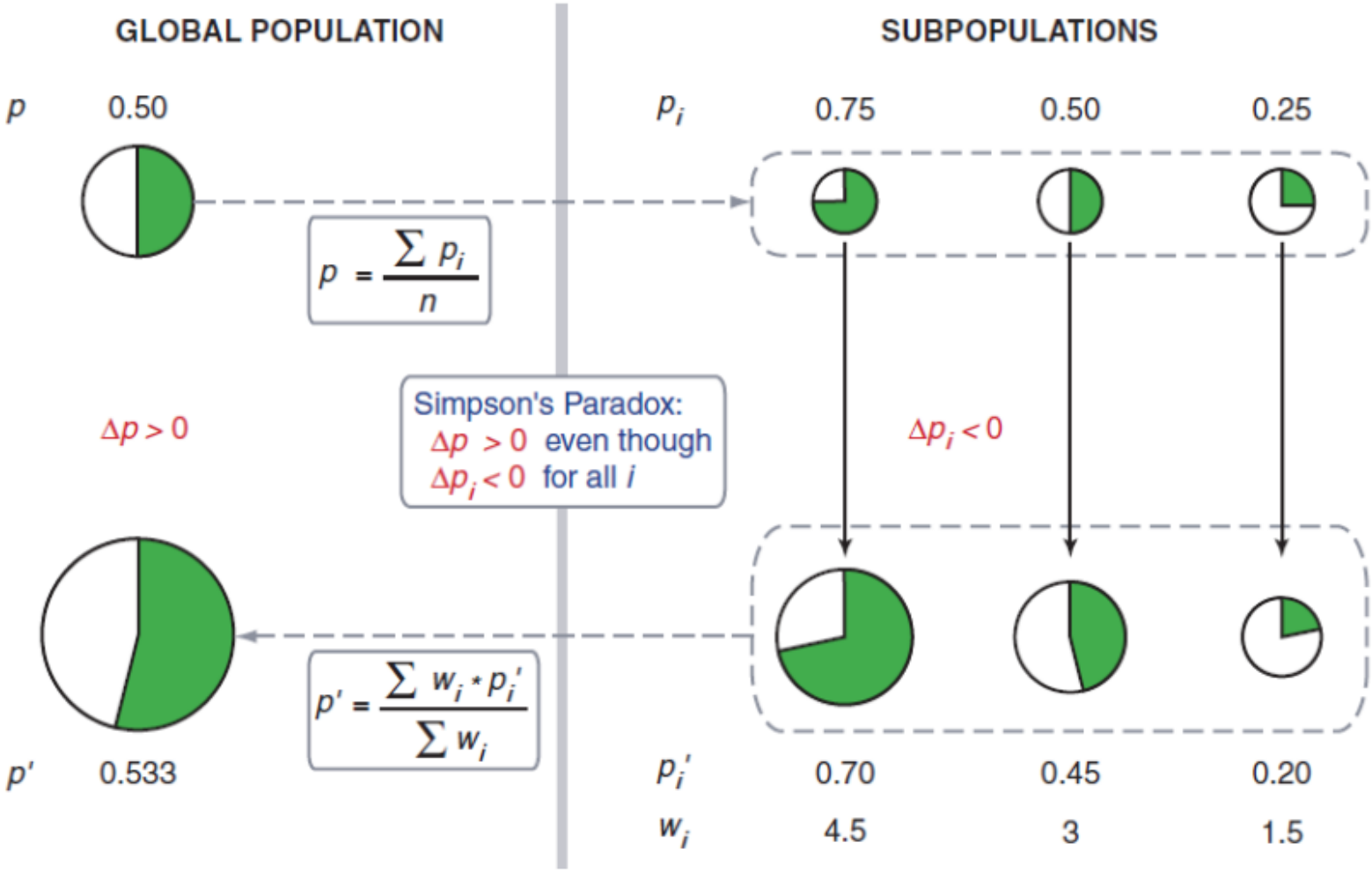
Day 3

A brief intro to social dilemmas ... and how bacteria and humans solve them

Juan F Poyatos
Logic of Genomics Systems Laboratory (CNB-CSIC)

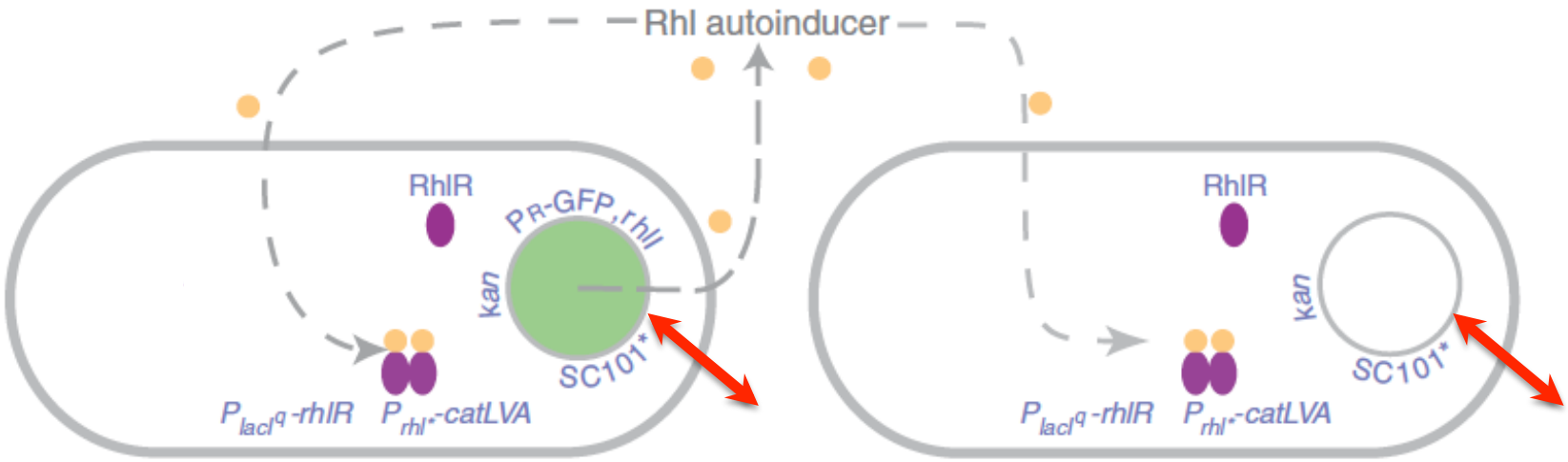
Master in Biophysics 2012/2013
Universidad Autónoma de Madrid
Madrid, Spain
Feb 25-27, 2013

