On the structural robustness of evolutionary models of cooperation

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PRESENTATION OUTLINE

- **Aim and necessary background**
- **Previous work and problems with it**
  - **Classical Game Theory**
  - **Axelrod's (1984) Tournaments**
  - **(*Mainstream*) Evolutionary Game Theory**
- **Our work:**
  - **Methodology: Agent-based modelling**
  - **Results and discussion**
- **Conclusions**

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AIM

To advance our formal understanding of the evolution of cooperation

by determining

in the context of social dilemmas

what behavioural traits

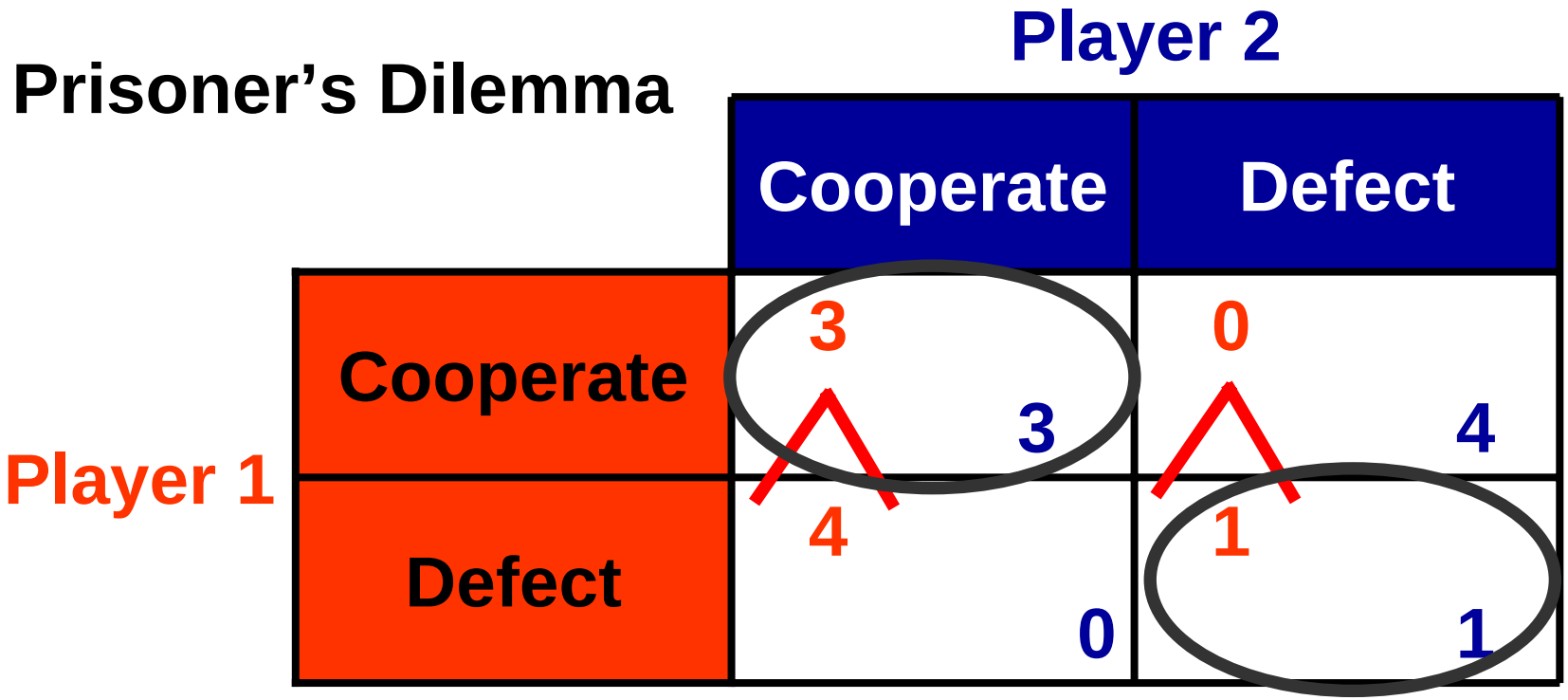
are likely to emerge and be sustained under evolutionary pressures.

BACKGROUND: Social dilemmas …

- **Social Dilemmas:**
  - **Each individual receives a higher payoff for a socially defecting choice than for a socially cooperative choice, no matter what the other individuals in society do, but**
  - **All individuals are better off if all cooperate than if all defect.**

