Genotype or Phenotype?

The conflation of two concepts in evolutionary agent-based modelling

(with Will Braynen, Paul Dwyer, Mollie Poynton, Alejandro Balbin and Imre Risi Kondor)

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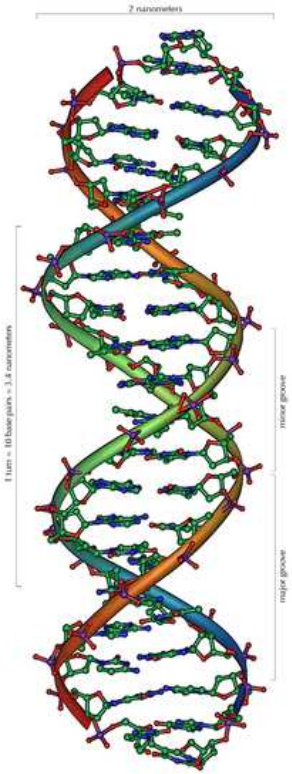
Agenda

1. Genotypes and phenotypes ...
2. The issue of *conflation*
3. Does it matter? (a numerical simulation)
4. What to do?

Genotype-Phenotype mapping: Biology

Genotype + Environment $\longrightarrow$ *Donax-variabilis* (many phenotypes)



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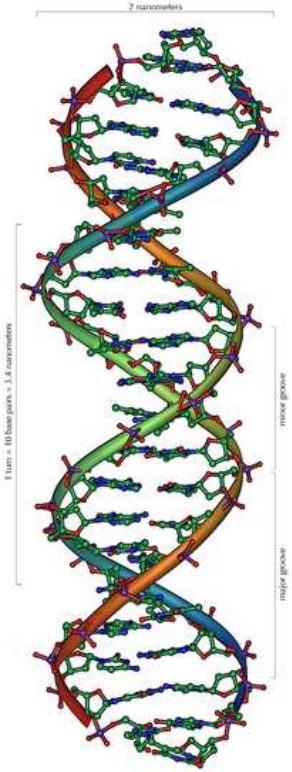

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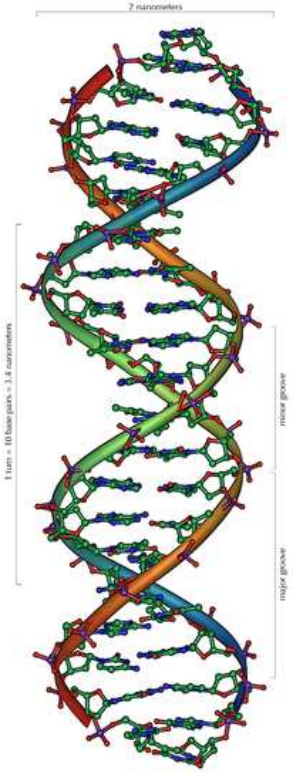

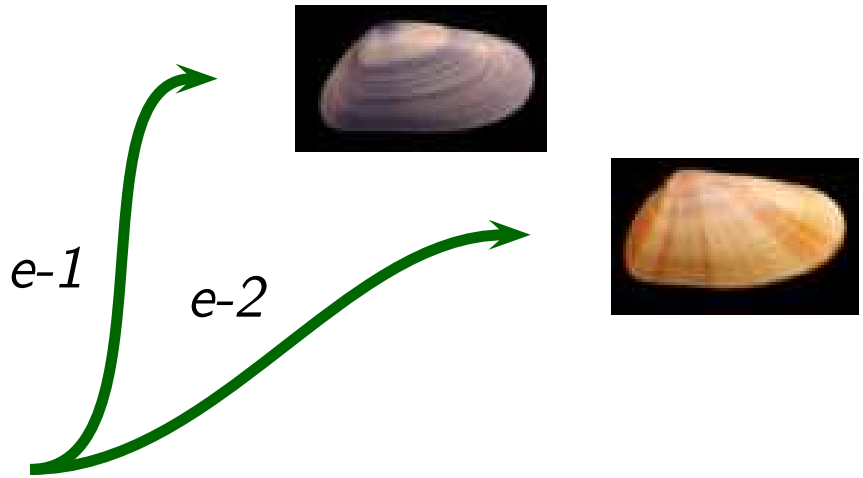

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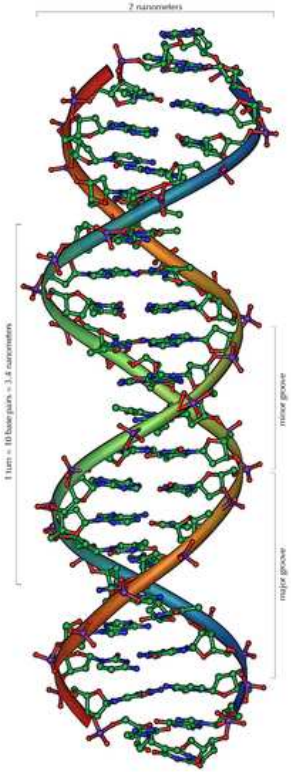