Multilevel cooperation

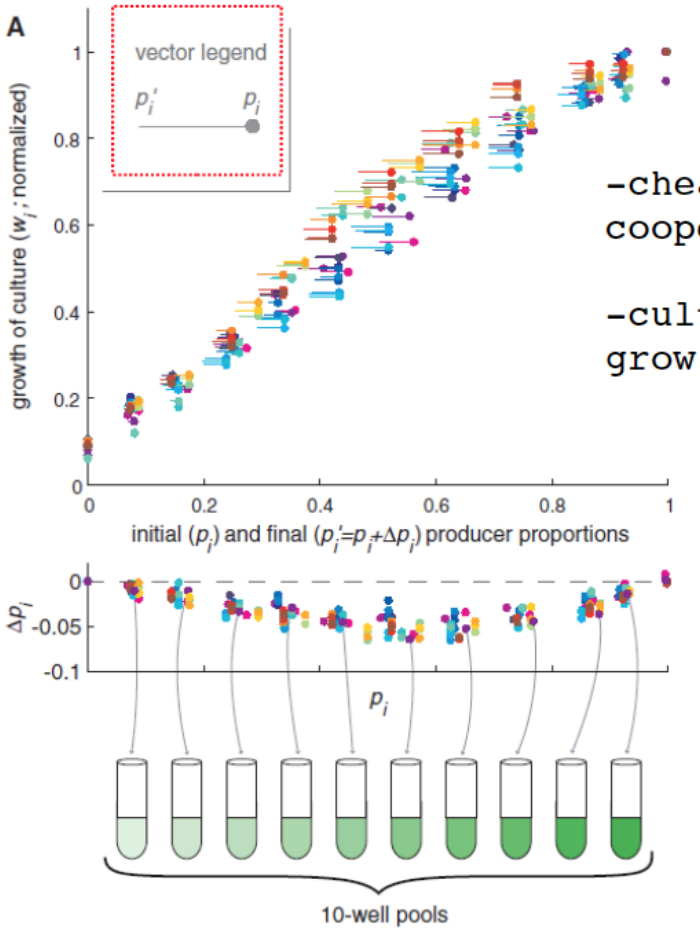


Chuang JS. *et al*, Mol Syst Biol. 6 (2010) 398

Migration and differential fitness; synthetic design

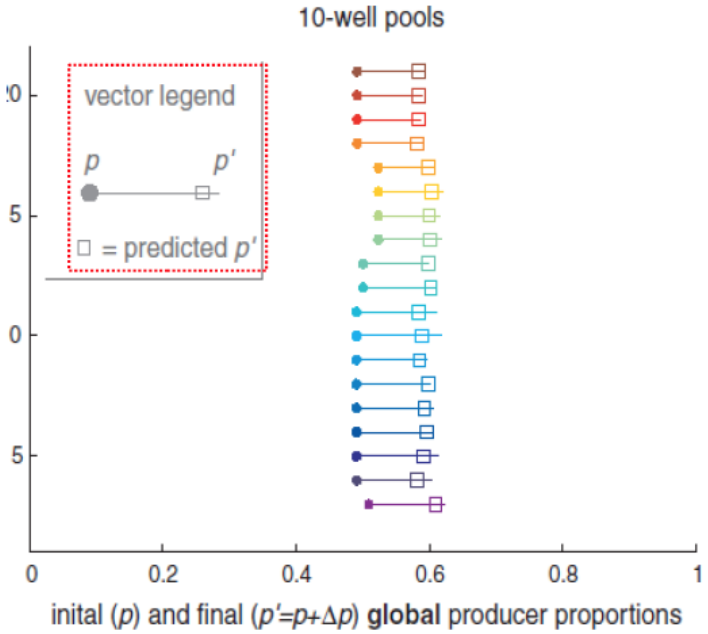


The not-so-easy-to-test Hamilton's rule

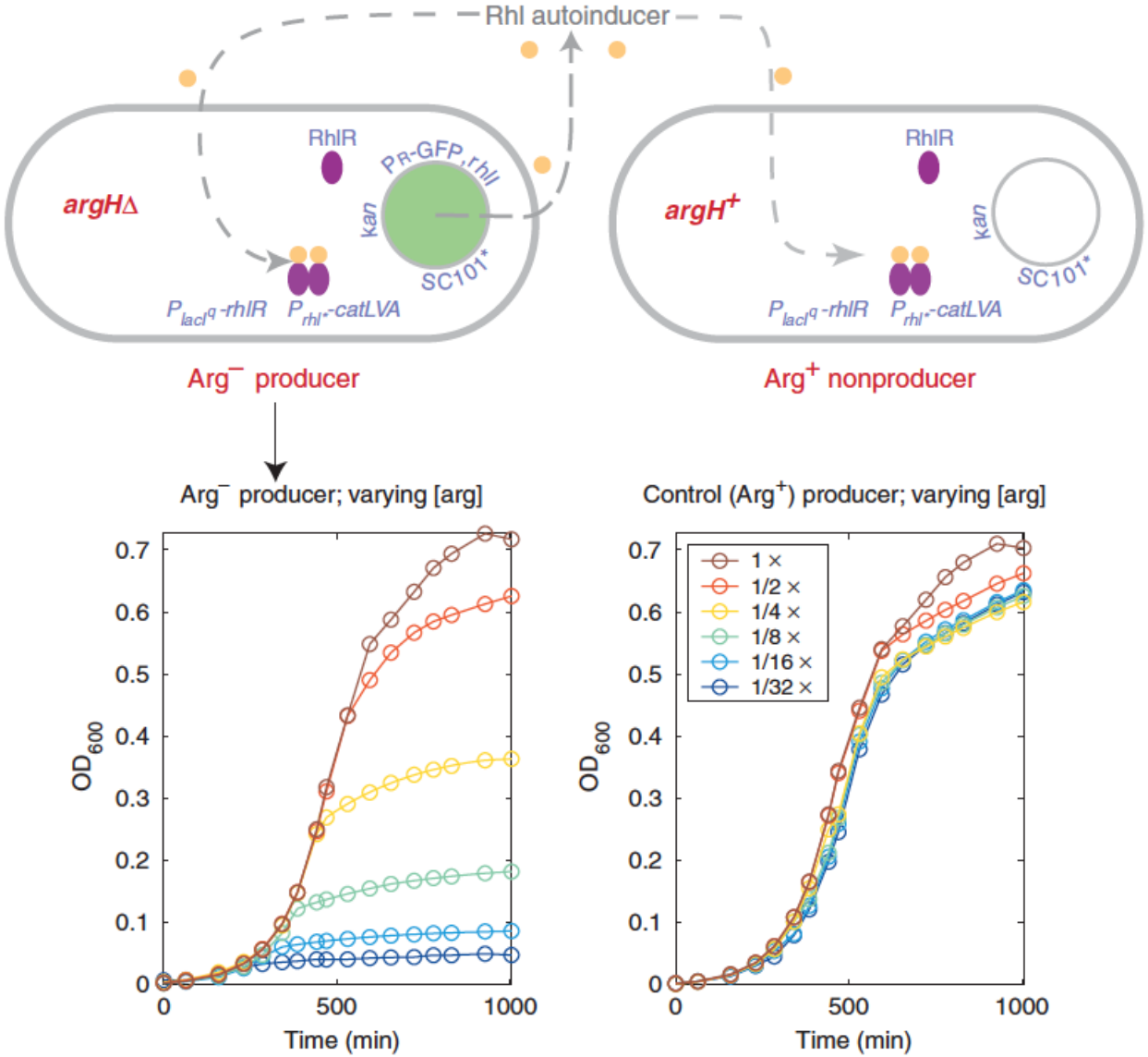


-cheaters grow faster than cooperators within each culture

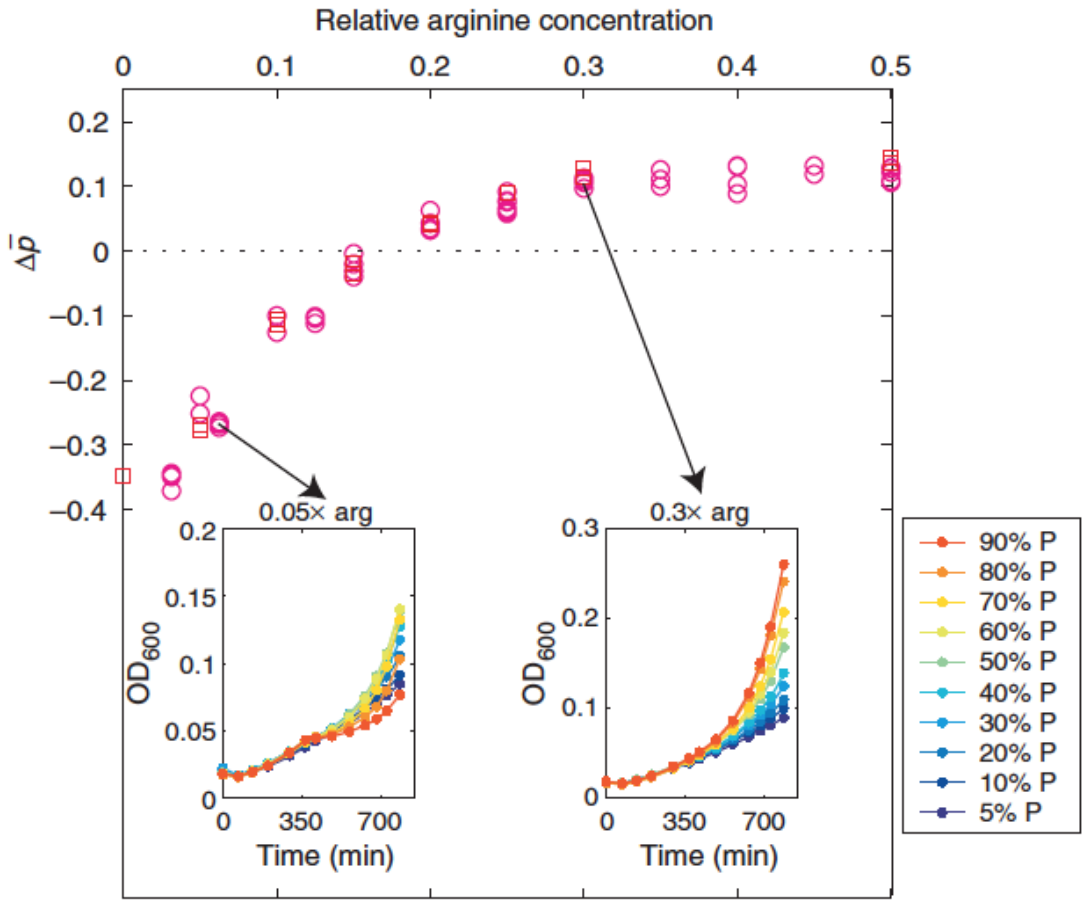
-cultures with more cooperators grow to larger densities



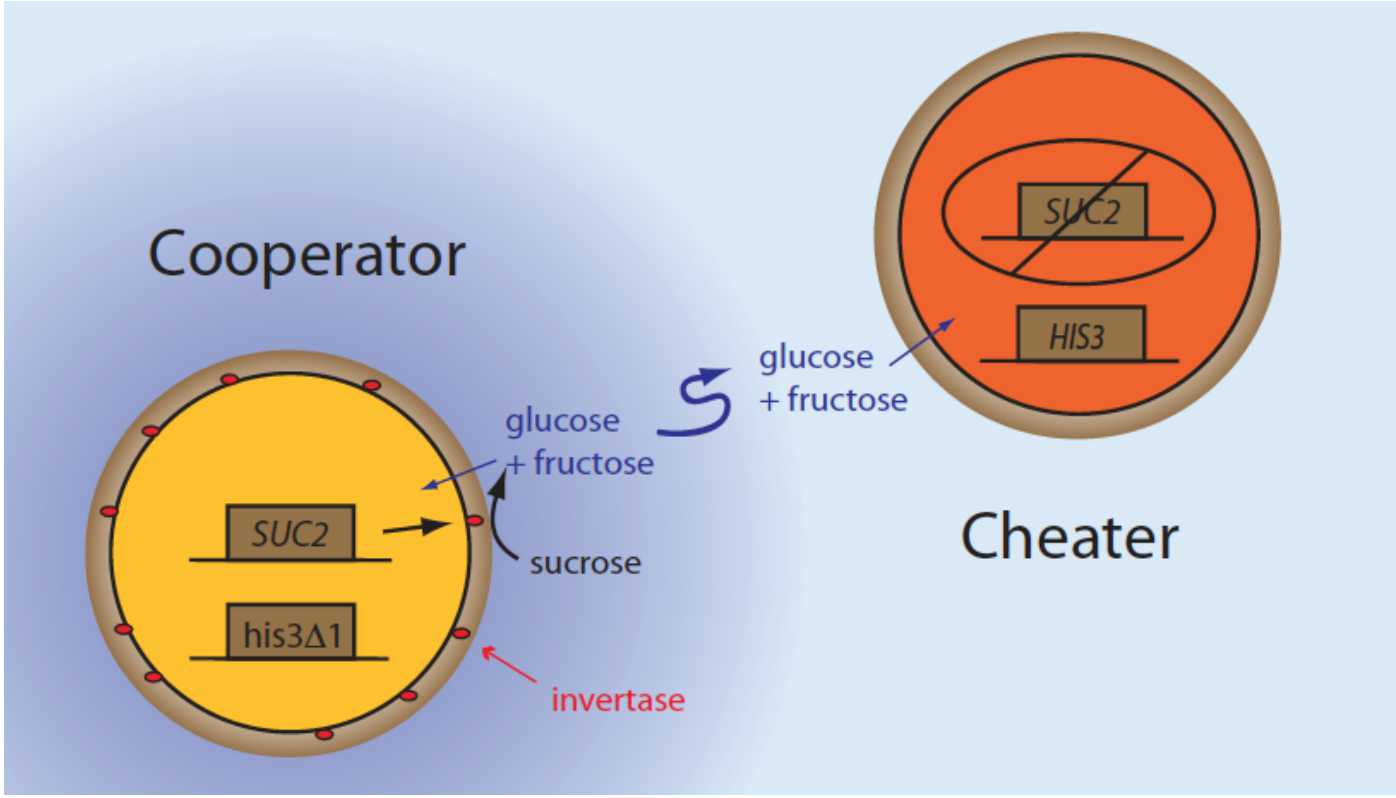
Controlling the growth difference between Ps and nPs