… and its simplest formalisation

The Prisoner's Dilemma

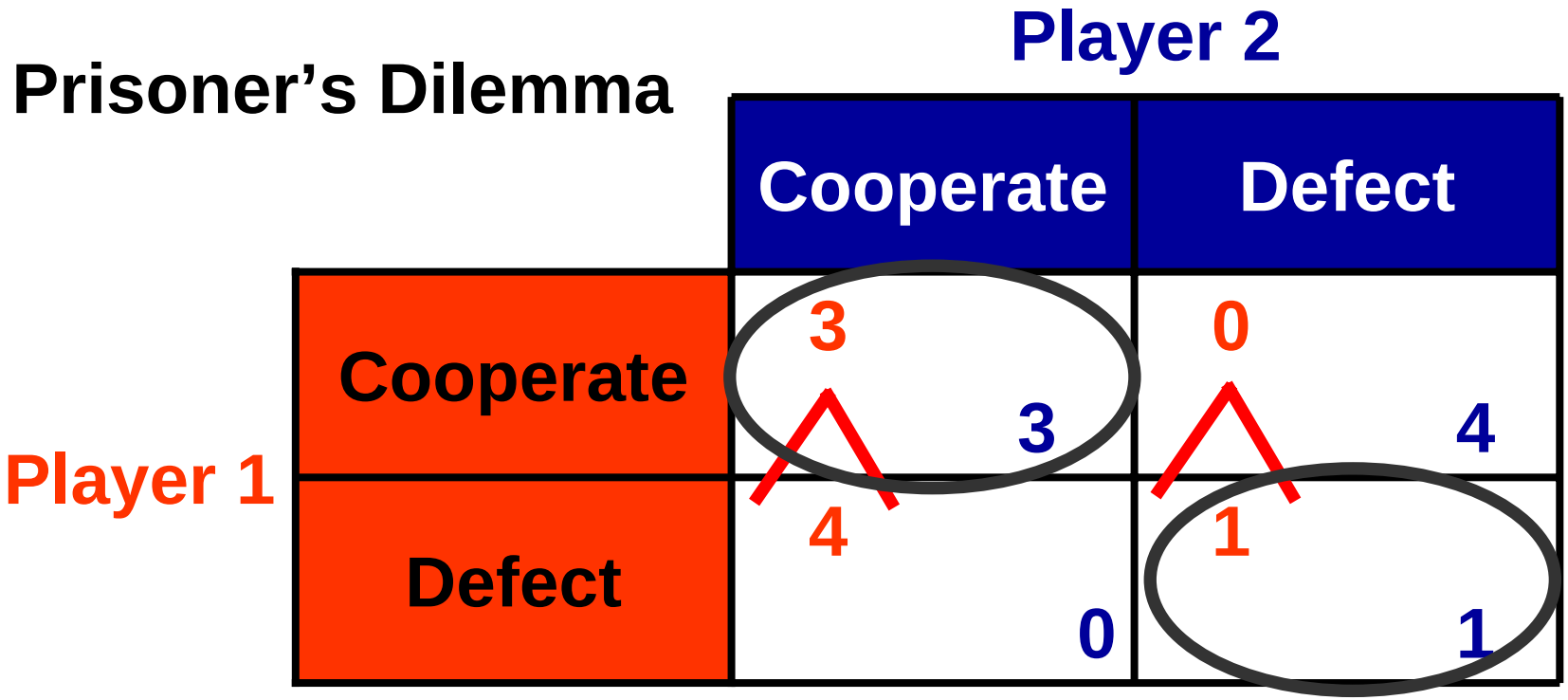


Both players prefer defecting no matter what the other one does

Both players are better off if they both cooperate than if they both defect

… and its simplest formalisation

The Prisoner's Dilemma



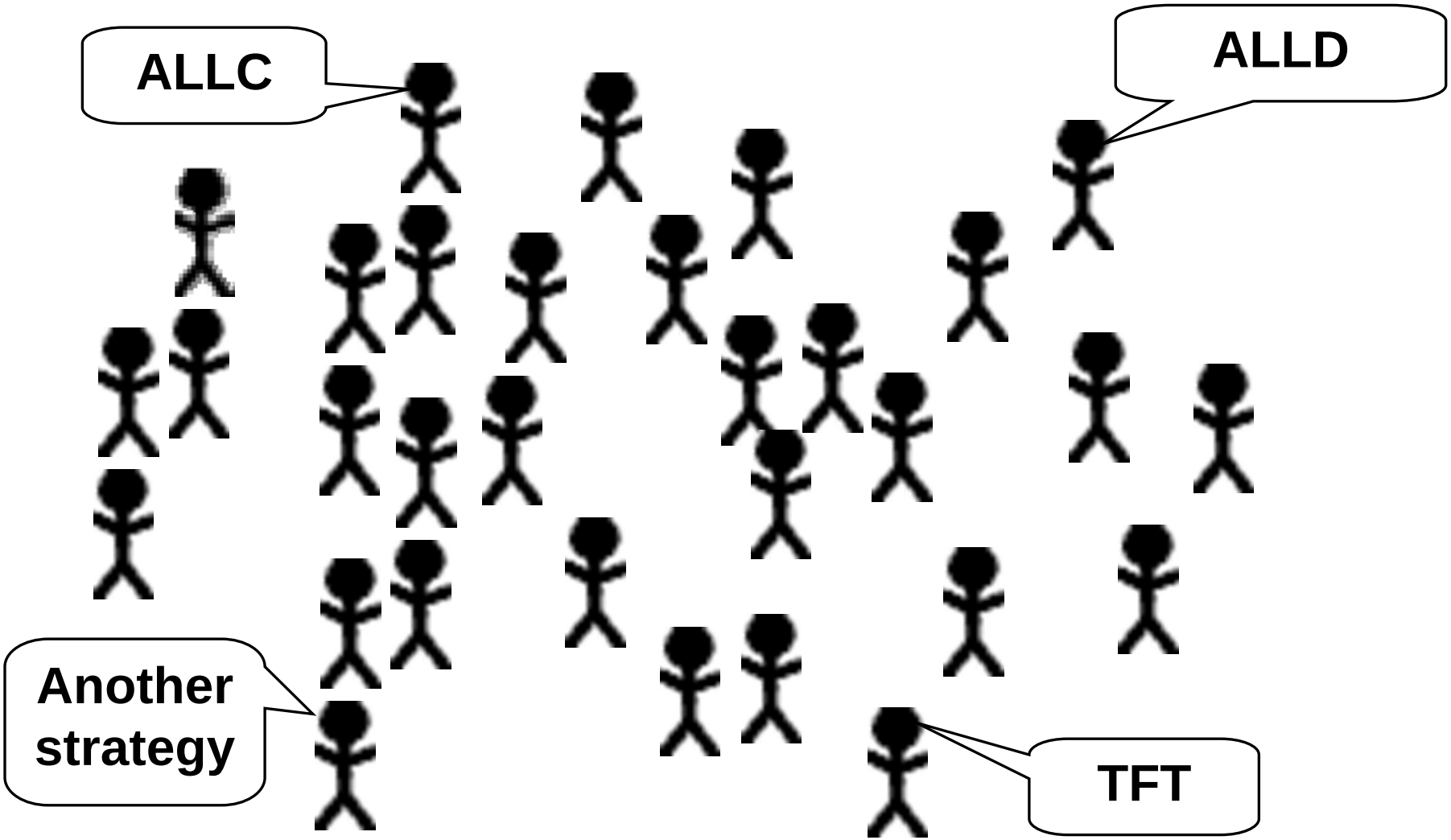
Examples of strategies or behavioural traits:

ALL D: Always Defect

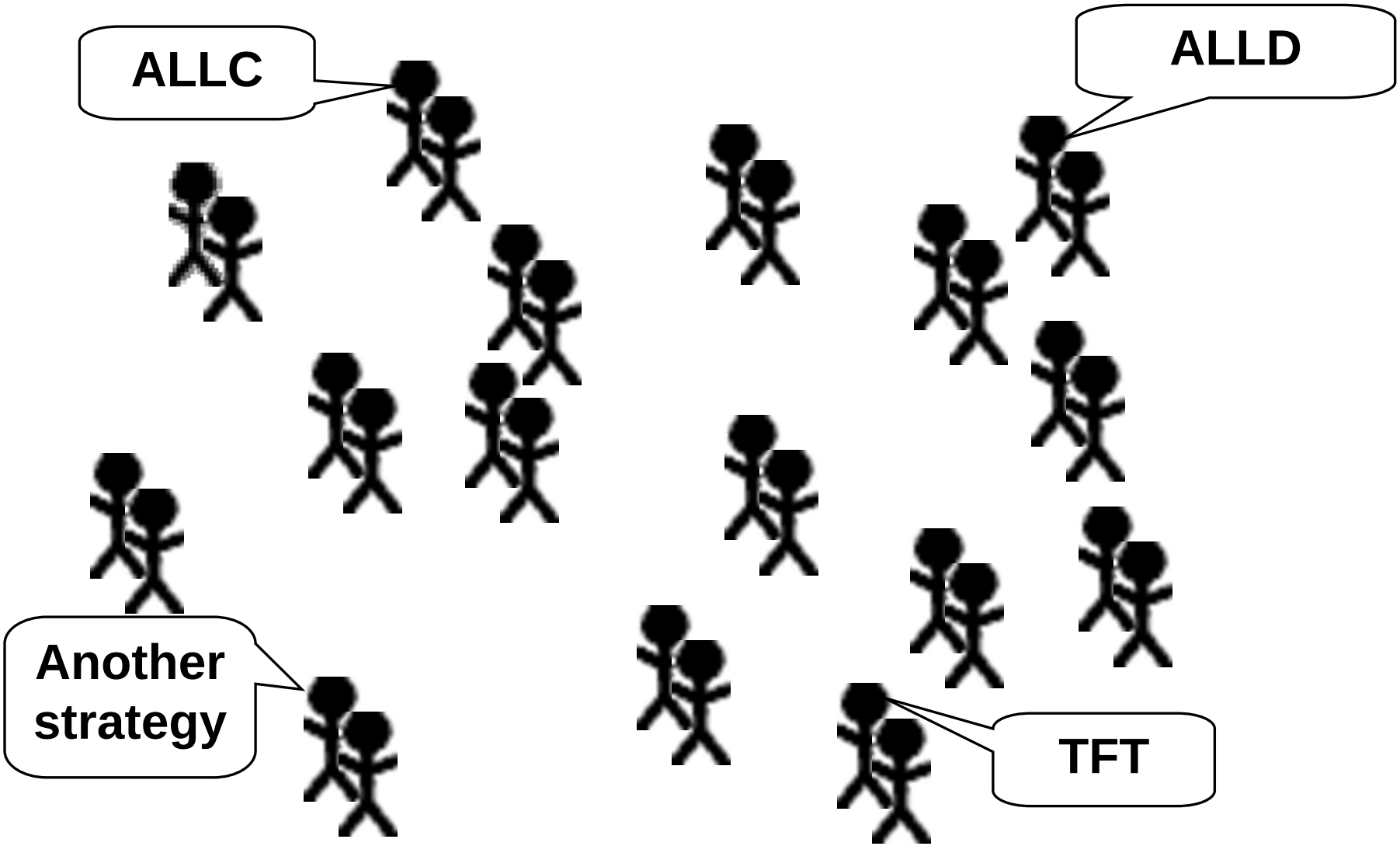
ALL C: Always Cooperate

TFT: C and then do what the other player did

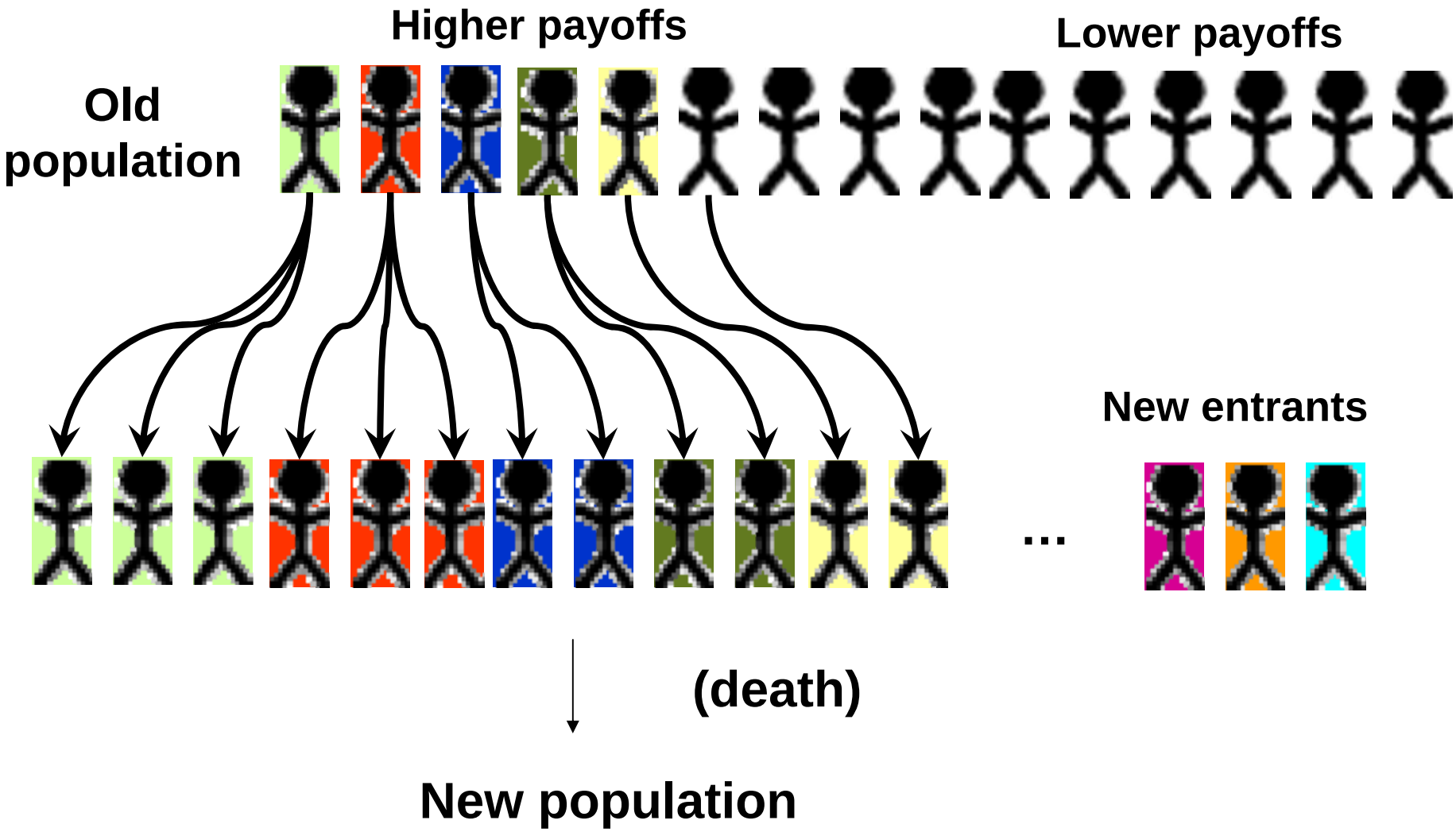
The initial population



The pairing and the game



The selection



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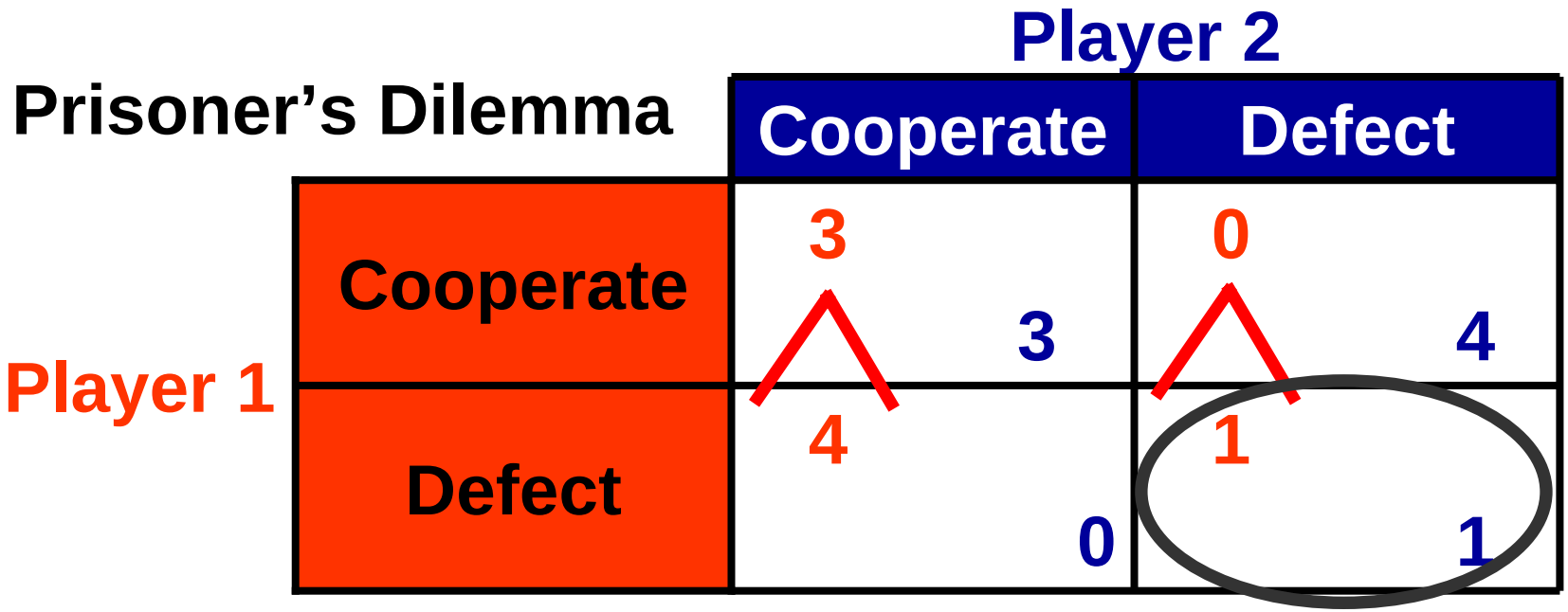
CLASSICAL GAME THEORY:

The Prisoner's Dilemma



- **Played only once:** **Rational players defect.**
- **Played *any* finite number of times:**

  Rational players ALWAYS defect!

  Crucial assumption: Common knowledge of rationality

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AXELROD'S TOURNAMENTS

- **Finitely repeated PD (200 rounds)**
- **Round robin (and vs. random strategy)**

- **Under common knowledge of rationality, everyone should play ALLD...**

  ... but the winner was TFT !!!

Would TFT be the winner under other (more general) conditions?

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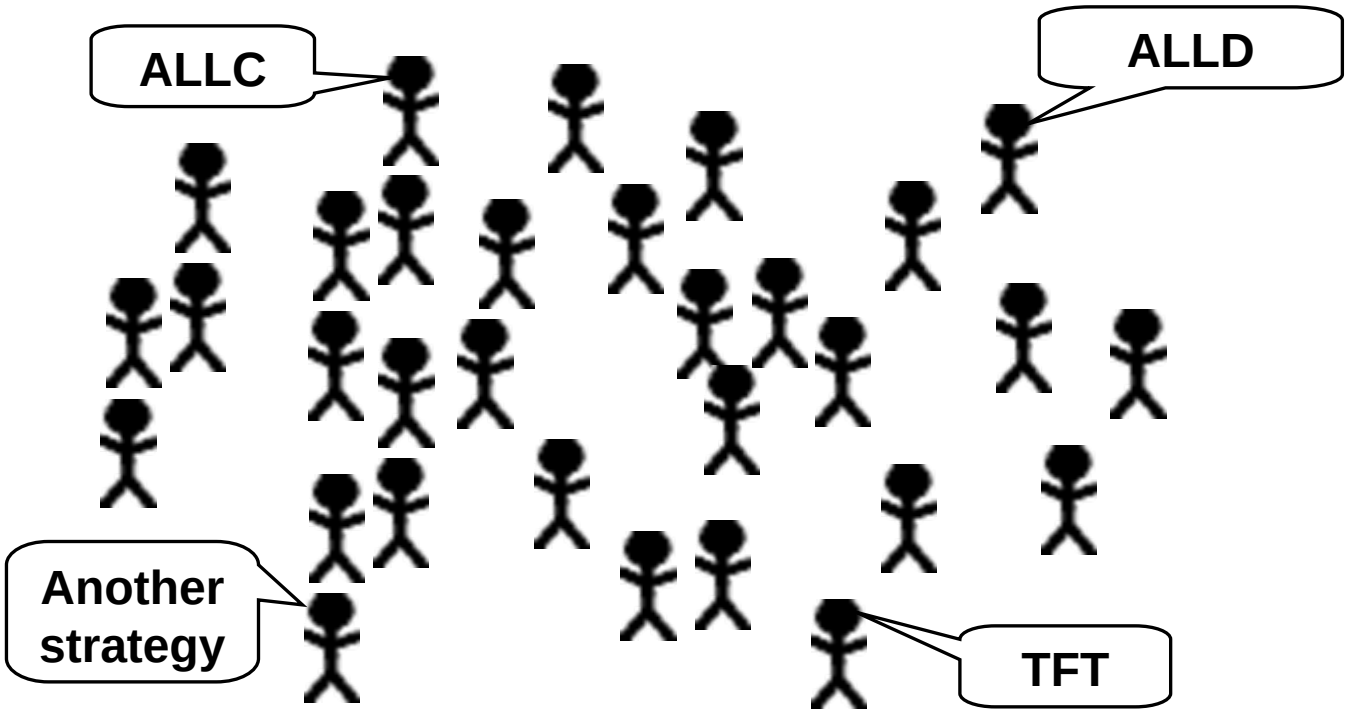
EVOLUTIONARY GAME THEORY

What strategies (i.e. behavioural traits) are likely to emerge and be sustained under evolutionary pressures?



