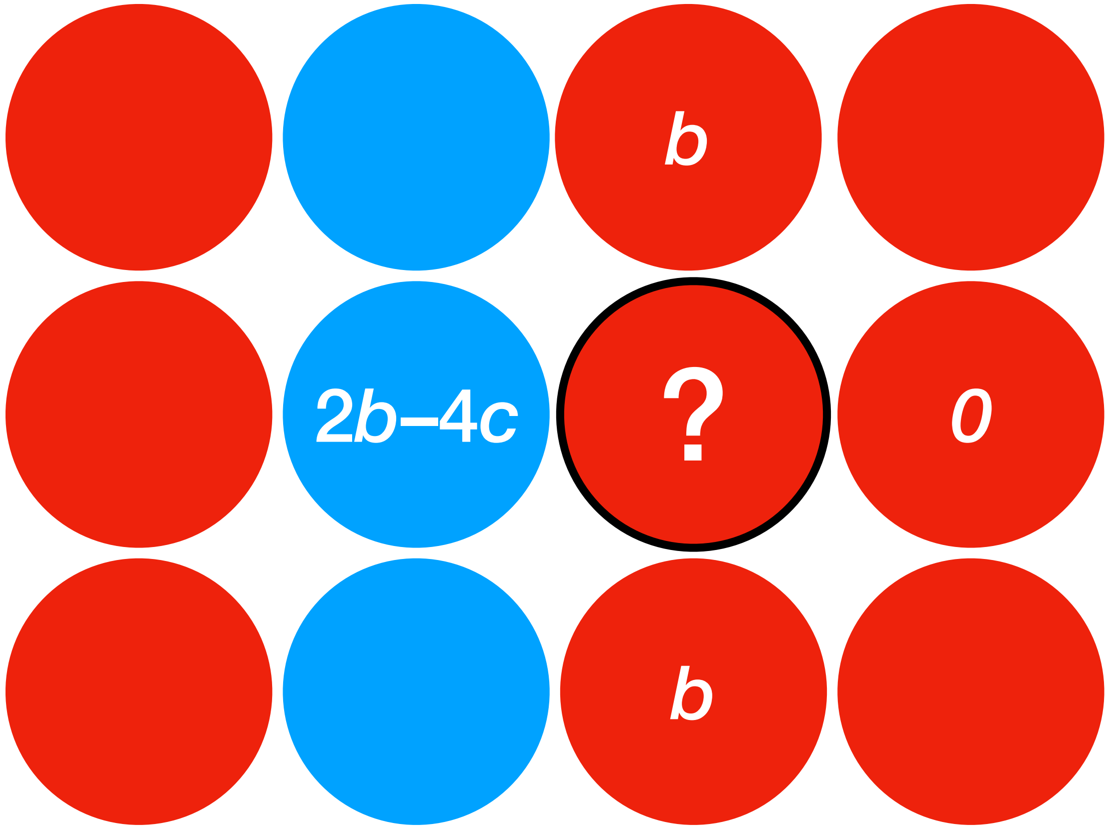
c = 0.2
init-coop-freq = 0.5





init-coop-freq = 0.5

When costs are low, cooperators can spread



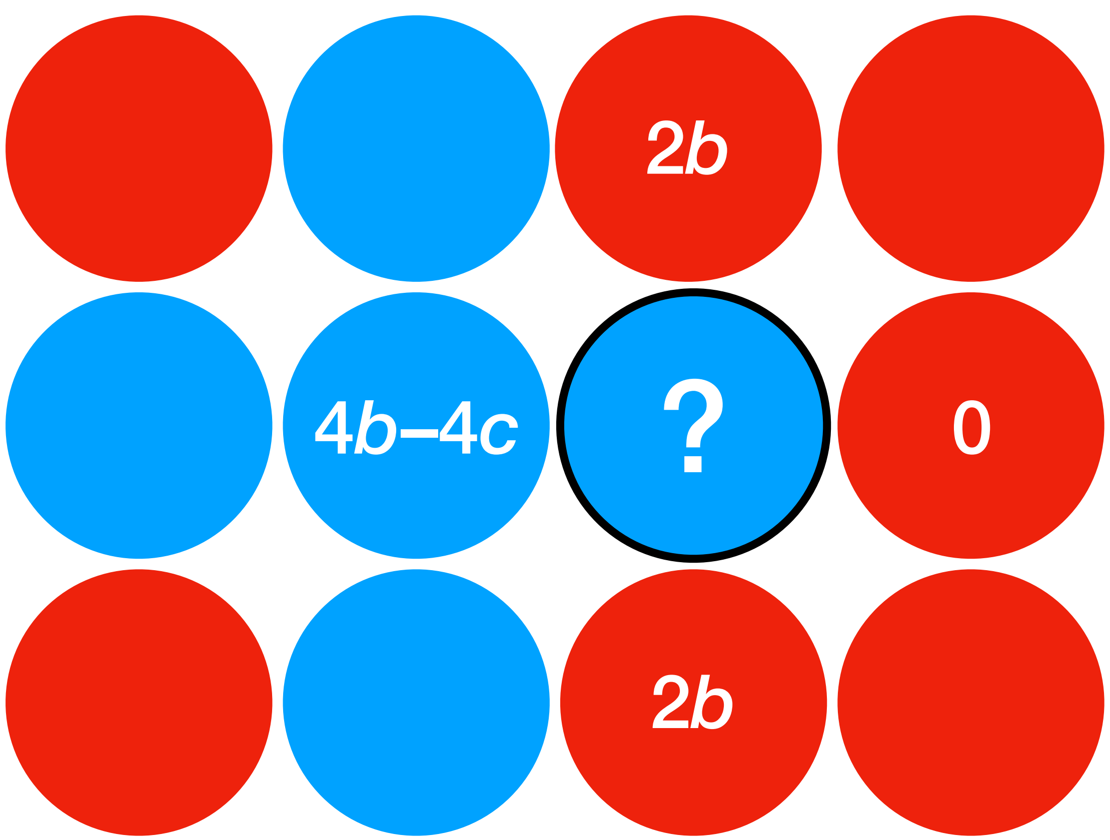
Cooperation spreads when

$$2b - 4c > b$$

or

$$c < b/4$$

When costs are too high, cooperators cannot survive at all



Cooperation disappears when

$$4b - 4c < 2b$$

or

$$c > b/2$$

Cooperation and assortment

- Cooperation can do well if the cost isn’t to high (relative to the benefit) and there is sufficient assortment.

- These are strong assumptions, particularly regarding assortment.

- We assumed your neighbors now are your neighbors forever (or their offspring are your offsprings’ neighbors, if we are thinking about genetic evolution).