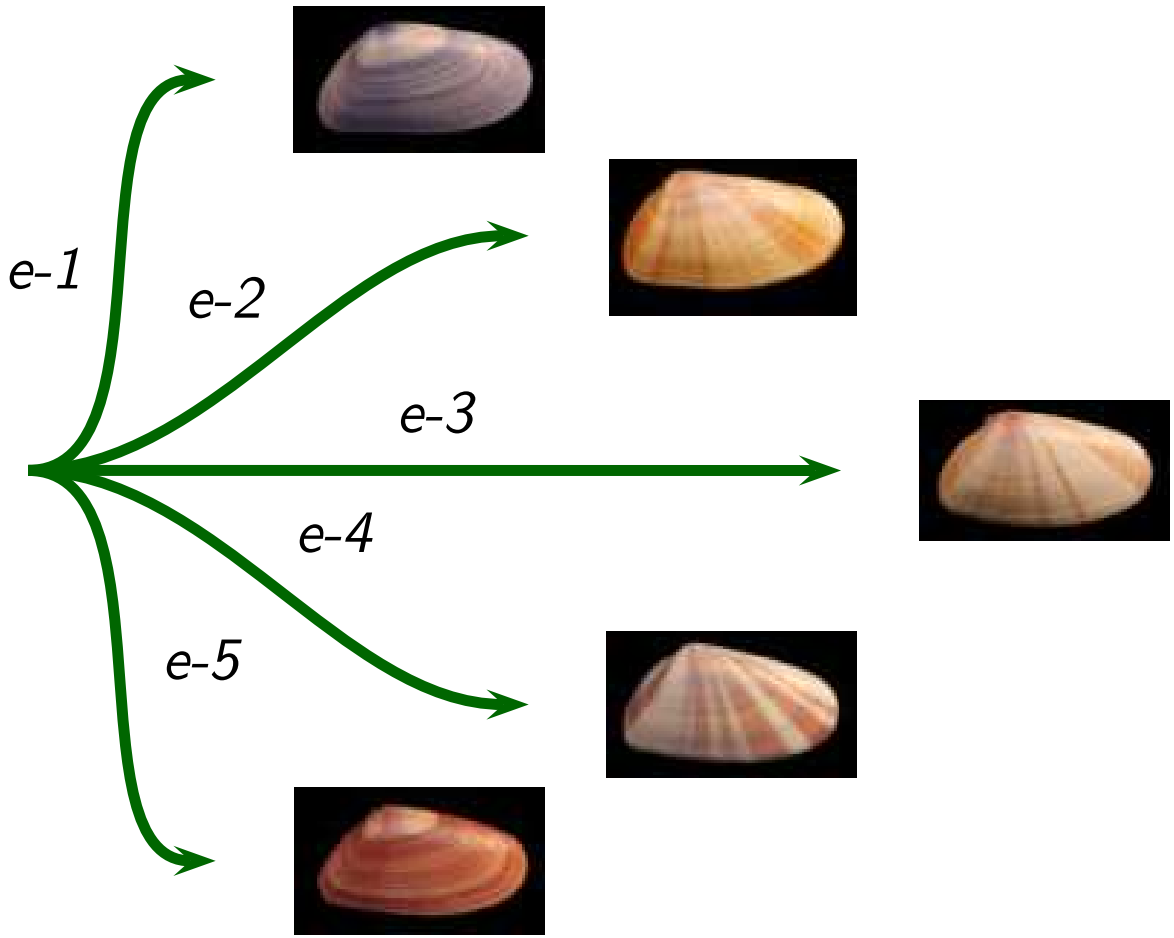

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Genotype-Phenotype mapping: Business

Strategy + Environment $\longrightarrow$ *Behaviour* (many phenotypes)

(Image sources: http://www.mcdonalds.com/)

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USA

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Genotype-Phenotype mapping: Business

Strategy + Environment $\longrightarrow$ *Behaviour* (many phenotypes)

USA

Columbia

i'm lovin' it

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Genotype-Phenotype mapping: Business

Strategy + Environment $\longrightarrow$ *Behaviour* (many phenotypes)