High variability of cheater frequency between groups



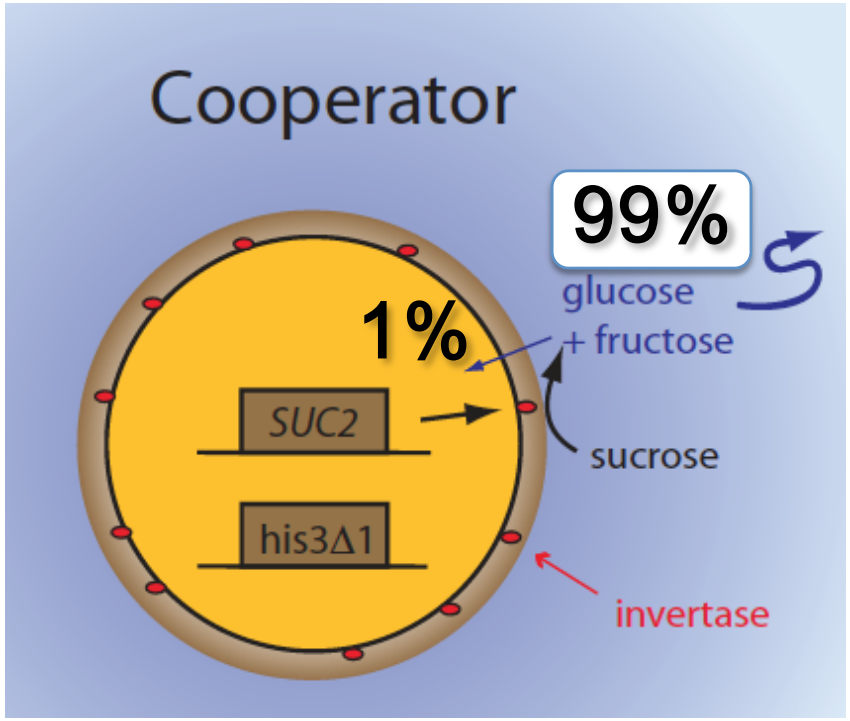
Facultative cheating in yeast



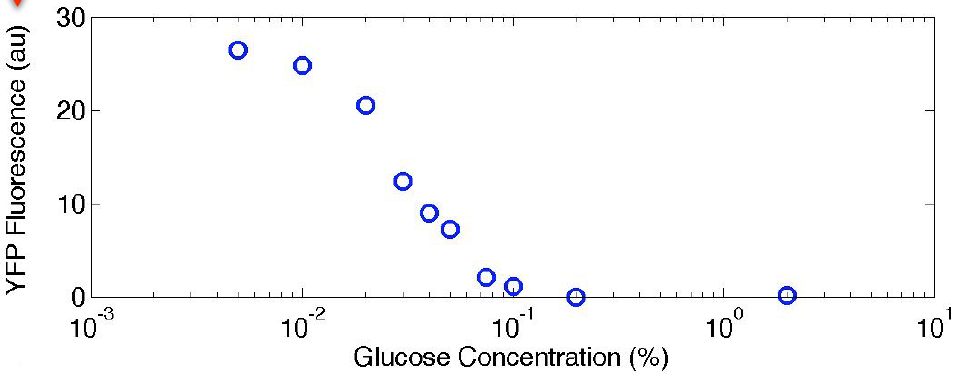
By limiting the histidine in the media we can impose a cost on the cooperator strain because it is a histidine auxotroph

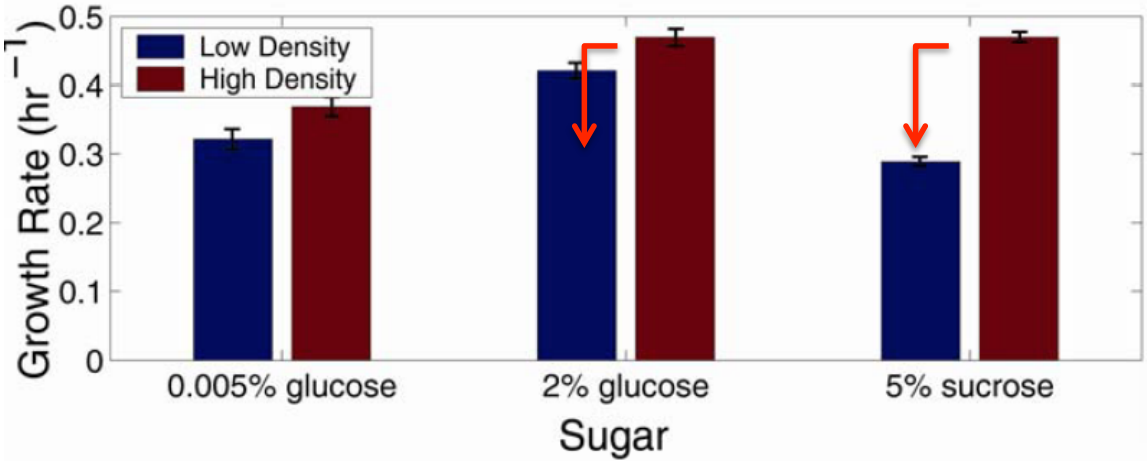
Gore J. *et al*, Nature 459 (2009) 253

Cells grow faster at high density

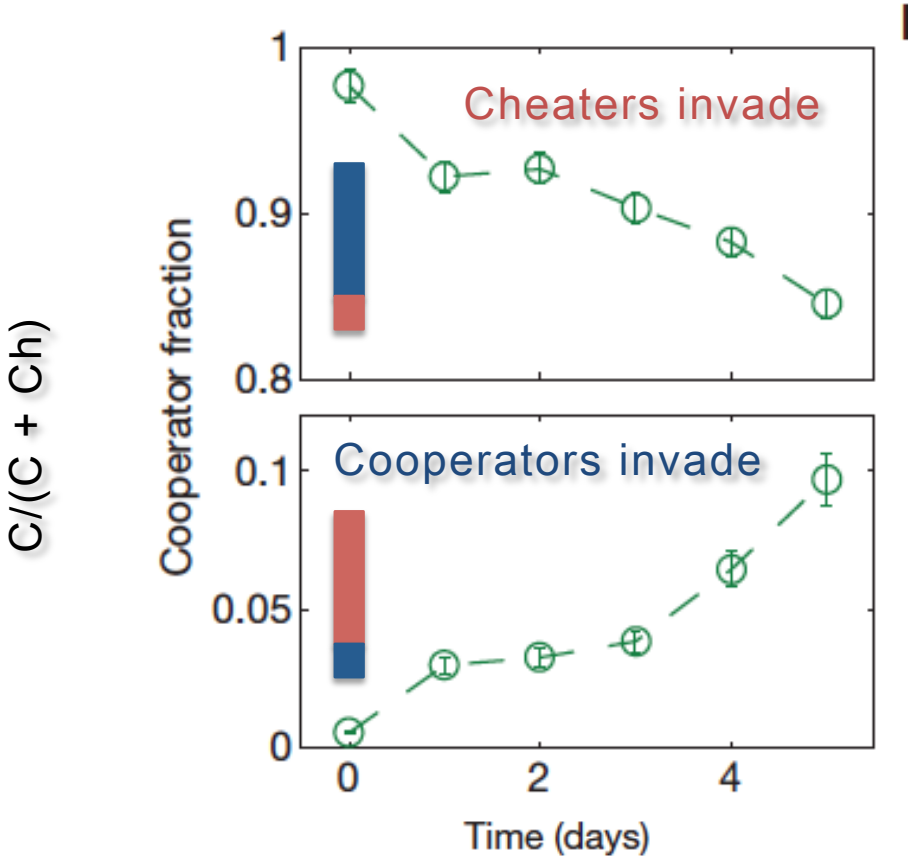


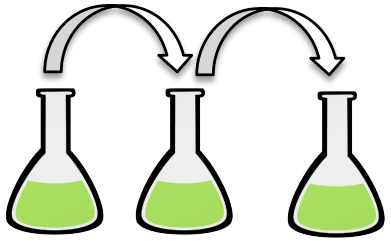
Invertase activity (P_{suc2}:YFP) with different glucose concentration





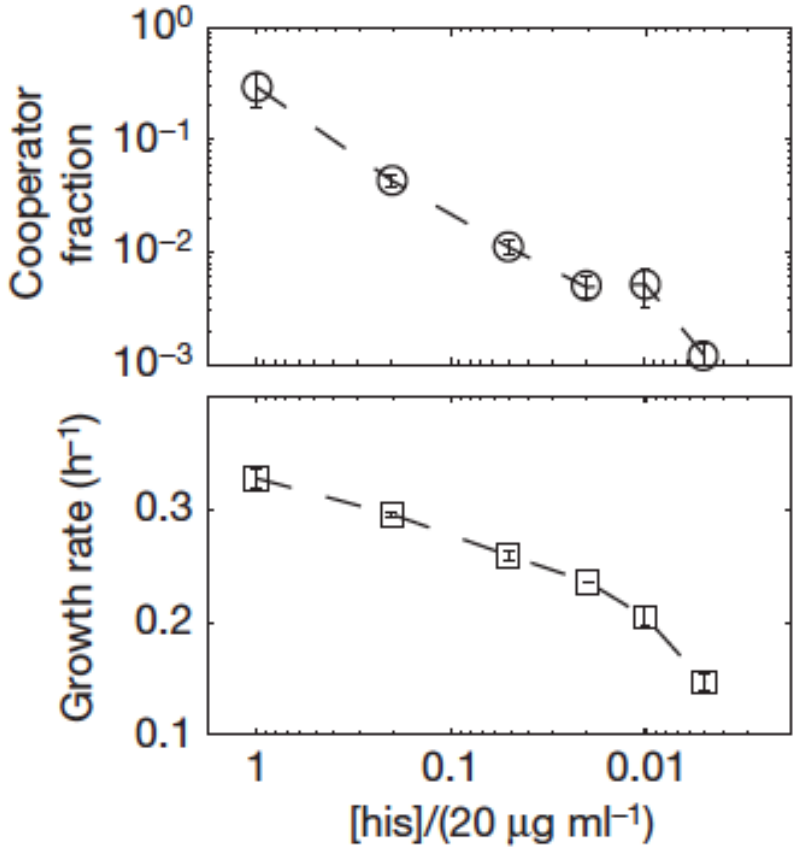
Cheaters and cooperator can invade each other