Mainstream
EVOLUTIONARY GAME THEORY

PROBLEM:

Some assumptions made

to achieve mathematical tractability:

- **Infinite populations**
- **Only deterministic strategies**
- **Pairing: Random**
- **Selection: Proportional fitness rule**
- **No mutation or random drift**

Even with many of these assumptions, we don't really know what strategies are more plausible

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Definition of the (unbiased) strategy space

[*PC*, *PC/C*, *PC/D*]

- ***PC*:** **Probability to cooperate in the first round**
- ***PC/C*:** **Probability to cooperate in round *n* (*n* > 1) given that the other player has cooperated.**
- ***PC/D*:** **Probability to cooperate in round *n* (*n* > 1) given that the other player has defected.**

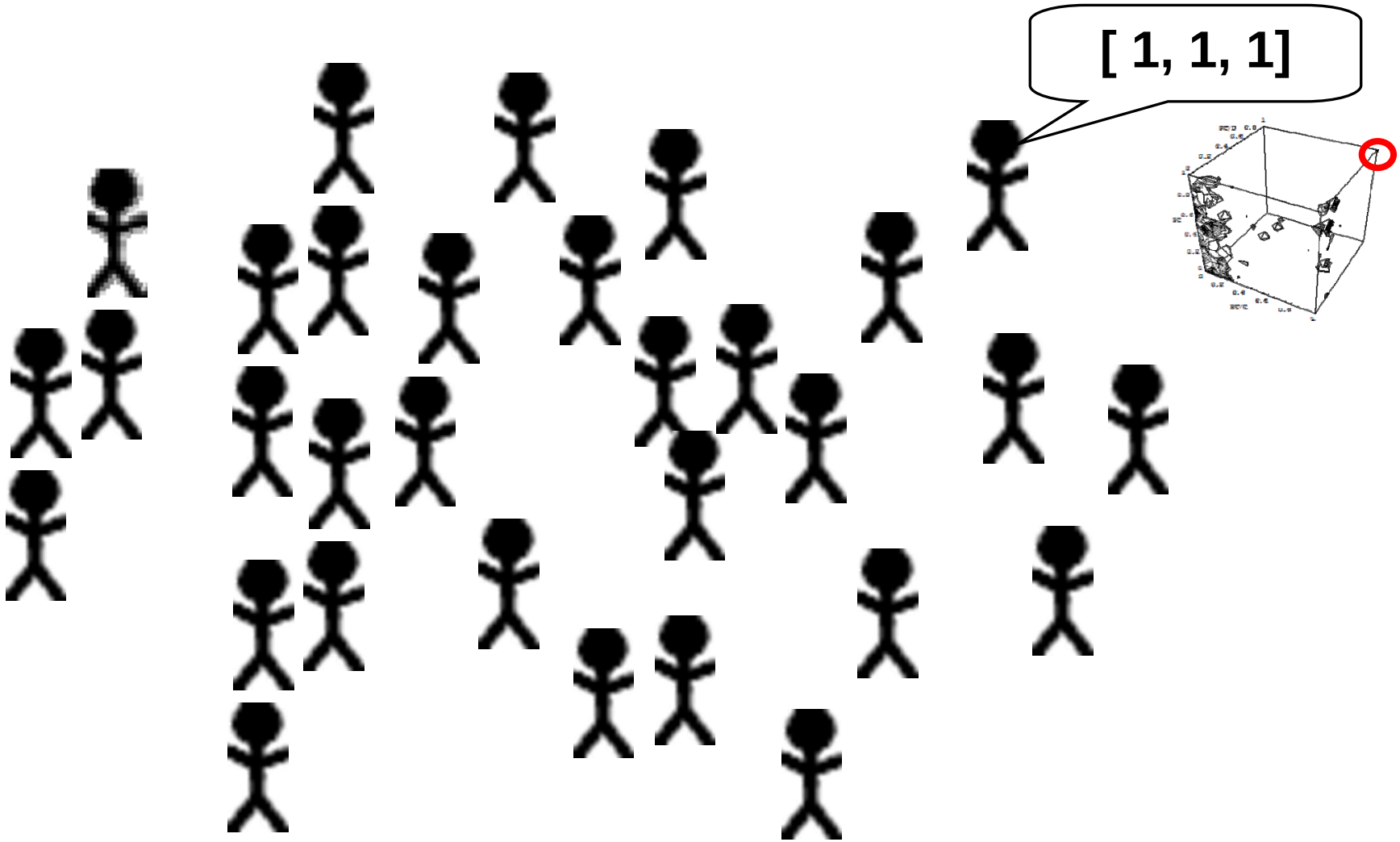
Example: [0.13, 0.34, 0.93]

ALLC: [1, 1, 1]

ALLD: [0, 0, 0]

TFT: [1, 1, 0]

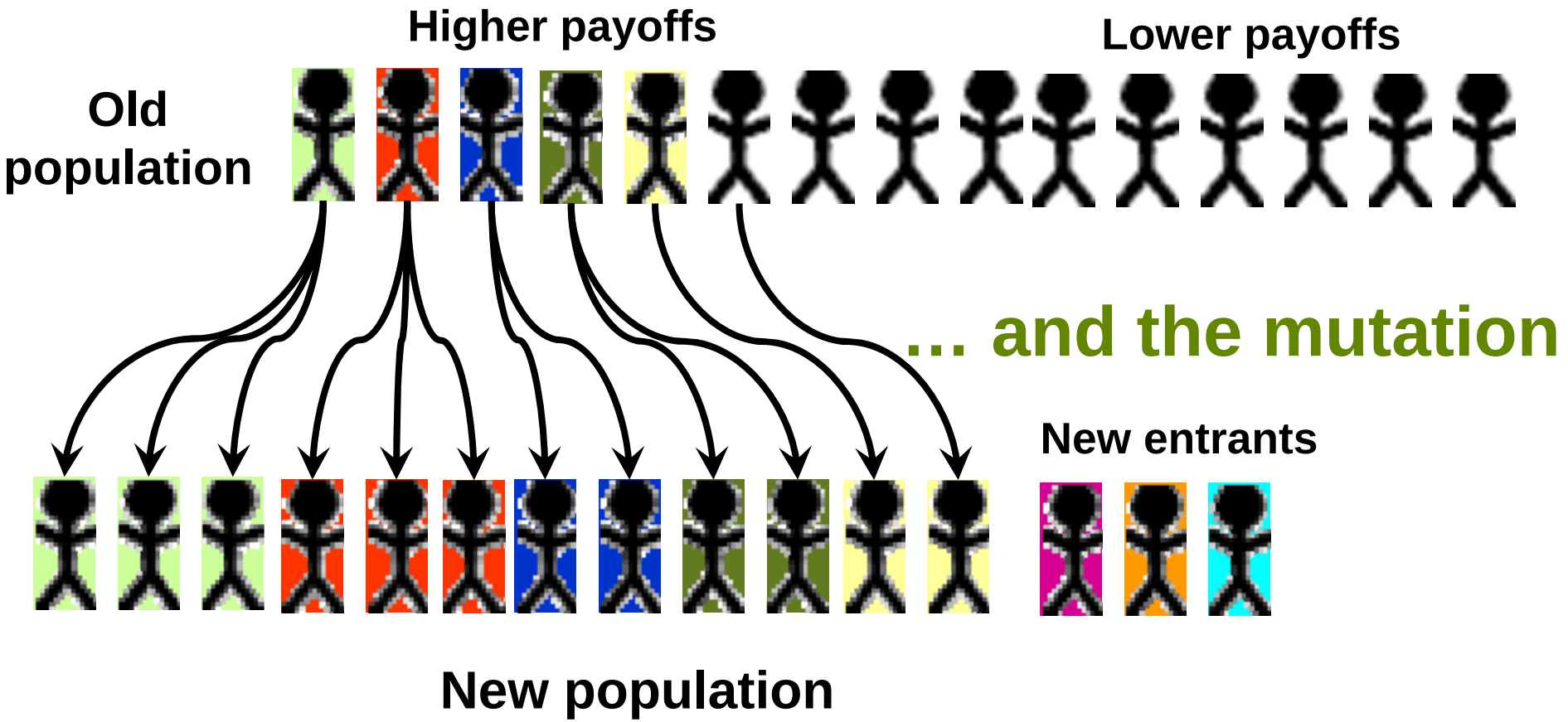
The initial population (different sizes)