USA

Columbia

Czech Republic

New Zealand

Australia

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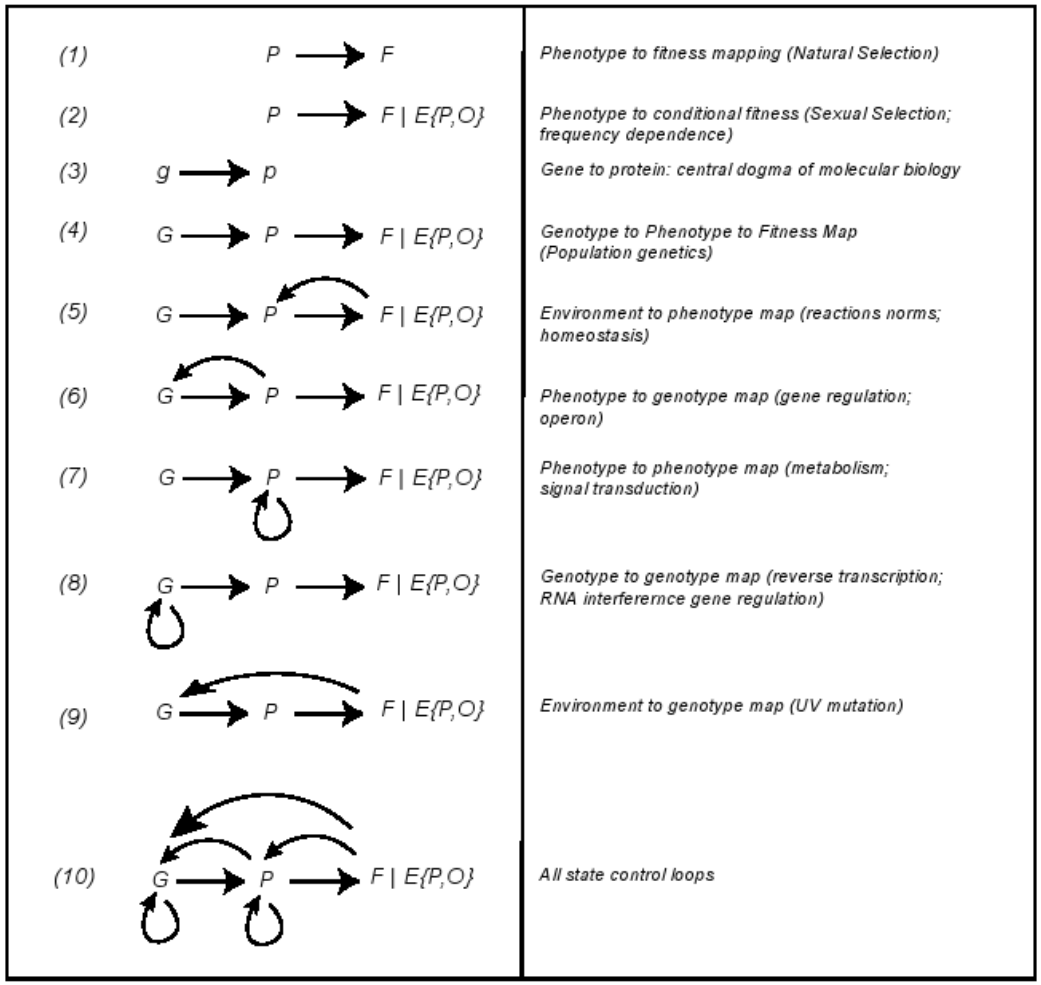
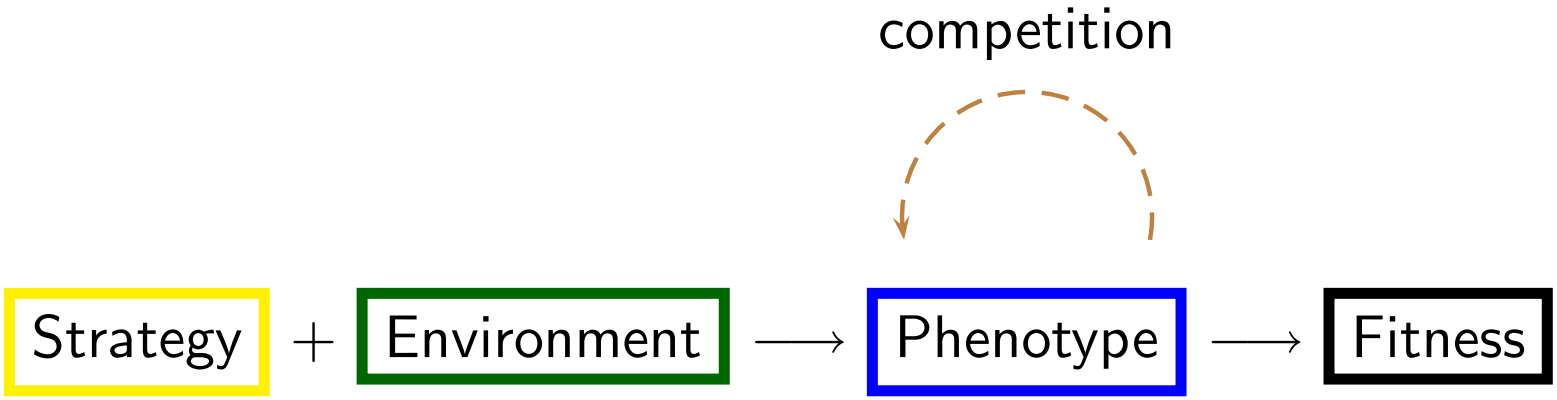
Is there a Genotype–Phenotype Map??