Sucrose media

Equilibrium fraction of cooperators and growth decrease as cost of cooperation increases (by reducing [histidine])

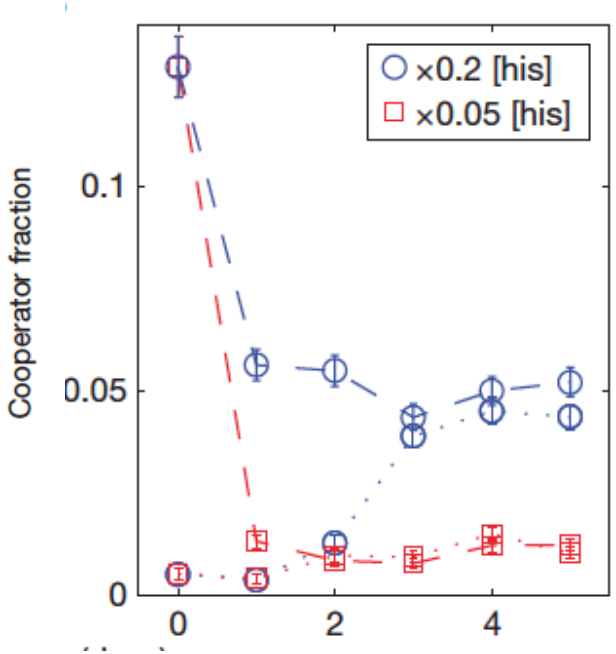


Coexistence C and D

It is a ‘snow-drift’ game! Coexistence C and D

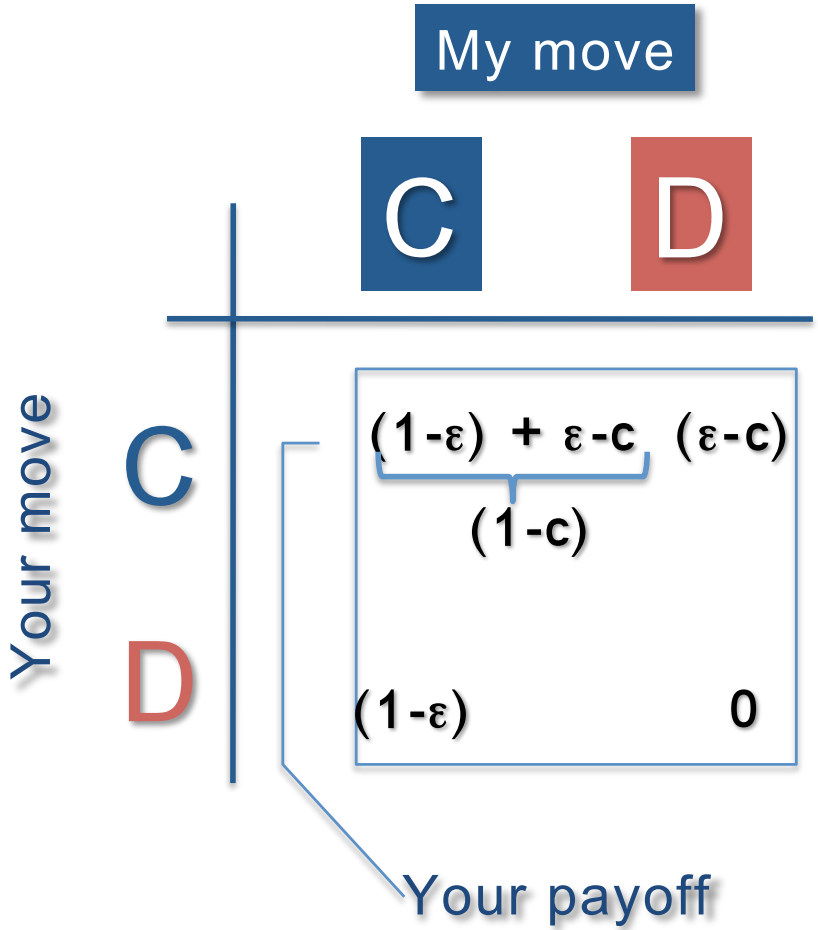
Your move \ My move	C	D
C	3	1
D	5	0

Your payoff



Do the opposite of what the other did!

But the linear 'sucrose game' does not lead to coexistence …



Cooperator fraction

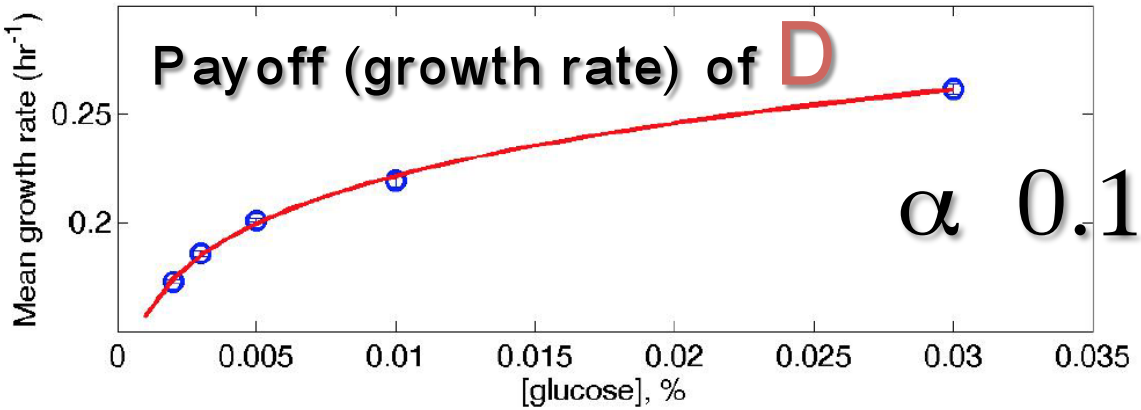
$$\text{Payoff}_C = \varepsilon + f\,(1-\varepsilon) - c$$

$$\text{Payoff}_D = f\,(1-\varepsilon)$$

$\varepsilon < c \rightarrow$ Defectors invade

$\varepsilon > c \rightarrow$ Cooperators invade

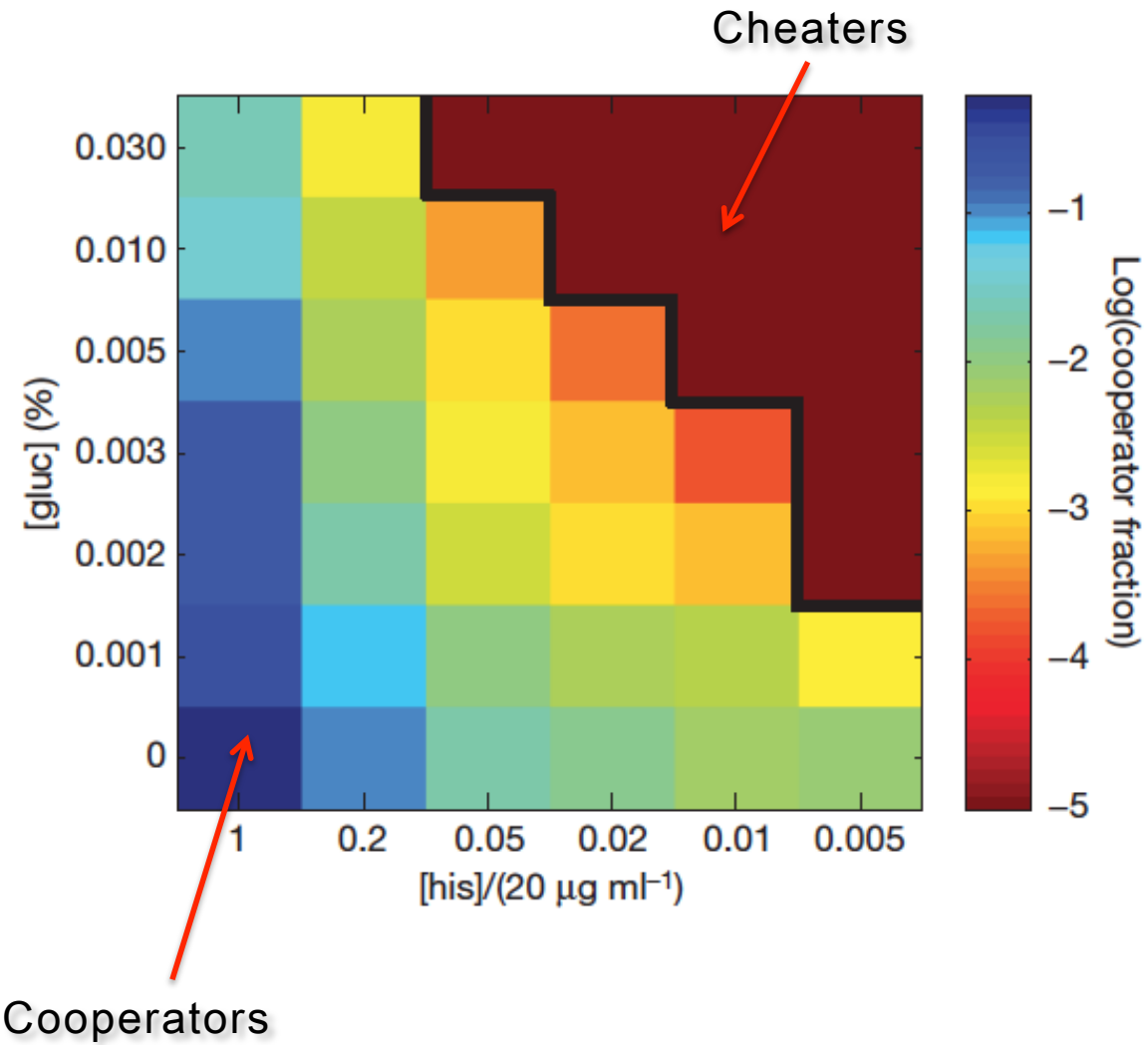
One needs non-linear benefits!