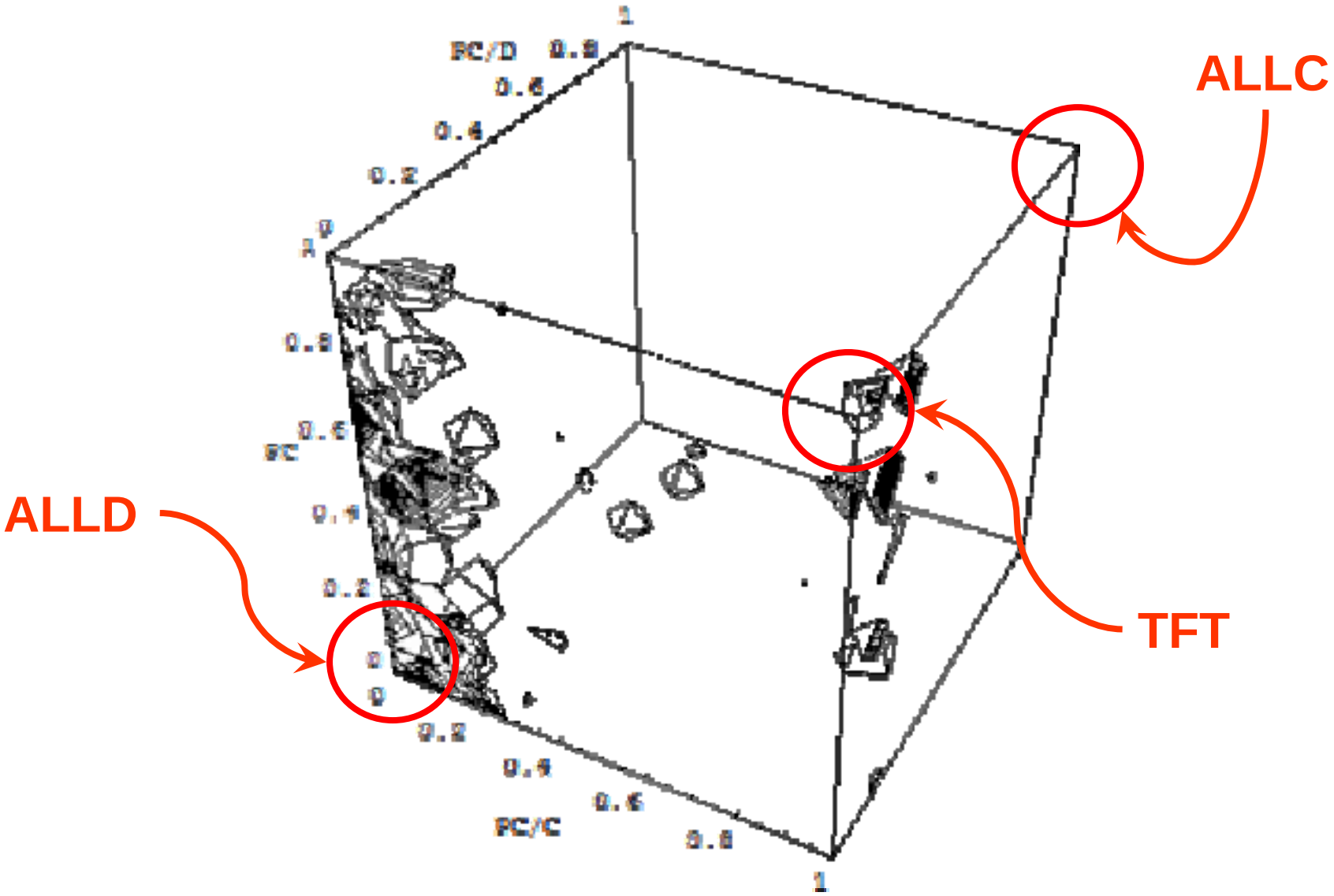
The pairing (random, children together…)

… and (different) number of rounds

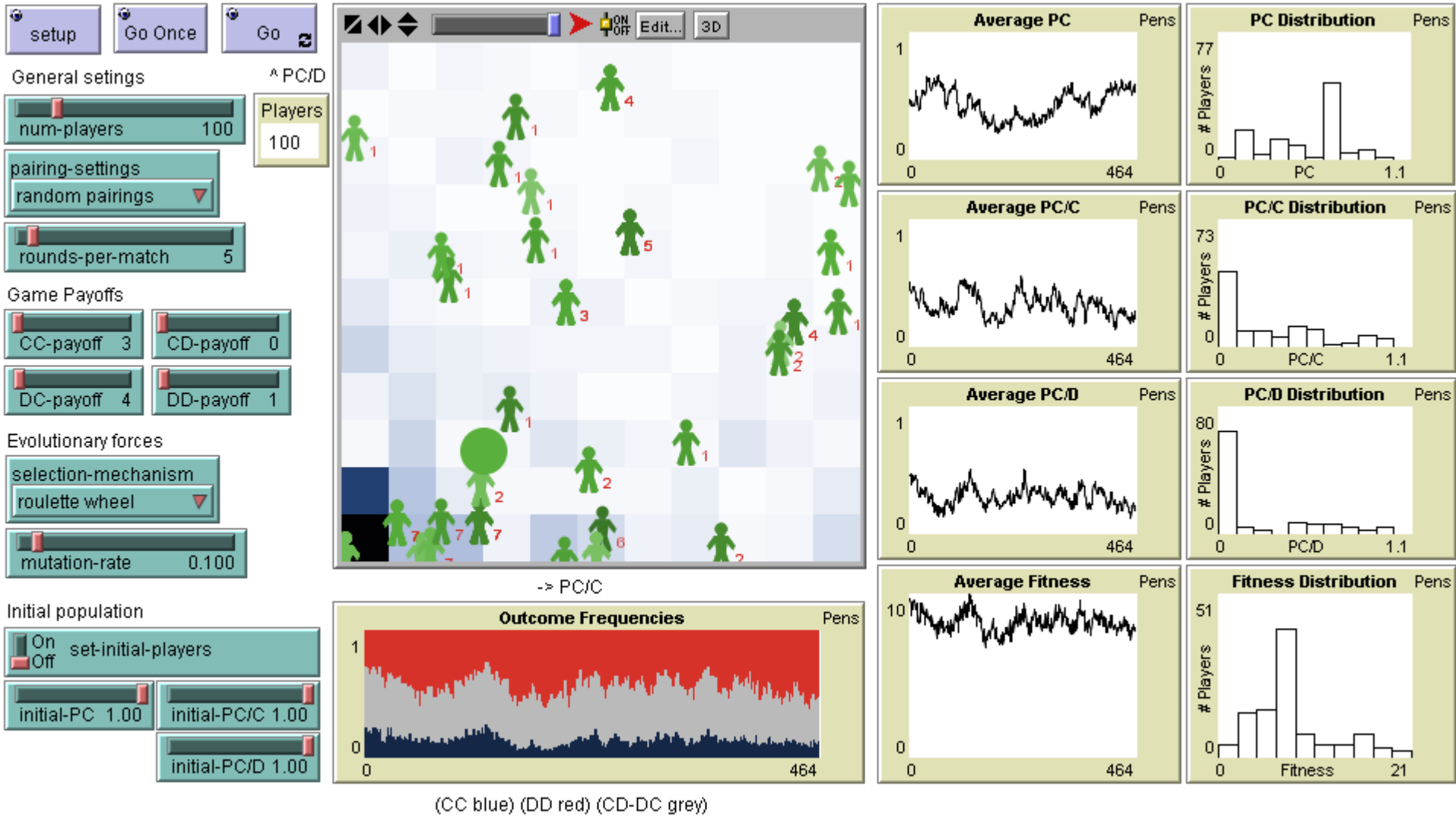
The selection (roulette wheel, tournament…)