Source: Krakauer, D; 'Domains of Interaction in Evolution, Transmission, Construction and Selection', unpublished (2004, SFI)

But in our models ...



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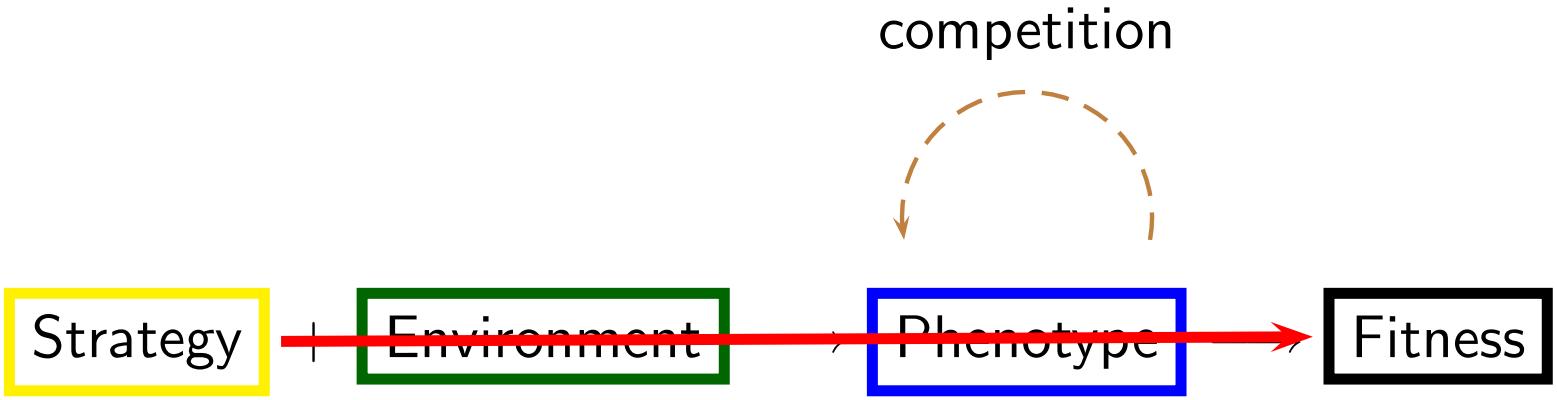

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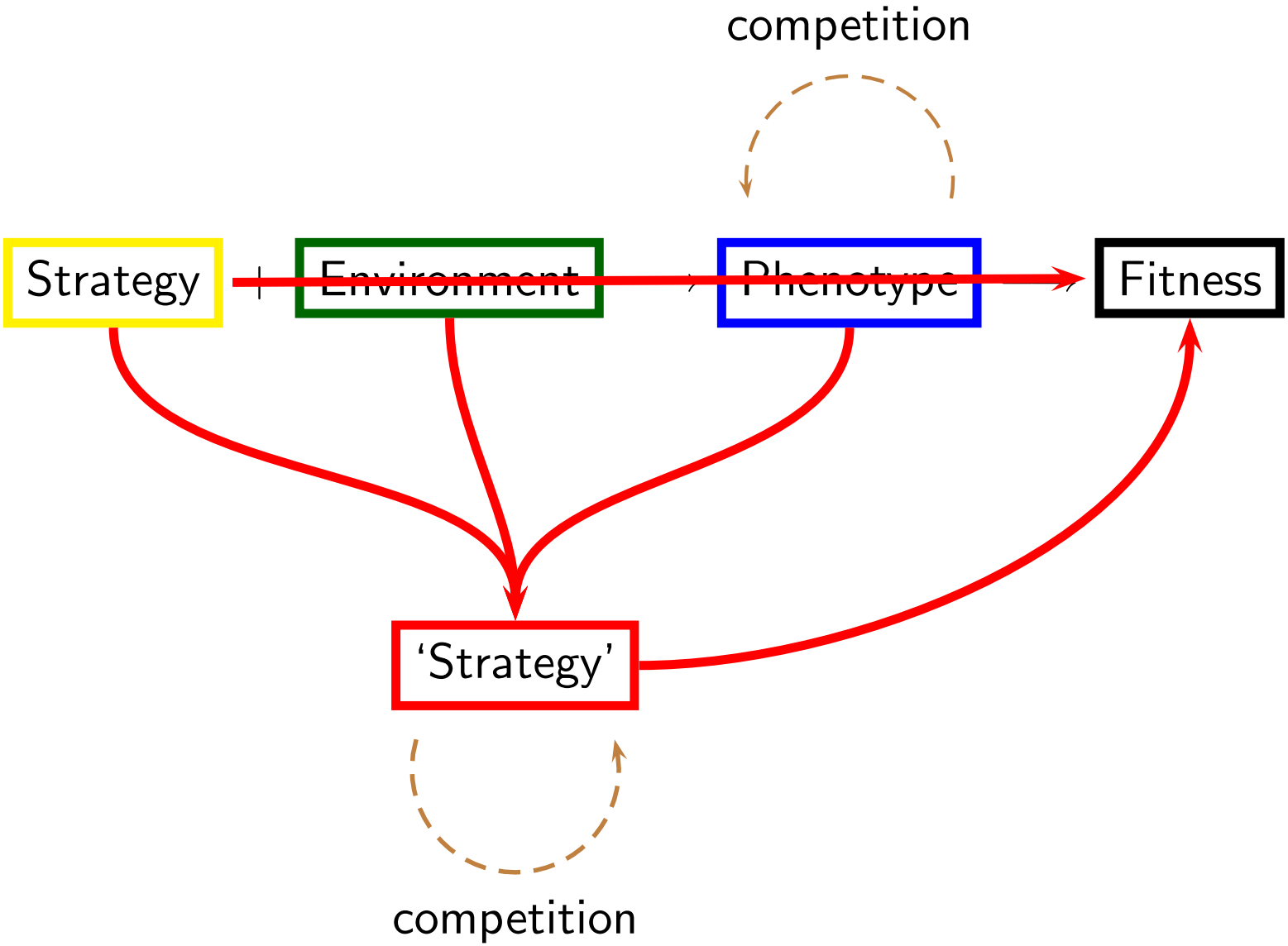