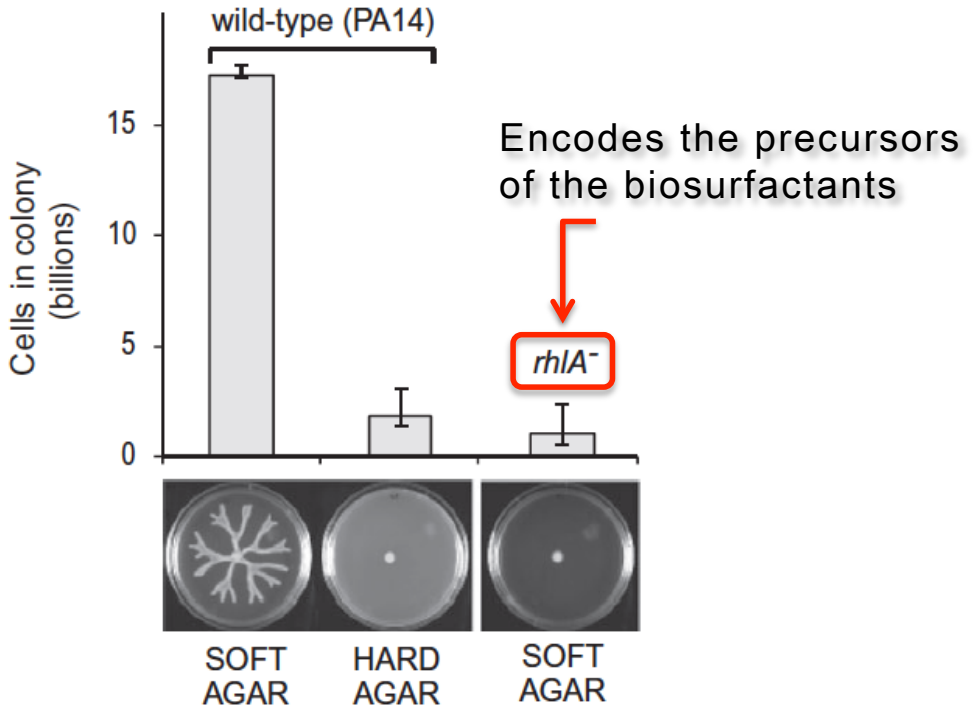
α 0.15 ± 0.01

$\text{Payoff}_D = f(1-\varepsilon) \rightarrow \text{Payoff}_D = [f(1-\varepsilon)]^{\alpha}$

Glucose changes it all!

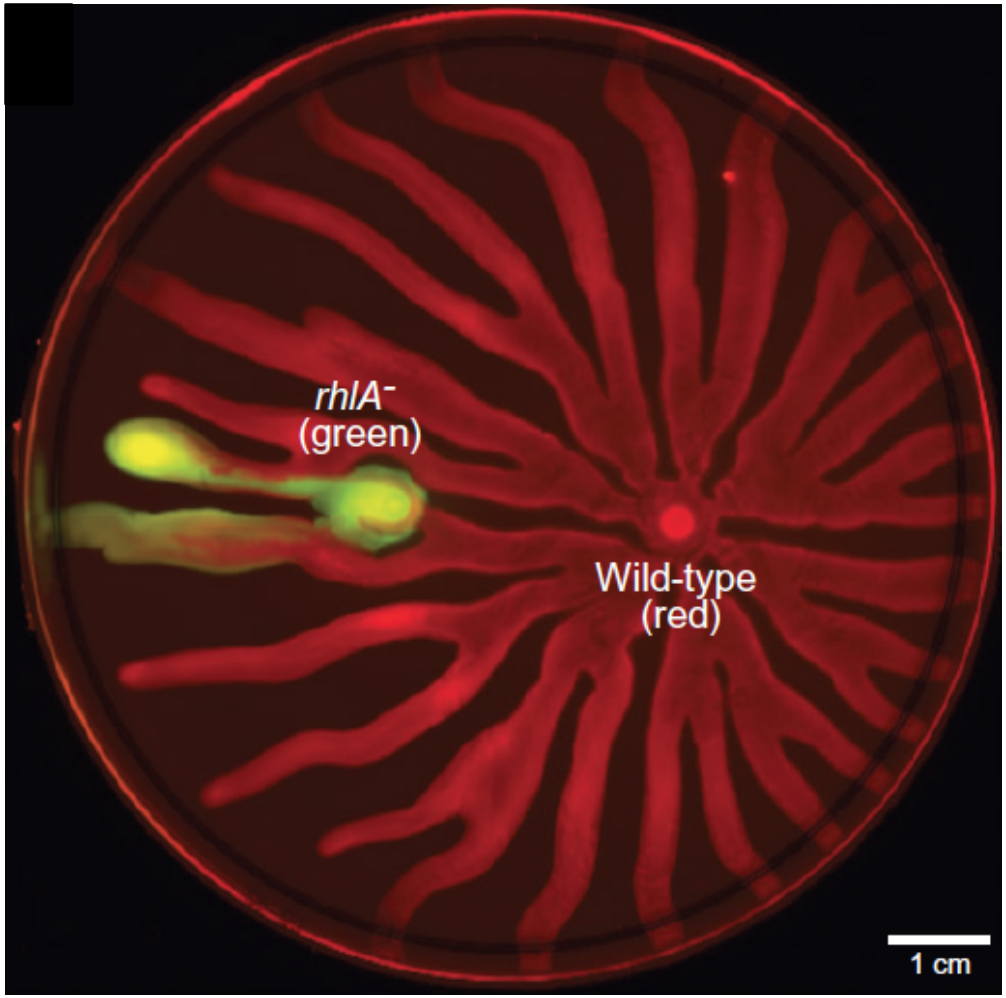


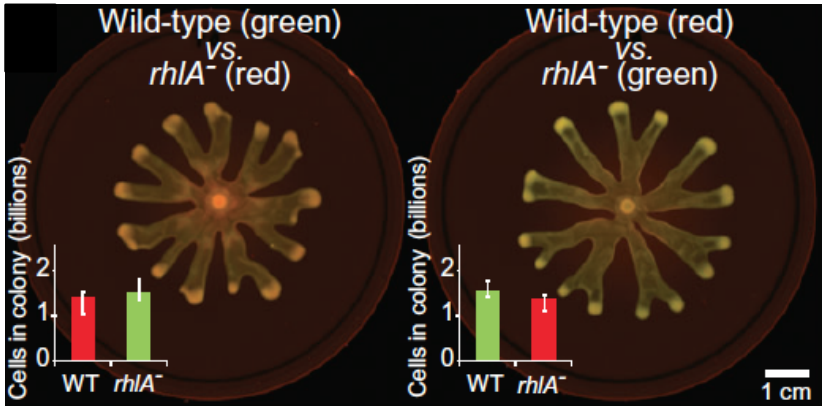
Swarming; a collective form of surface motility resting on a PG



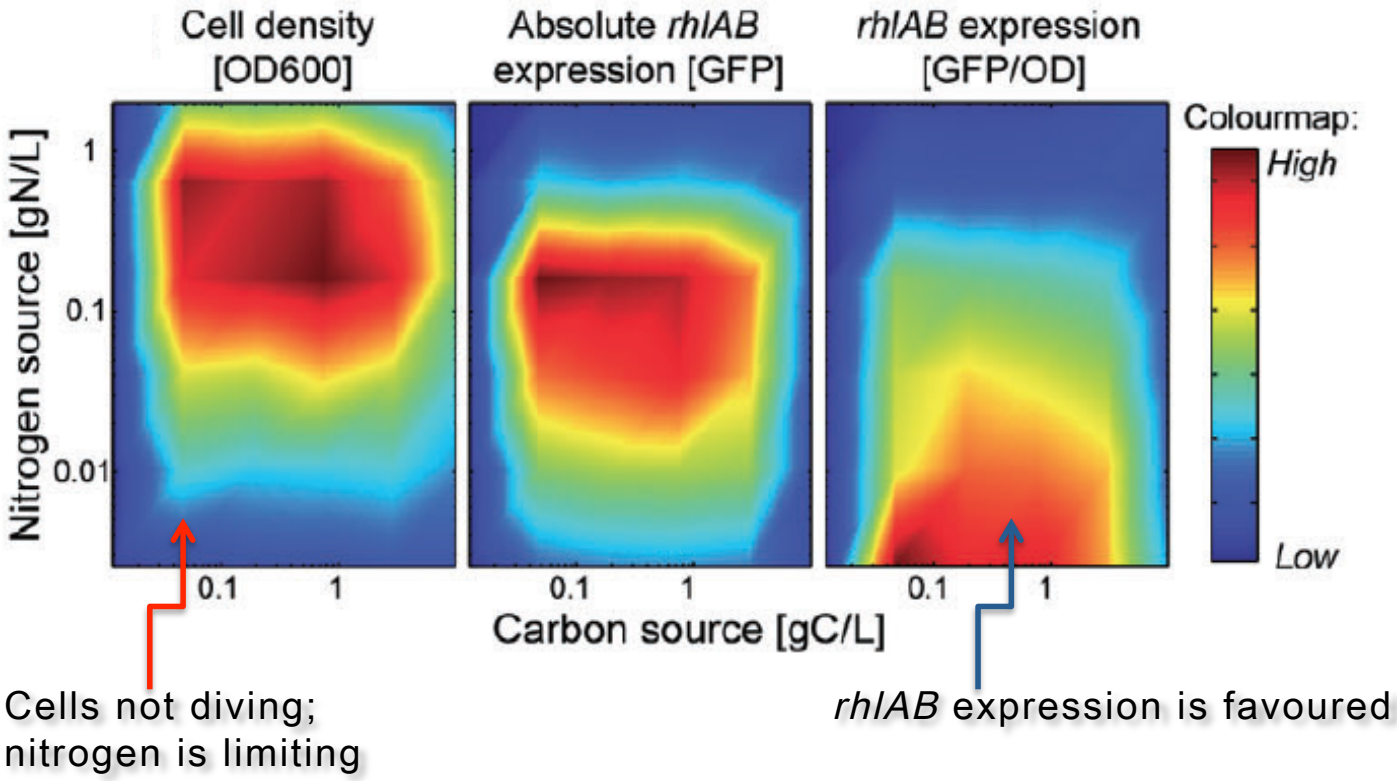
Xavier JB. *et al*, Mol Microbiol. 79 (2011) 166

rhlA$^-$ can use the secretions of others to swarm yet has no measurable competitive advantage!?