The (unbiased) strategy space

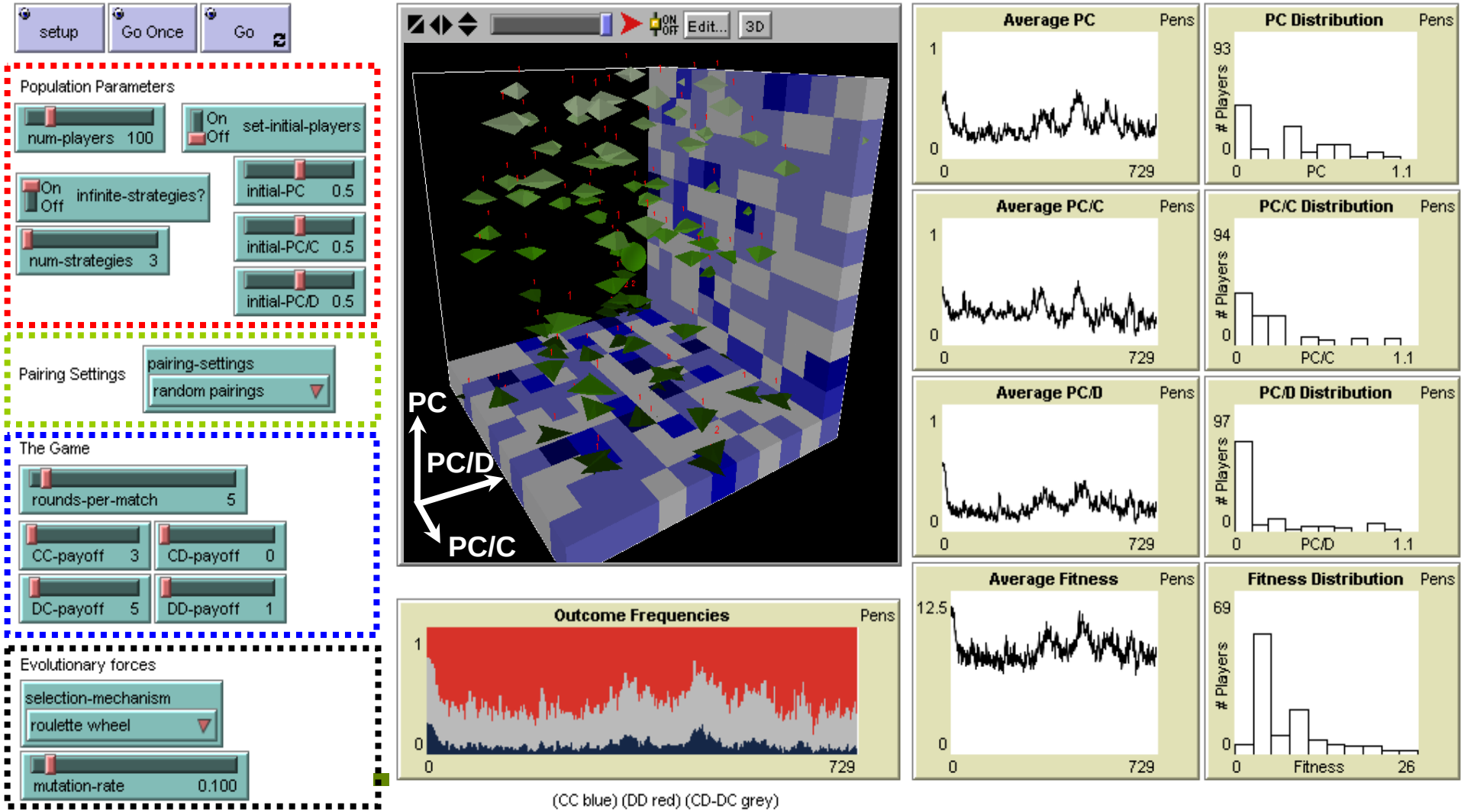


The modelling framework interface



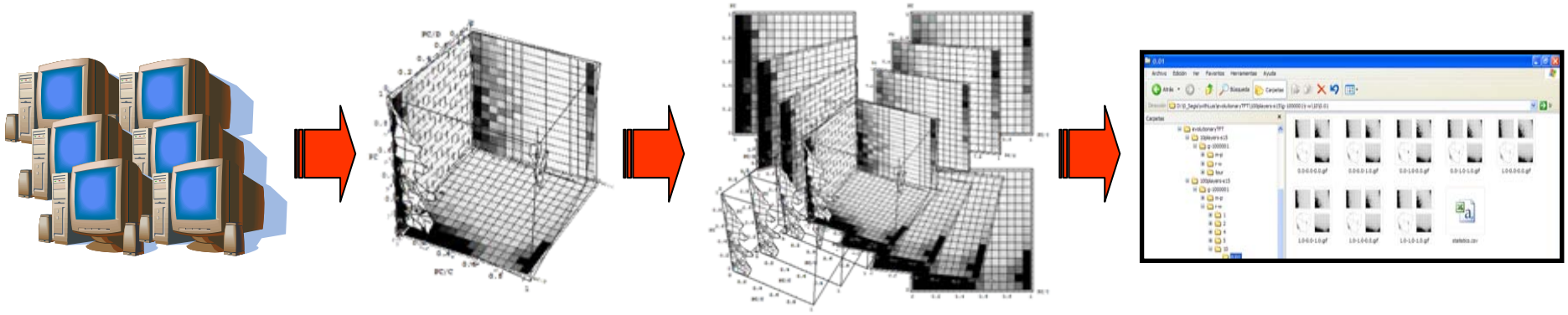
EVO-2x2 – A Modelling Framework to Study the Evolution of Strategies in 2x2 Symmetric Games under Various Competing Assumptions

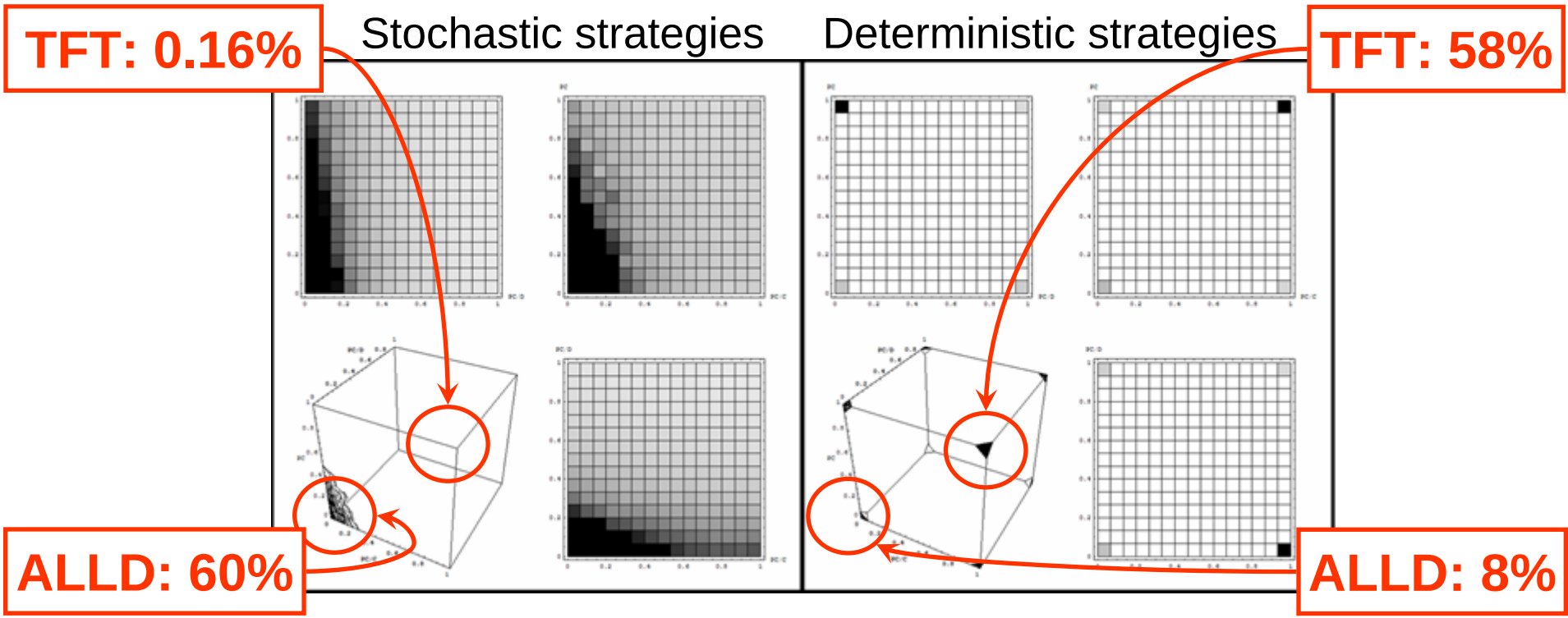
Izquierdo et al.



(CC blue) (DD red) (CD-DC grey)

EVO-2x2 – An Application to the Study of the Evolutionary Emergence of Cooperation