Randomization

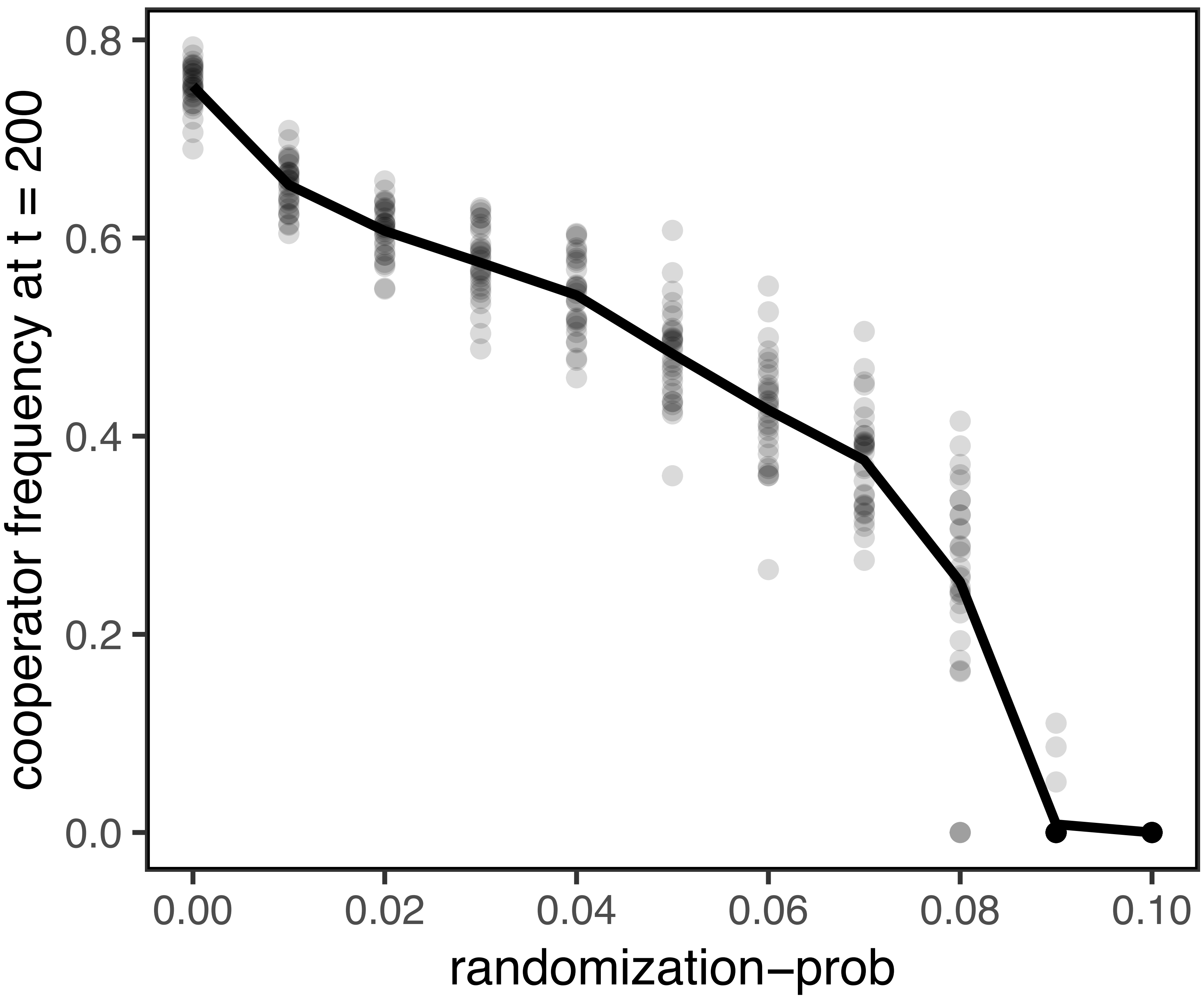
- Each time step, every agent has a probability of switching its spatial position with a randomly selected agent.

- This disrupts spatial assortment.

reducing assortment

CODE: PD_randomized.nlogo

reducing assortment hinders cooperation



c = 0.2
init-coop-freq = 0.5

The Iterated PD game

- What if interactions last for a while?
- Provides an opportunity for **contingent strategies**, which can use past behavior to adjust their own.

Tit-For-Tat

- TFT is cooperative but responsive. Follows a principle of **reciprocity**.
- Starts out cooperative, thereafter copies co-player's previous move.
- This only matters if the game is iterated. TFT is only exploited once, thereafter preferring mutual defection to being played for a sucker.

Payoffs after x iterations

Against a defector		
defector	cooperator	TFT
0	$-xc$	$-c$

Against a cooperator		
defector	cooperator	TFT
xb	$x(b-c)$	$x(b-c)$

Against TFT		
defector	cooperator	TFT
b	$x(b-c)$	$x(b-c)$

Payoffs

- A agent considers N neighbors ($N = 4$), of which n_T are TFT and n_D are defectors ($n_D = N - n_T$).

- The payoff to a TFT agent after x iterations is:

$$V_T = xn_T(b - c) - n_D c$$

- The payoff to a defector is:

$$V_D = n_T b$$

iterated prisoner's dilemma

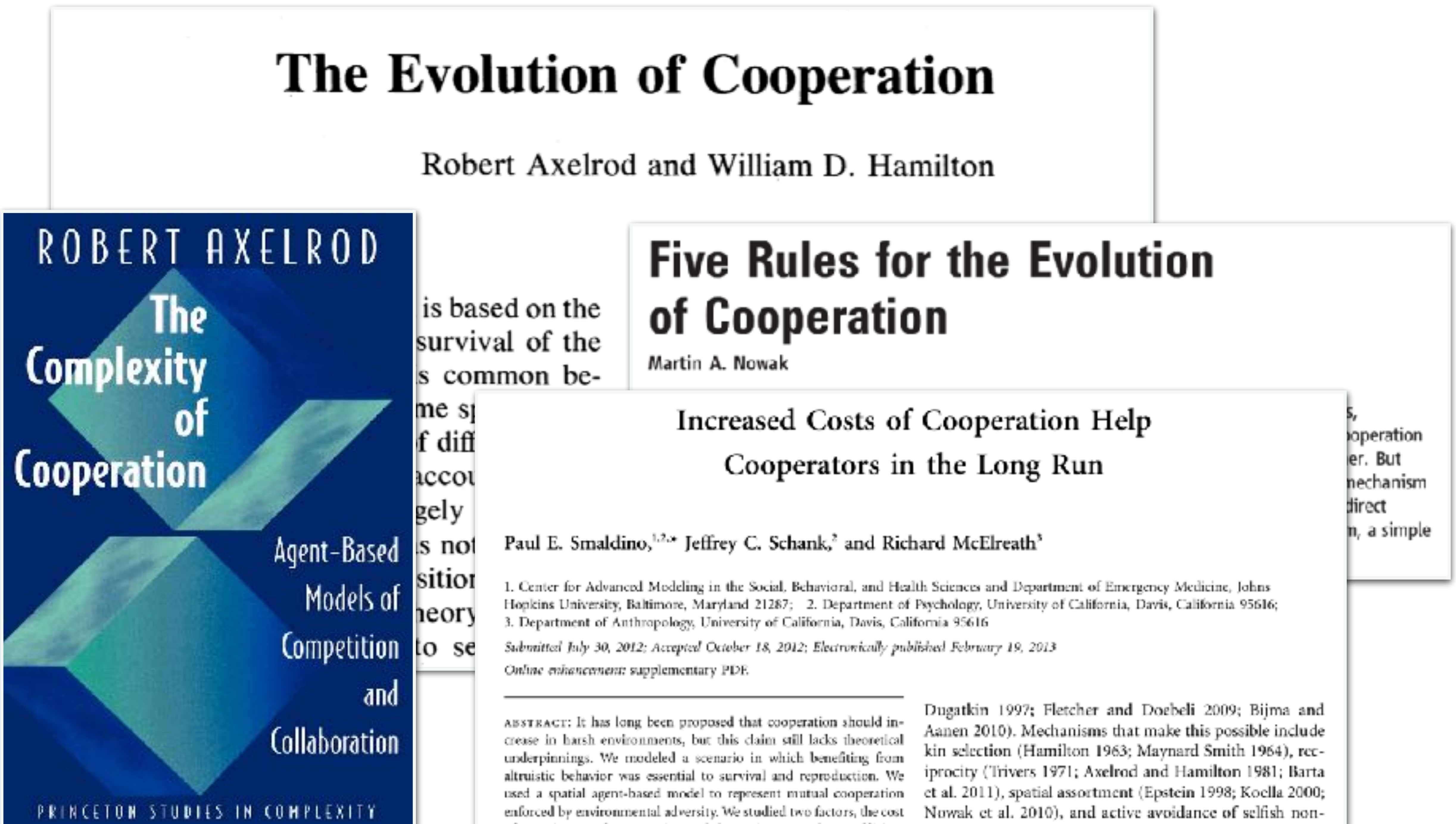
CODE: PD_reciprocity.nlogo

Reciprocity wins

- TFT is a lot more robust than pure cooperation
- It can permit persistence of cooperation under greater costs and lower assortment, as long as there is sufficient opportunity for reciprocity.