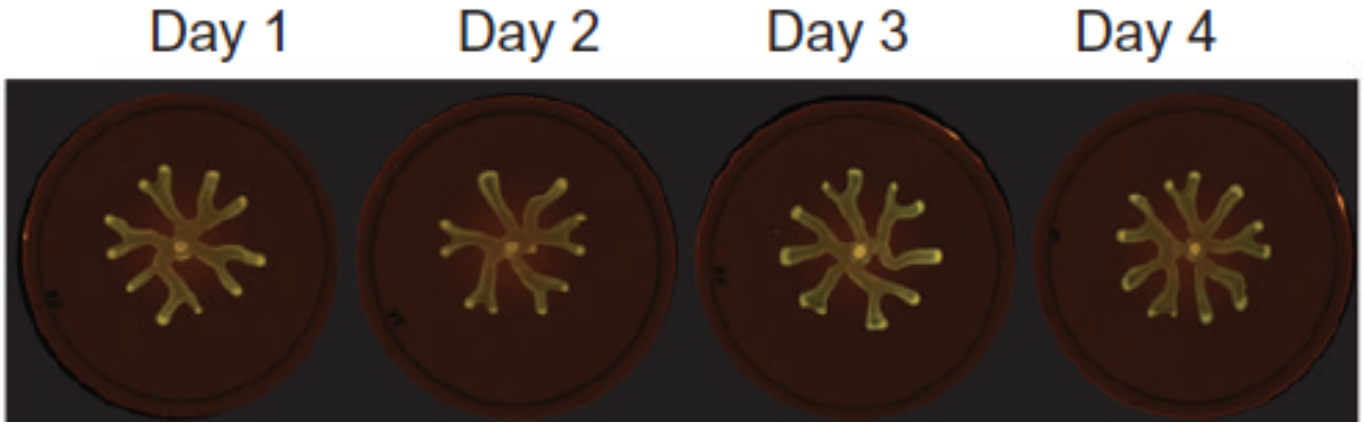




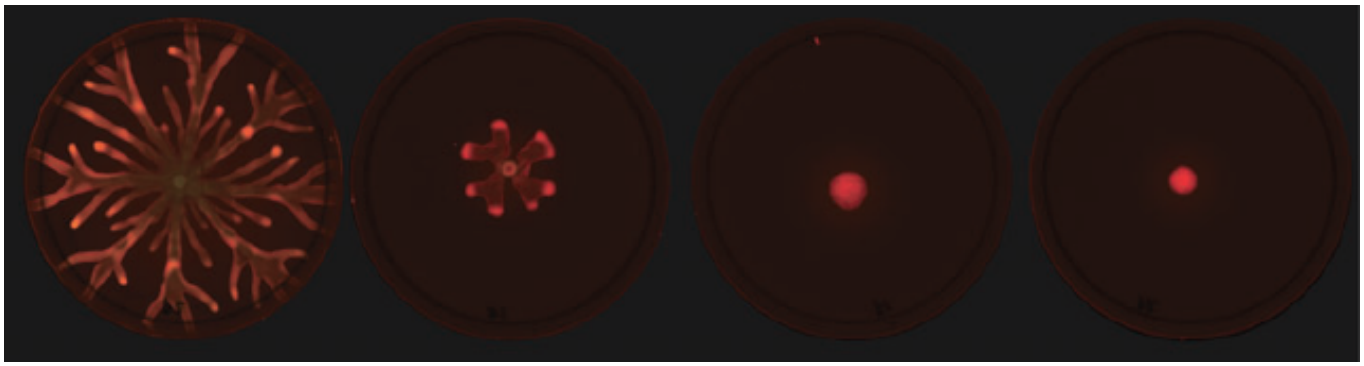
Bio-surfactants are only produced when the cells are not dividing, due to *nitrogen limitation*, and use carbon source that under these circumstances cannot be use for growth



Bio-surfactant secretion becomes exploitable in a inducible strain lacking the native regulation

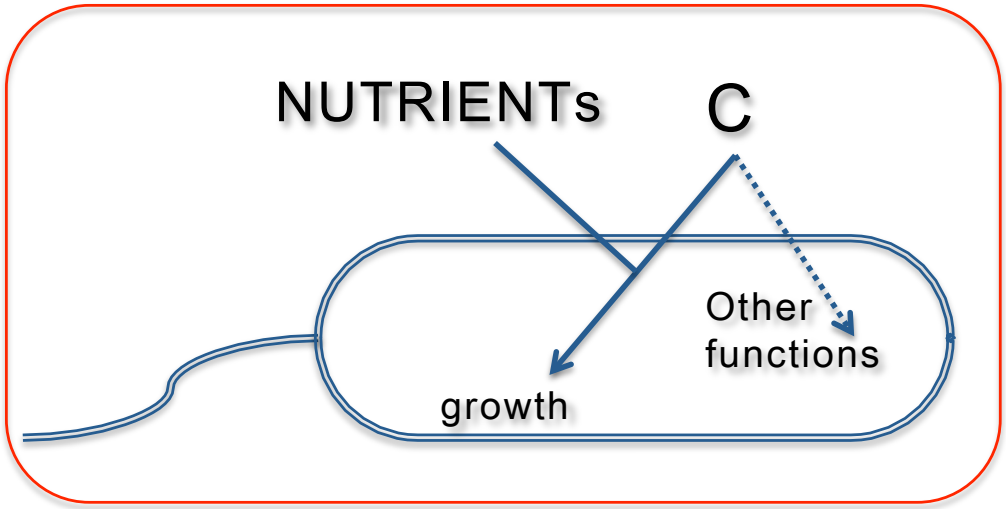


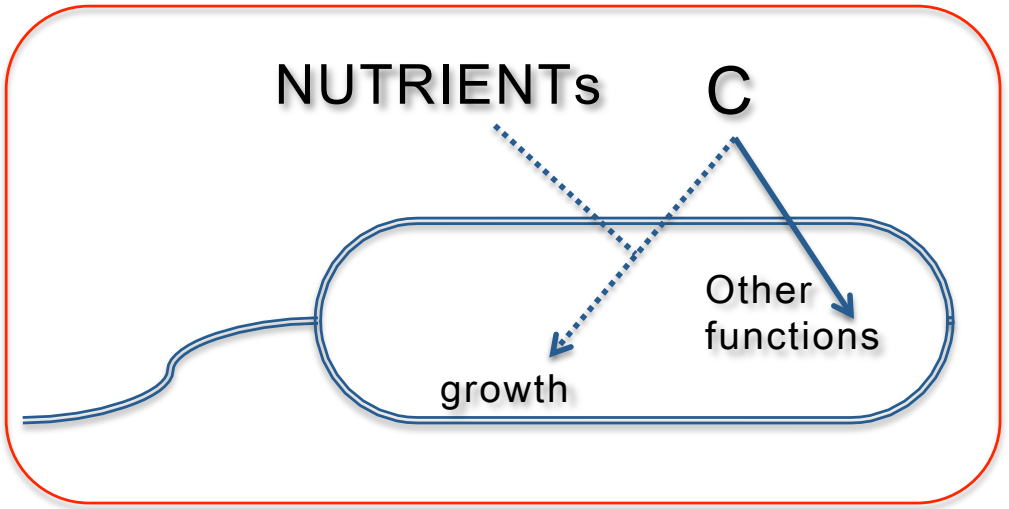
wt (green) vs. *rhlA*$^-$ (red)



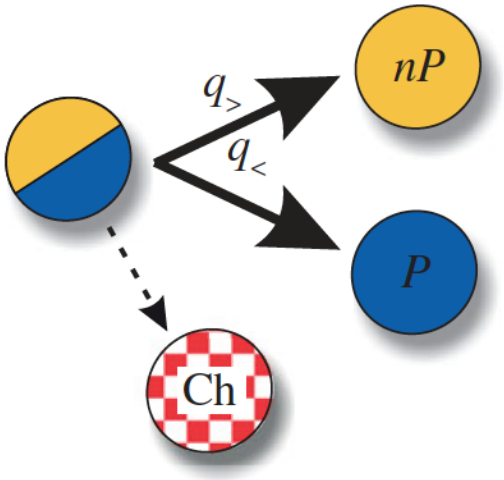
Inducible strain (green; *rhlA*$^-$ P_{BAD}*rhlAB*) vs. *rhlA*$^-$ (red)

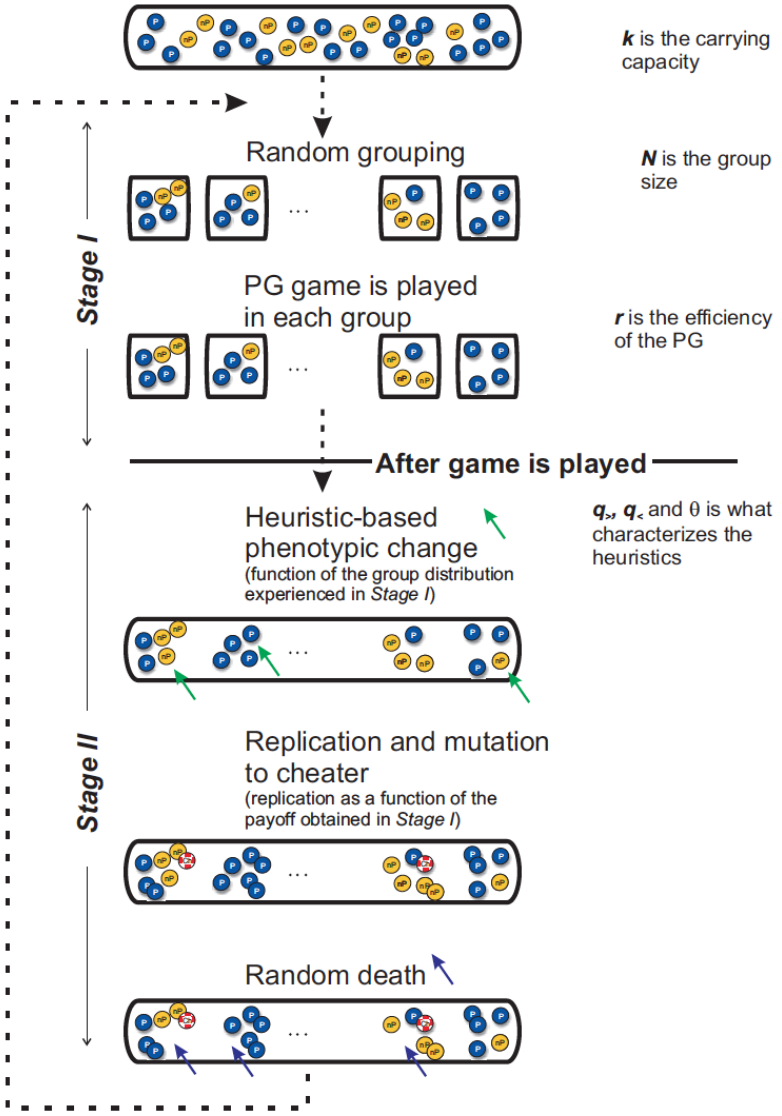
Cells tend to redirect the non-limiting carbon flux