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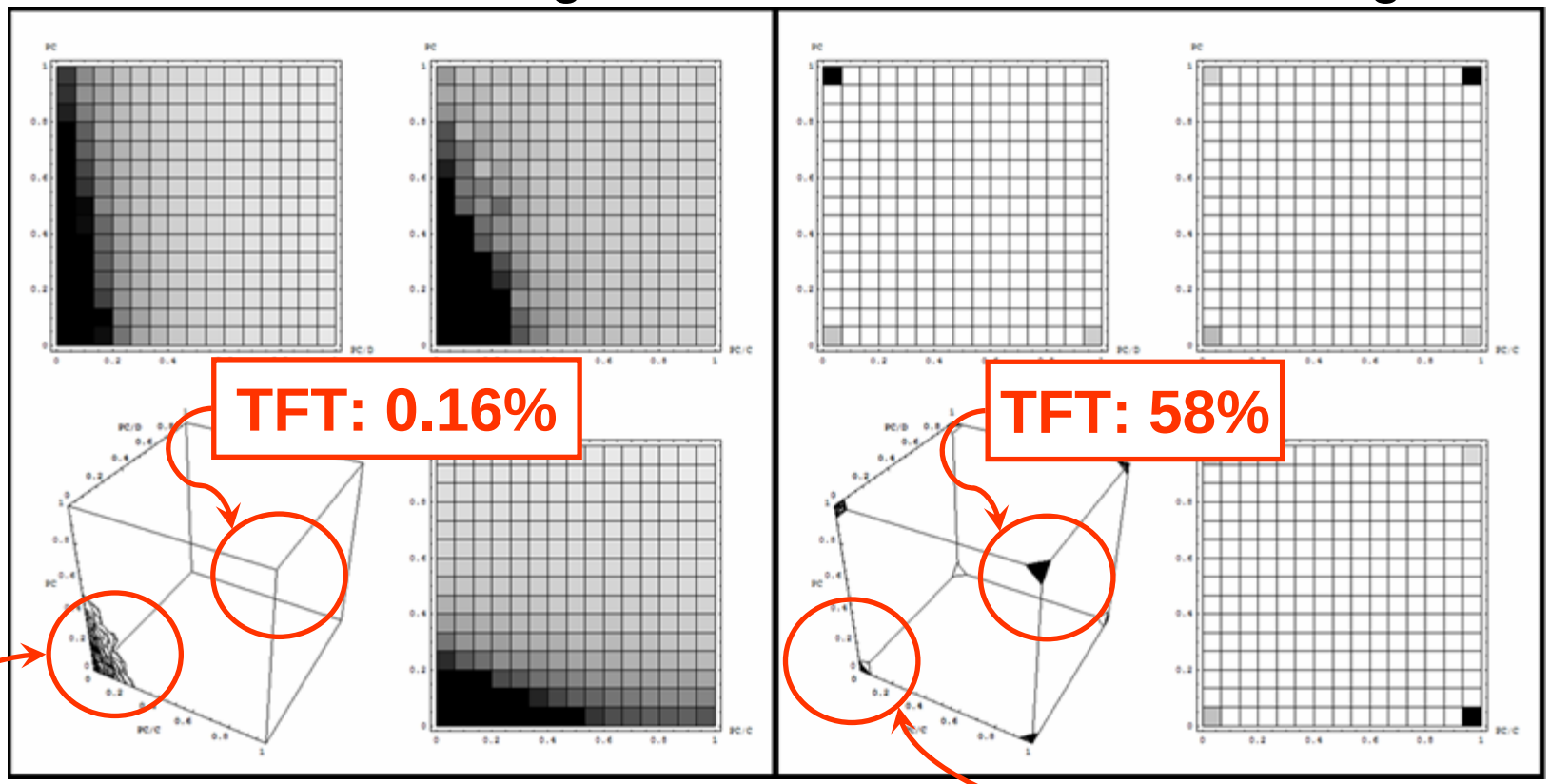
RESULTS AND DISCUSSION

Stochastic strategies

Deterministic strategies



ayoff = 3; ***CD-payoff*** = 0; ***DC-payoff*** = 5; ***DD-pa***

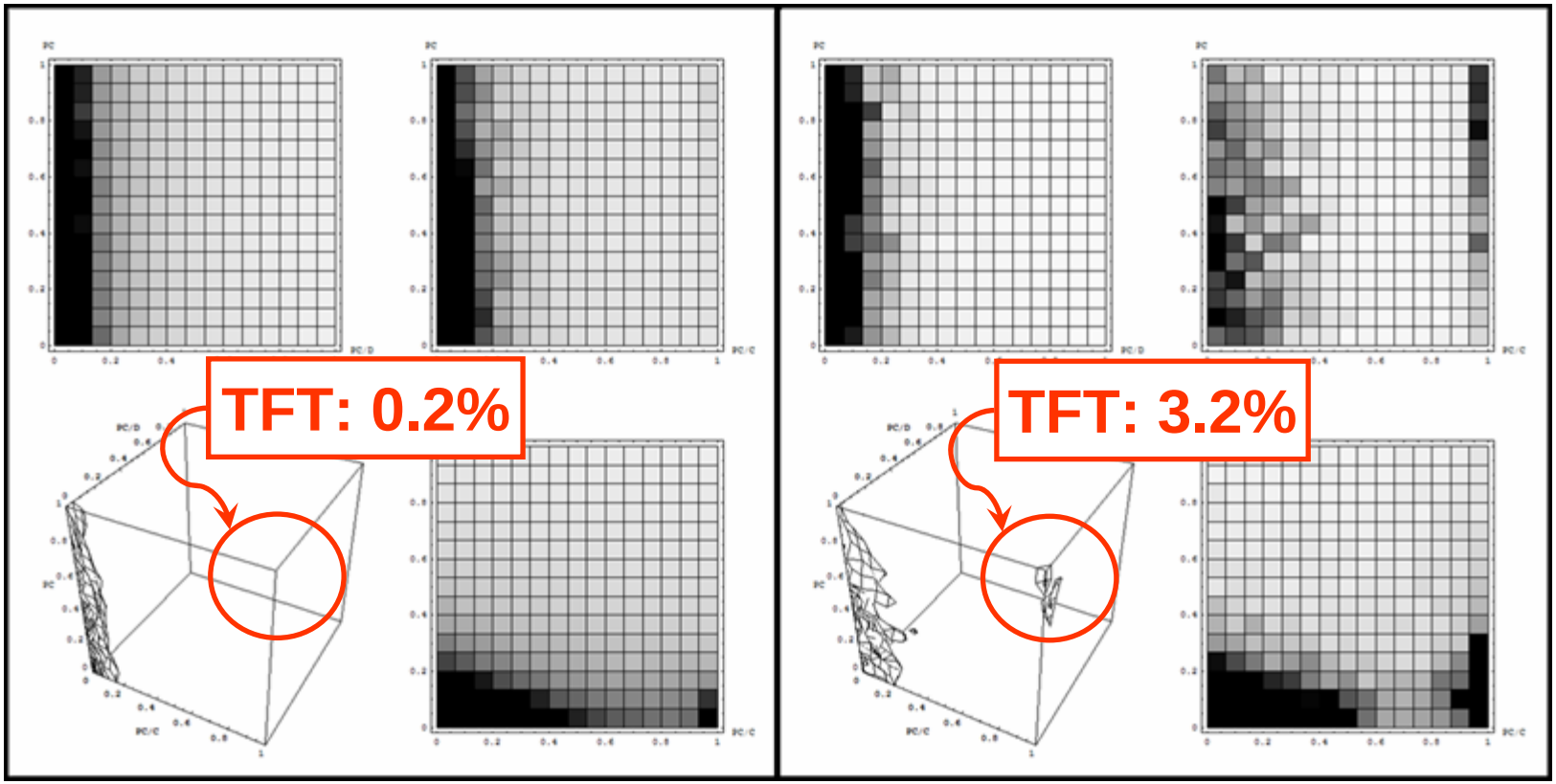
num-players = 100; ***mutation-rate*** = 0.05; ***rounds-per-match*** = 10;

selection-mechanism = *roulette wheel*; ***pairing-settings*** = *random pairings*;

RESULTS AND DISCUSSION

Mutation rate = 0.05

Mutation rate = 0.01



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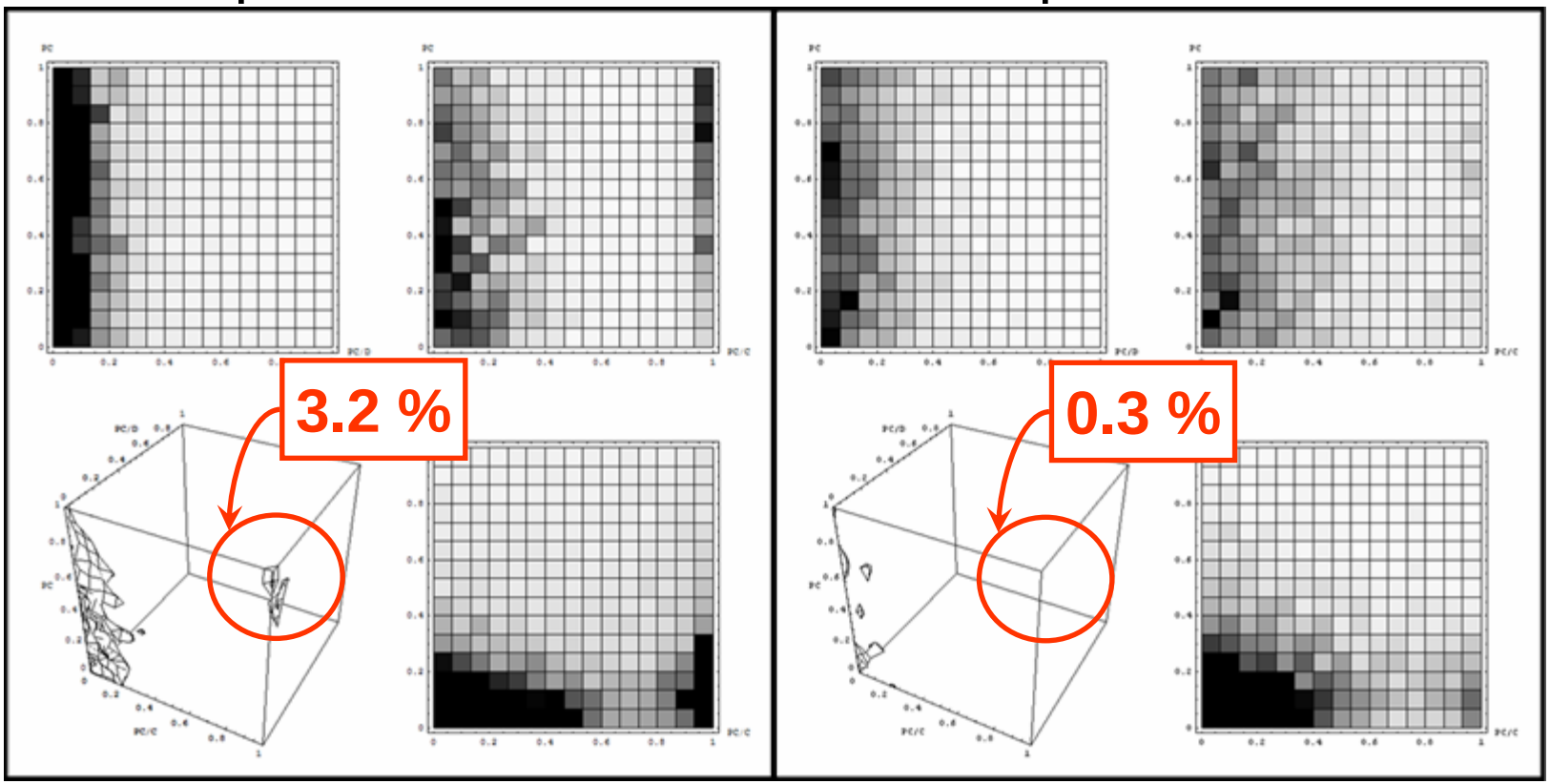
RESULTS AND DISCUSSION