Further directions

Diving deeper



Further directions

Cooperation in larger groups

A theory of leadership in human cooperative groups

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ARTICLE INFO

ABSTRACT

t the origins of rank differen
hat the formation of social
rcive social dominance and
t that rank differentiation
rom subject – may sometim
o the challenges of life in
l free-riding in cooperative

Punishment Allows the Evolution of Cooperation (or Anything Else) in Sizable Groups

Robert Boyd* and Peter J. Richerson†

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procity is unlikely to evolve in large groups as a result
odels, reciprocators punish noncooperation by with-
hus also penalize other cooperators in the group. Here,
response is some form of punishment that is directed
fer to such alternative forms of punishment as *retri-*
n enforced by retribution can lead to the evolution of
different ways. (1) If benefits of cooperation to an
osts to a single individual of coercing the other n –
trategies which cooperate and punish noncooperators,
punished, and, sometimes, strategies which cooperate
the long run. (2) If the costs of being punished are
which cooperate, punish noncooperators, and punish
perators can be evolutionarily stable. We also show,
ies can cause any individually costly behavior to be
not it creates a group benefit.

Institutions and Cooperation in an Ecology of Games

Paul E. Smaldino*,**
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University of California, Davis

Abstract Social dilemmas
cooperation games that pit
group. In the real world, i
they play many such games
co-players. Here, we study
of public goods games and
institutional mechanisms fo
institution of limited group
institution based on observ
allow much higher relative
constraints, but only if (1)
flow is fast enough relative
(2) cooperators are relativel
these conditions are not m
as protecting the interests o
of the limited-group-size r
social organization, which p
than can reputation. Our
normative prescriptions and
that regulate cooperation. M
approach developed here p
for studying a wide variety

A Mechanism for Social Selection and Successful Altruism

HERBERT A. SIMON

Within the framework of neo-Darwinism, with its focus on fitness, it has been hard to account for altruism, behavior that reduces the fitness of the altruist but increases average fitness in society. Many population biologists argue that, except for altruism to close relatives, human behavior that appears to be altruistic amounts to reciprocal altruism, behavior undertaken with an expectation of reciprocation, hence incurring no net cost to fitness. Herein is proposed a simple and robust mechanism, based on human docility and bounded rationality, that can account for the evolutionary success of genuinely altruistic behavior. Because docility—receptivity to social influence—contributes greatly to fitness in the human species, it will be positively selected. As a consequence, society can impose a "tax" on the gross benefits gained by individuals from docility by inducing docile individuals to engage in altruistic behaviors. Limits on rationality in the face of environmental complexity prevent the individual from avoiding this "tax." An upper bound is imposed on altruism by the condition that there must remain a net fitness advantage for docile behavior after the cost to the individual of altruism has been deducted.

Further directions

Cooperation and competition

The Evolution of Ethnocentrism

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University of Michigan, Ann Arbor
ROBERT AXELROD
Gerald R. Ford School of Public Policy
University

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favoritism.
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The coevolution of economic institutions and sustainable consumption via cultural group selection

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us institutions that improve resource longevity by supporting individual
echanisms by which these institutions emerge have not been established.
s which support resource conservation, such as property regimes and sys-
process of cultural group selection amongst social-ecological systems. To
multilevel selection model of resource management institutions with en-
nous design permits us to determine whether a given social adaptation is
on. We demonstrate how resource conservation and supporting econom-
en cultural group selection is involved. In the model, sustainable societies
ulations reveal that property norms facilitate sustainable outcomes most,
production norms. We describe the institutional transitions which occur
likely to achieve sustainability. Analysis of the model reveals that when
in a harsh environment cultural group selection favors institutions that
er, when groups compete for abundant resources institutions emerge to

The Coevolution of Parochial Altruism and War

Jung-Kyoo Choi[1] and Samuel Bowles[2*]

Altruism—benefiting fellow group members at a cost to oneself—and parochialism—hostility toward individuals not of one's own ethnic, racial, or other group—are common human behaviors. The intersection of the two—which we term "parochial altruism"—is puzzling from an evolutionary perspective because altruistic or parochial behavior reduces one's payoffs by comparison to what one would gain by eschewing these behaviors. But parochial altruism could have evolved if parochialism promoted intergroup hostilities and the combination of altruism and parochialism contributed to success in these conflicts. Our game-theoretic analysis and agent-based simulations show that under conditions likely to have been experienced by late Pleistocene and early Holocene humans, neither parochialism nor altruism would have been viable singly, but by promoting group conflict, they could have evolved jointly.

Next up:
Coordination and norms