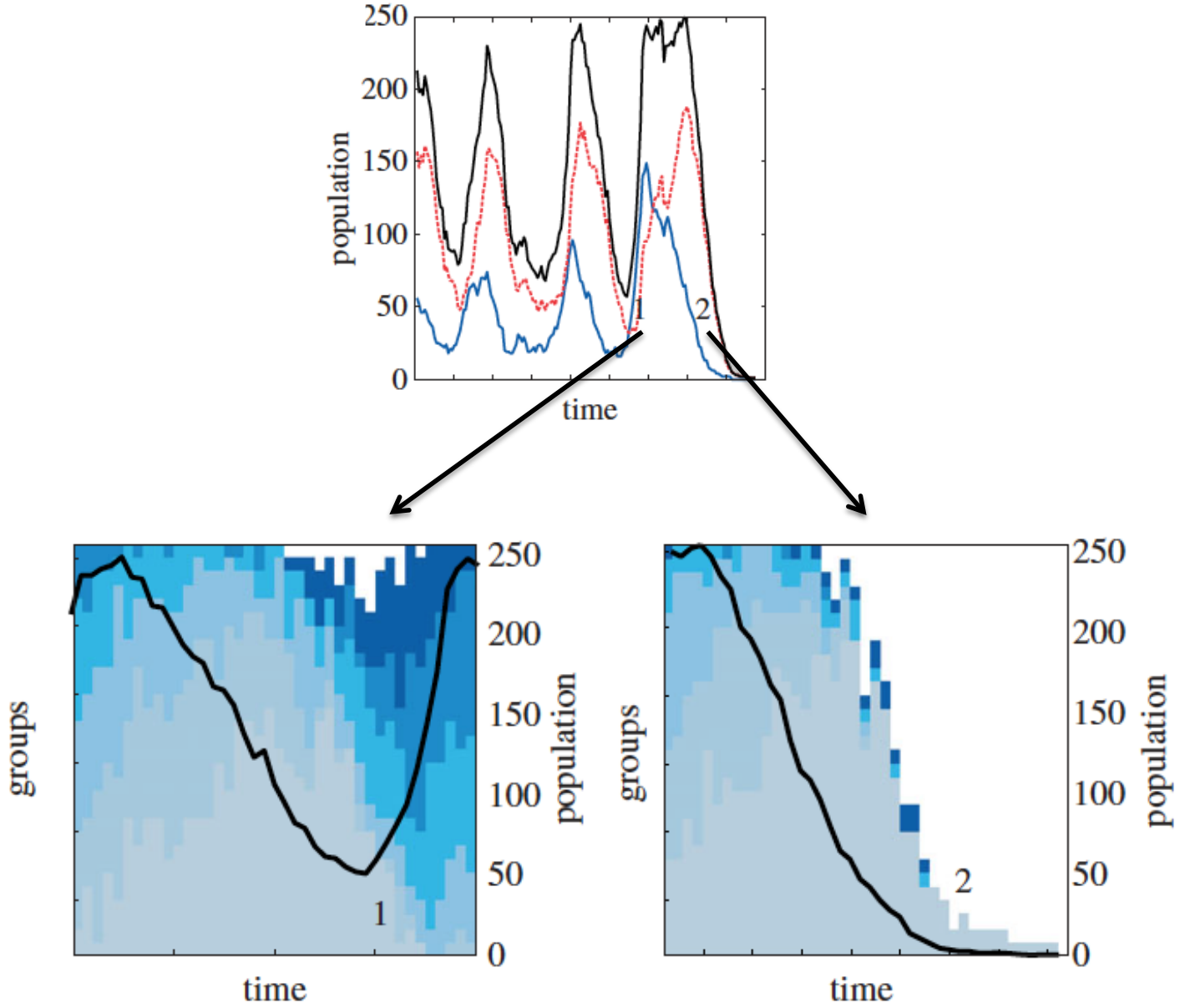
Plasticity as ecological rationality





Cavaliere M. *et al*, J R Soc Interface. 10 (2013) 20121006

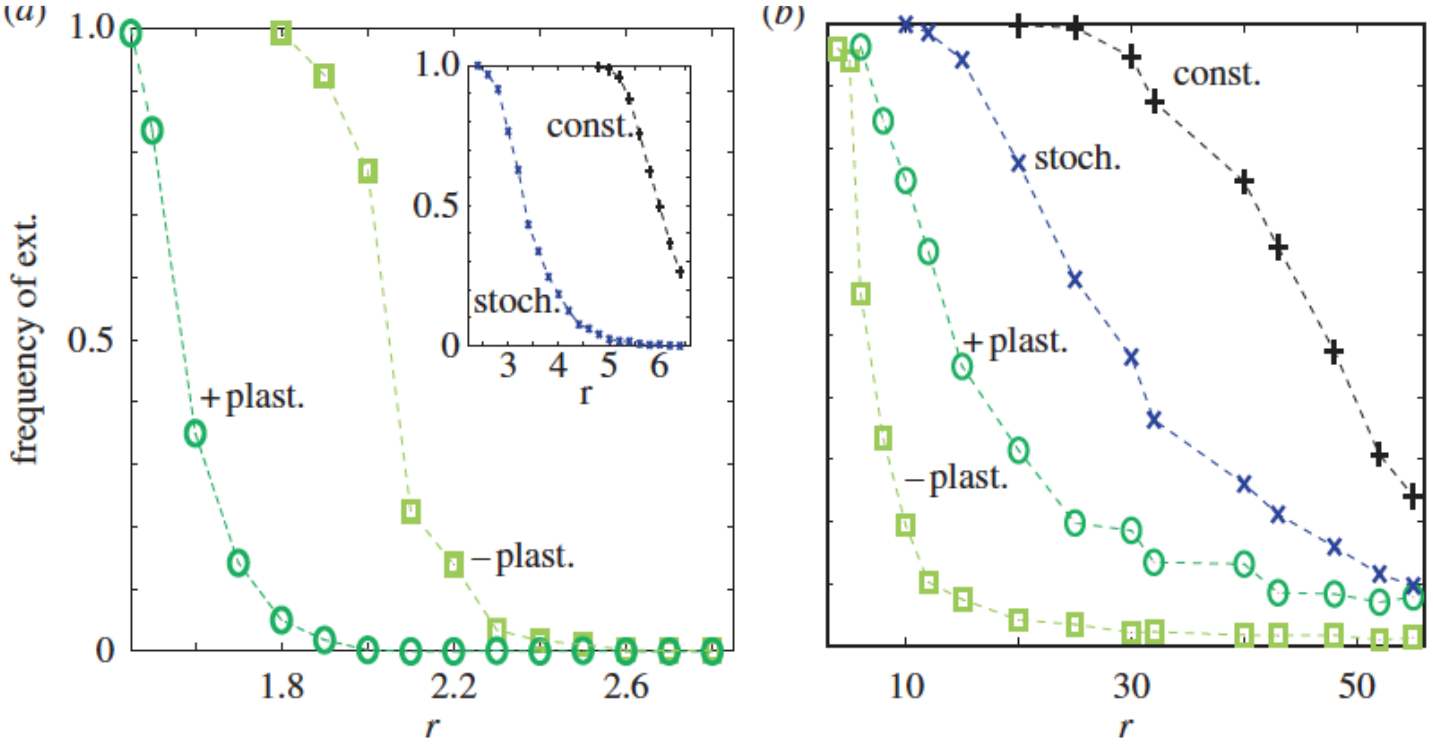
Cheater invasions can lead to recovery



Different heuristics associated to different environments

N small

N large



Are people conditionally cooperative?

people who are willing to contribute more to a public good the more others contribute

Experiment

- 4 individuals deciding how to spend 20 tokens into a so-called 'project'

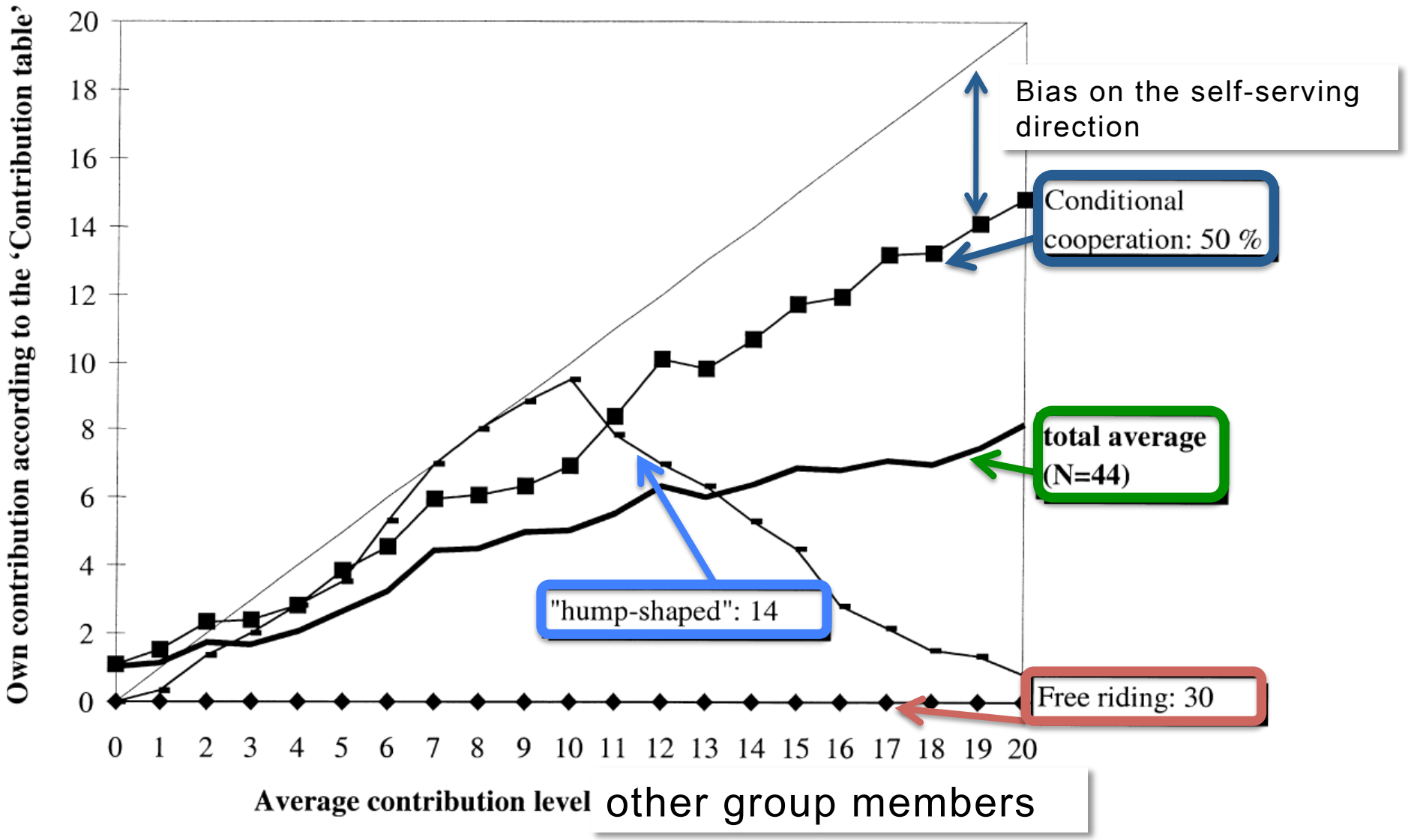
- Two classes of decision 1)unconditional or 2)conditional contribution (for each average contribution how much am I willing to contribute?)