Why did we 'miss' environment/phenotype?

1. It's *easier* to compete on strategies...
2. What is an 'environment' in economic models?
3. What is a 'phenotype' in economic models?

Teasing them apart...

The status quo... ('conflation')

'parent' $G_p + E \longrightarrow P \longrightarrow F(P|E, N)$

'child' $G_c + E \longrightarrow P \longrightarrow F(P|E, N)$

A 'real' model... ('limited observation')

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'parent' $G_p + E \longrightarrow P \longrightarrow F(P|E,N)$

inheritance

'child' $G_c + E \longrightarrow P \longrightarrow F(P|E,N)$

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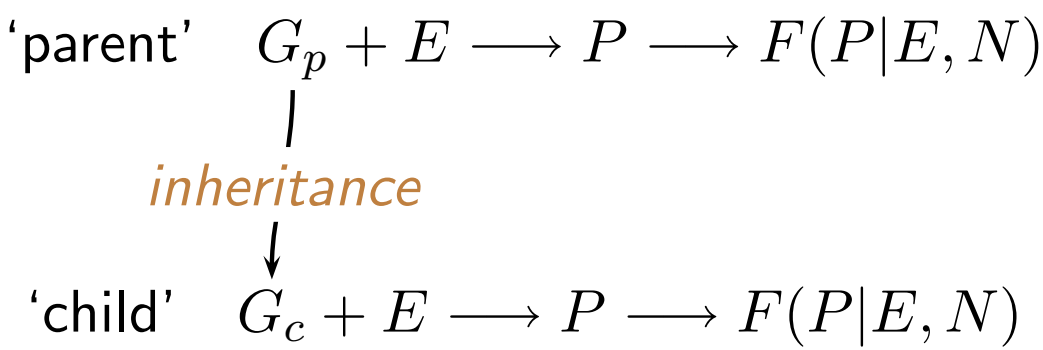

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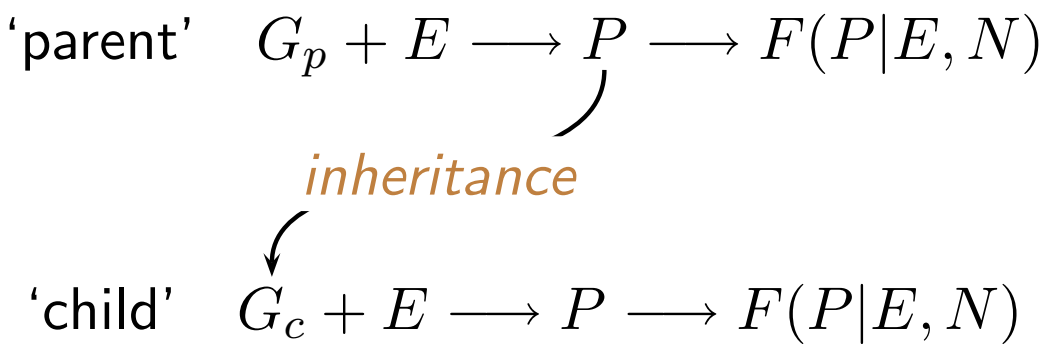

Model details

Strategy Agent i's *probability* p_i of playing '1'

Actions 'Flips' of a biased coin (based on p_i) yielding $a \in \{0, 1\}$

'Environment' Random number generator R that chooses a, that is,

$$a_i^t = R(p_i, E)$$

Competition Evaluated by *spatial* Prisoner's Dilemma $(0 = C, 1 = D)$ with i's neighbours in radius r

Fitness Mean payoffs via PD game-table, (Nowak and May, or Axelrod)