- Experiment played once

-1 out of 4 chosen to use decision class 2) based on unconditional decisions (class 1) of the other 3.

Fischbacher U. *et al*, Econ. Lett. 71 (2001) 397

The decline of cooperation



Are people using heuristics?

We consider two systems of reasoning
(dual-process framework)

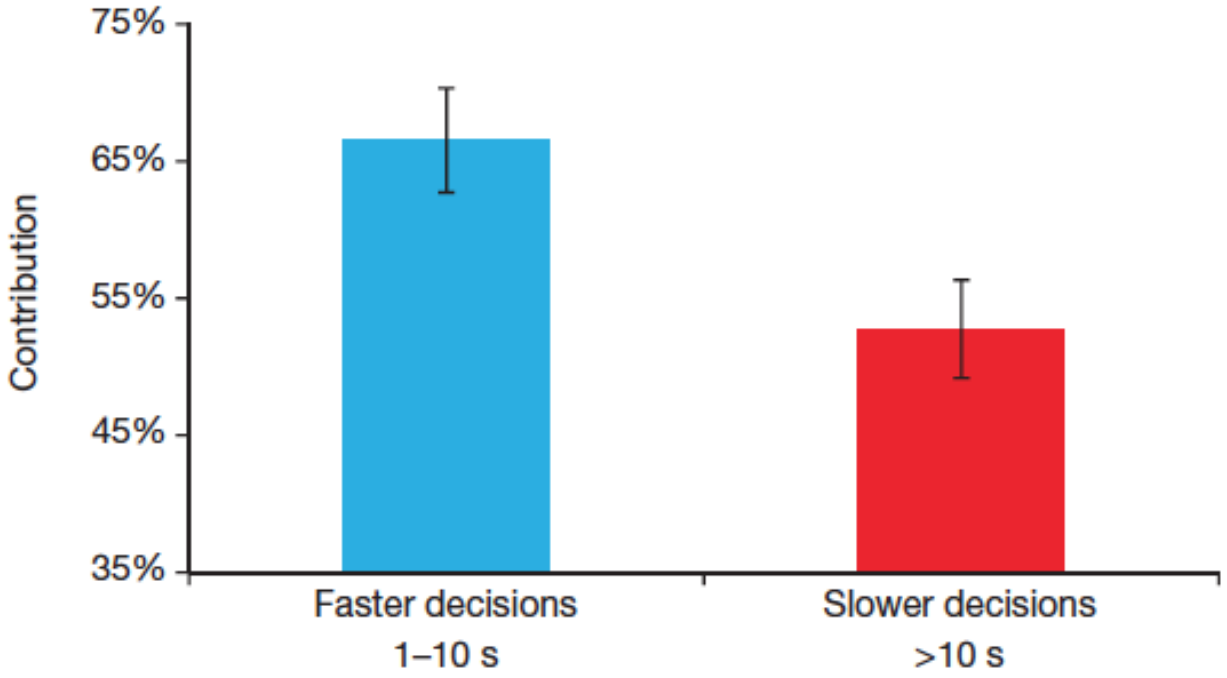
- System 1: fast, intuitive, heuristic-based, parallel processing, 'cheap'

- System 2: slow, reflexive, associative-based, serial processing, costly

How would these two systems influence cooperative decision-making?

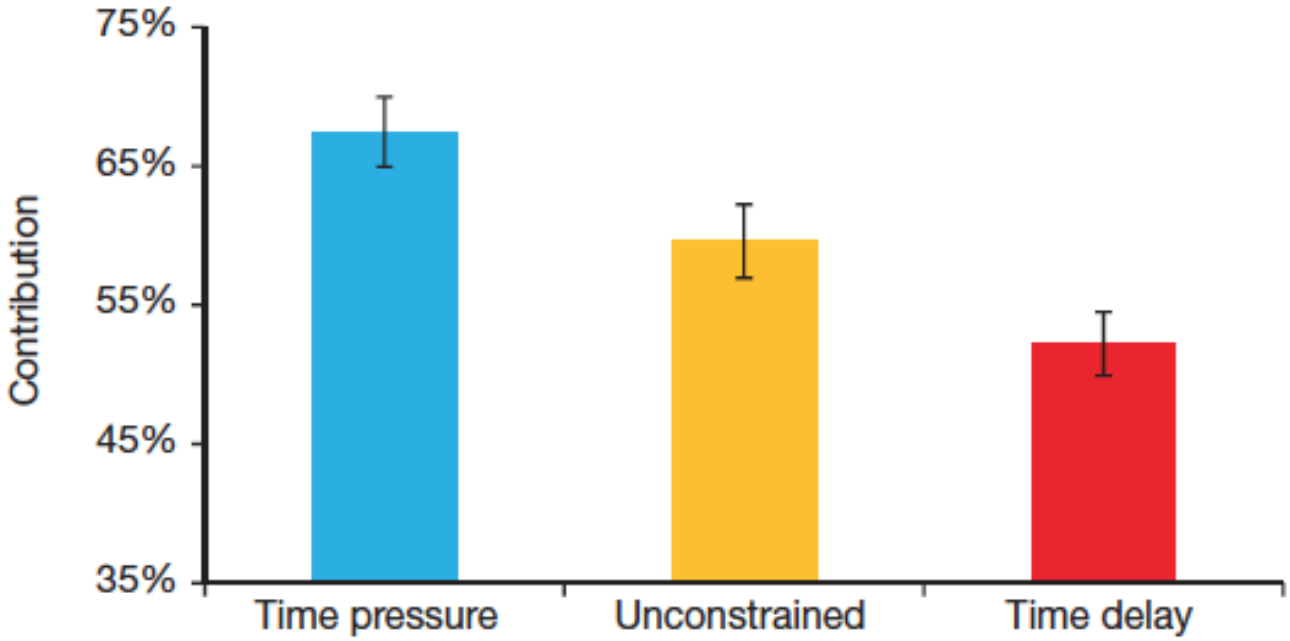
Rand GD. *et al*, Nature 489 (2012) 427

Faster decisions are more cooperative



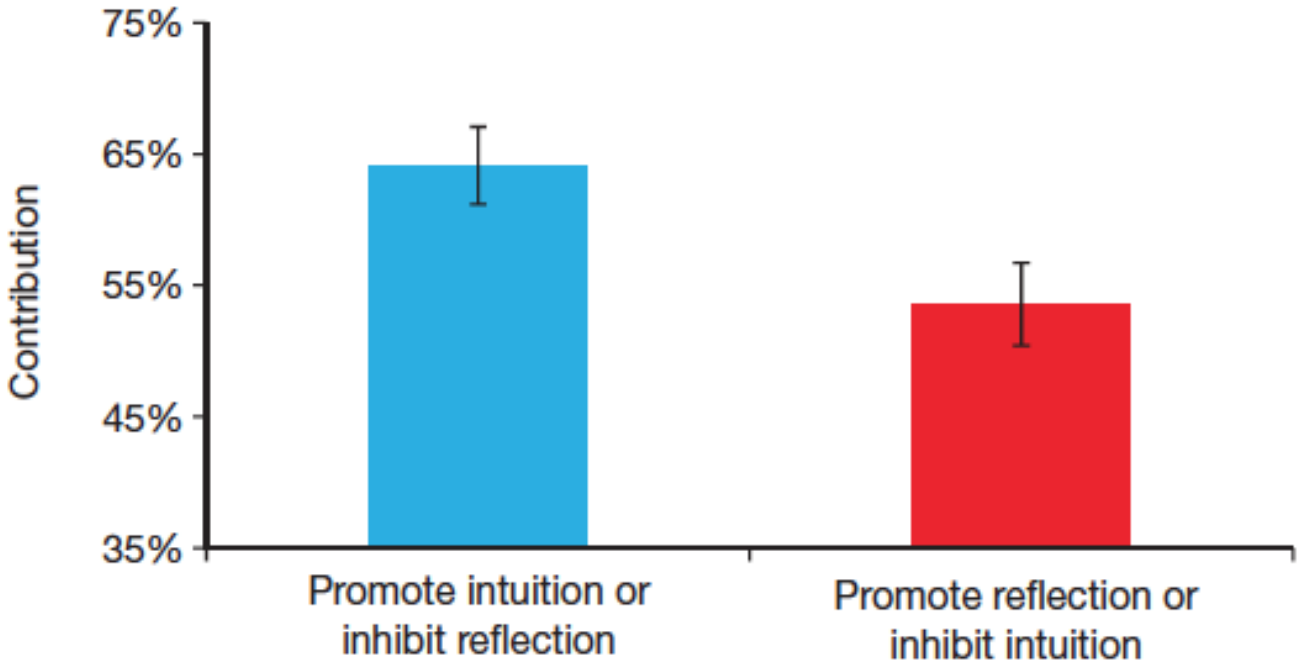
One-shot public good games with groups of 4 participants

Faster decisions are more cooperative



Inducing intuitive thinking promotes cooperation

Faster decisions are more cooperative



Priming modifies cooperation

It might be better for cooperation if we split in groups

Don't share all your public goods, keep a bit for yourself!

When in need … move!

This was not the most optimal decision but it sure was the most ecologically rational

Don't think … and cooperate!