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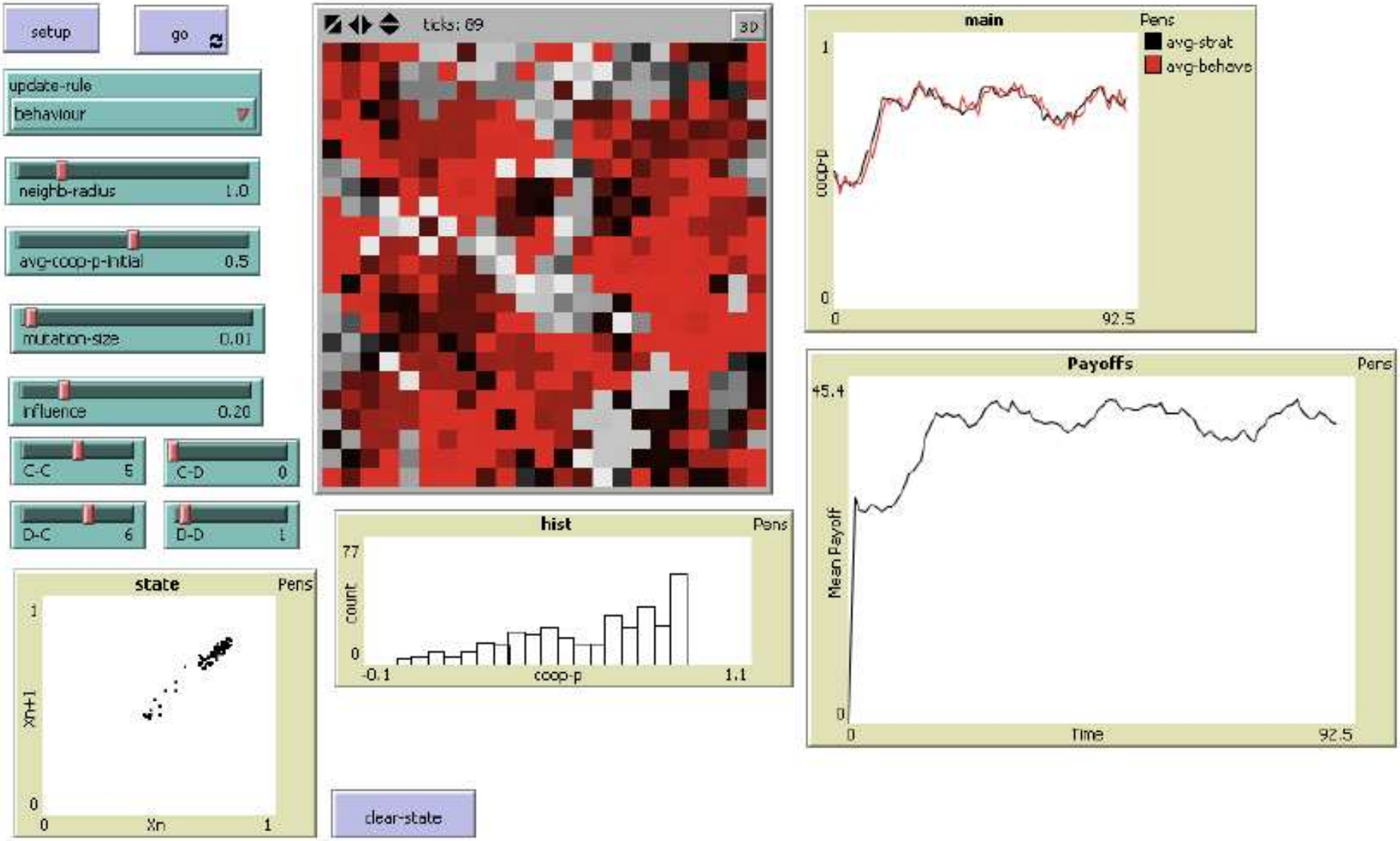
Timing

1 Step

1. For each agent i:
   1. For each neighbour j in i's radius r:
      1. Flip biased coin based on p_i to get a_i
      2. Flip biased coin based on p_j to get a_j
      3. Get payoffs due to $\Im(i, j)$
   2. Sum all payoffs
   3. Immitate: set $p_i = p_j : G^j = \max(G|r)$

Numerical simulation

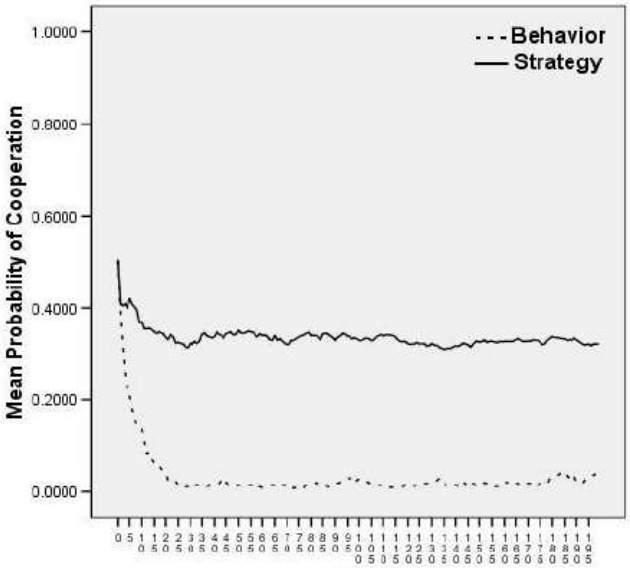


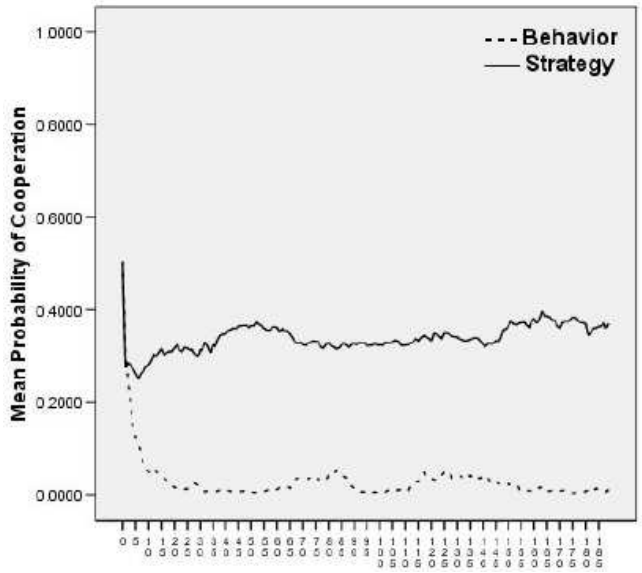
Wilensky (1999) *NetLogo 4.0 beta 3*

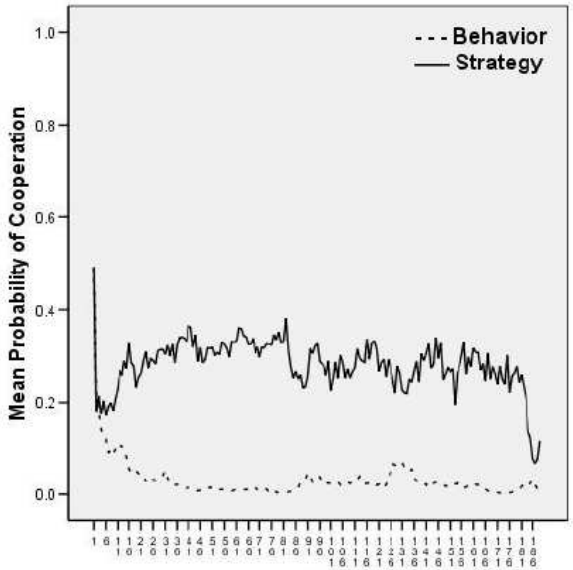
Numerical details

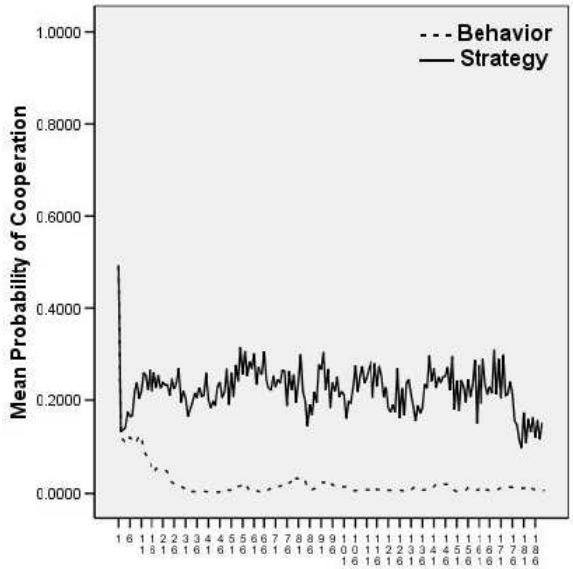
World	23 x 23 spatial grid, periodic boundary conditions
Trials	200 per experiment condition
Variables	1 Payoffs: Axelrod or Nowak/May; 2 Neighbourhood size r (Von Neumman, Moore, etc.)
Initialisation	Full map; gaussian (or uniform) p
Platforms	*NetLogo*; *Repast*

Axelrod (3,0,5,1)

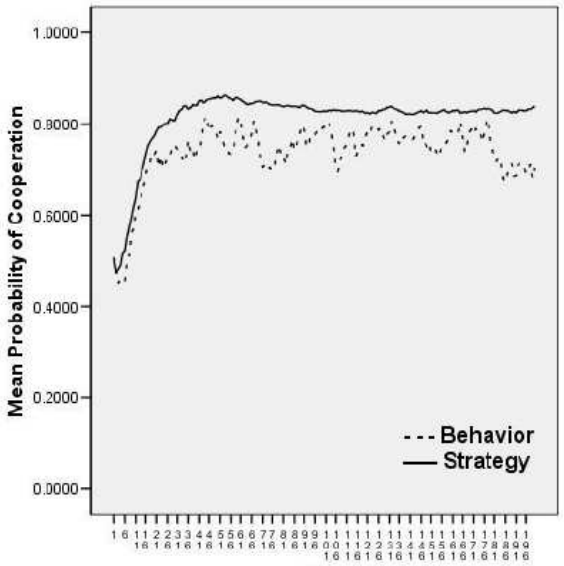


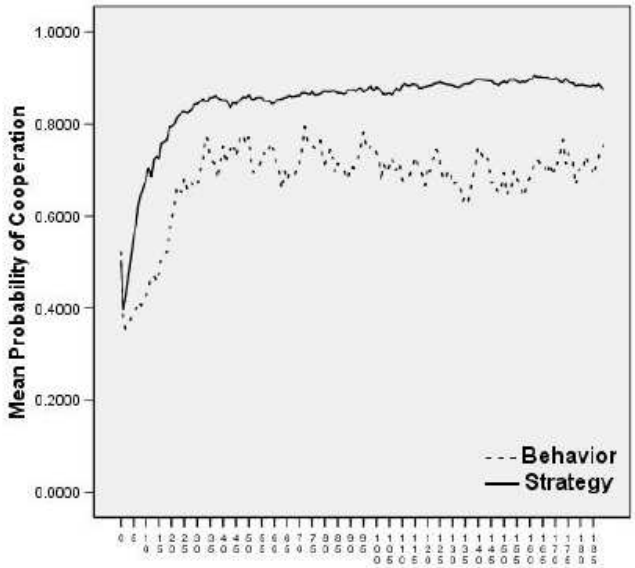


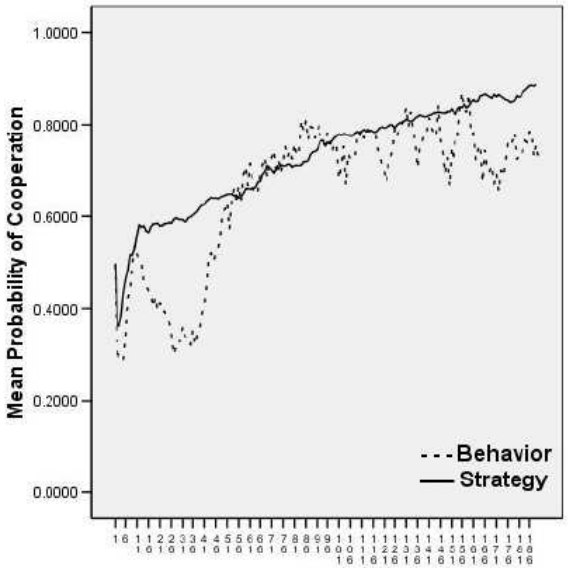


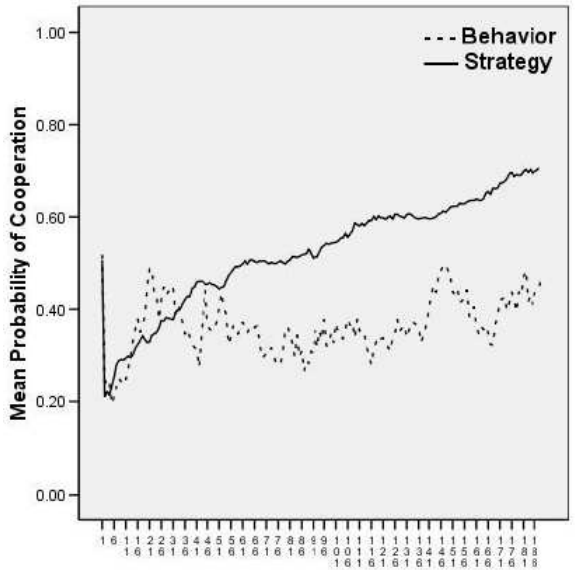


Nowak/May (5,0,6,1)









1. Immitating *strategy* (genotype) gives significantly better payoff than immitating *behaviour* (phenotype)
2. E.g. under Von Neumman neighbourhoods ($r = 1$):
   - Immitate behaviour (phenotype): $p = 0$
   - Immitate strategy (genotype): $p = 0.4$
3. Robust (statistically) across neighbourhood radii, and common payoffs

Intuition

- Different regimes change *information* access between players
- Larger r increase sample size, and so

$$\lim_{r \to \infty} a_j \longrightarrow p_j$$

- The behavioural information is noisy, can be thought of as

$$a_i = p_i + e_i$$

Discussion

1. Care is needed in applying evolutionary concepts to the socio-economic context
2. Immitating behaviour or strategy matters
3. Not just 'information', but environment/developmental considerations ... how does a particular strategy get 'implemented' in an environment?
4. Other studies:
    1. More versatile environmental implementation
    2. Memory as a signal generator
    3. The genotype-phenotype map...

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