Pop. size = 100

Pop. size = 10



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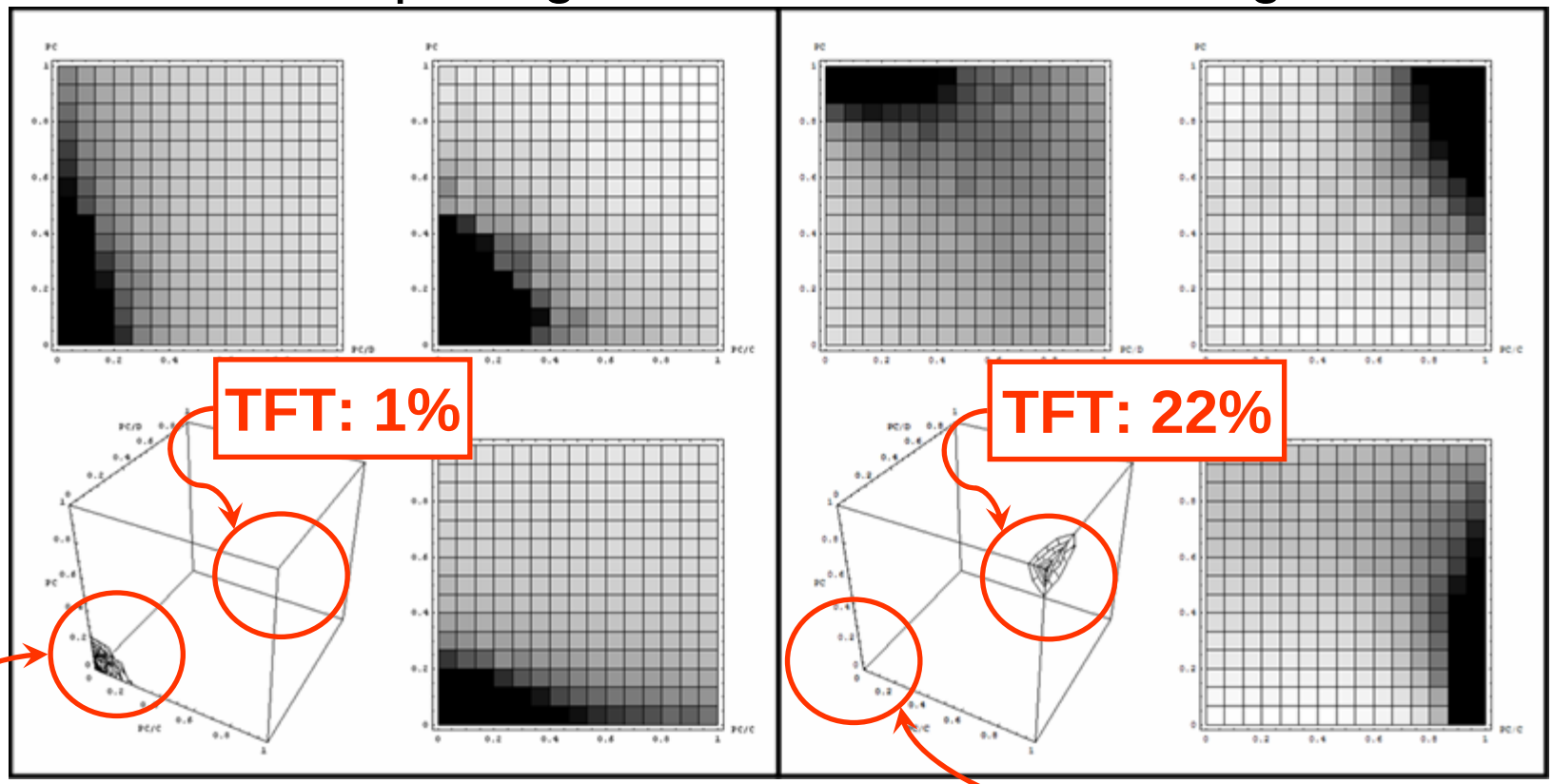
RESULTS AND DISCUSSION

Random pairings

Children together



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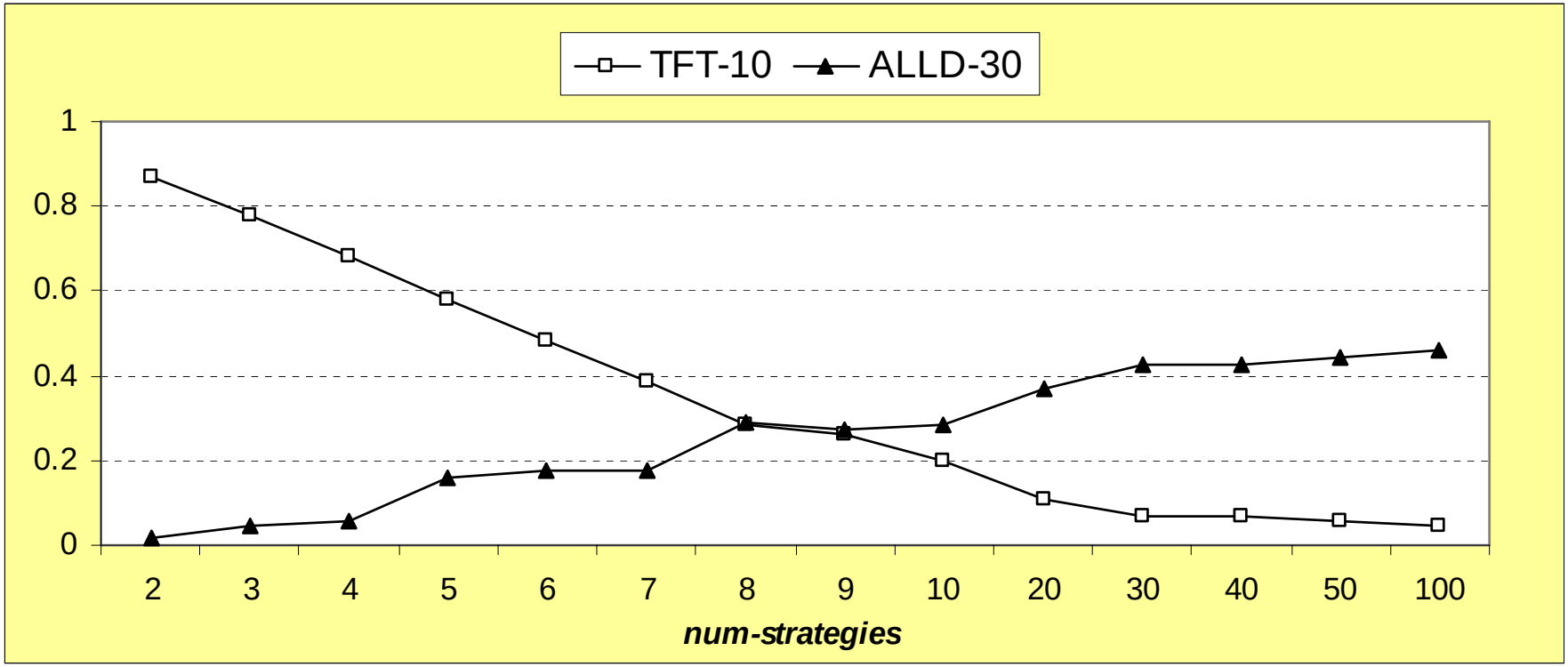

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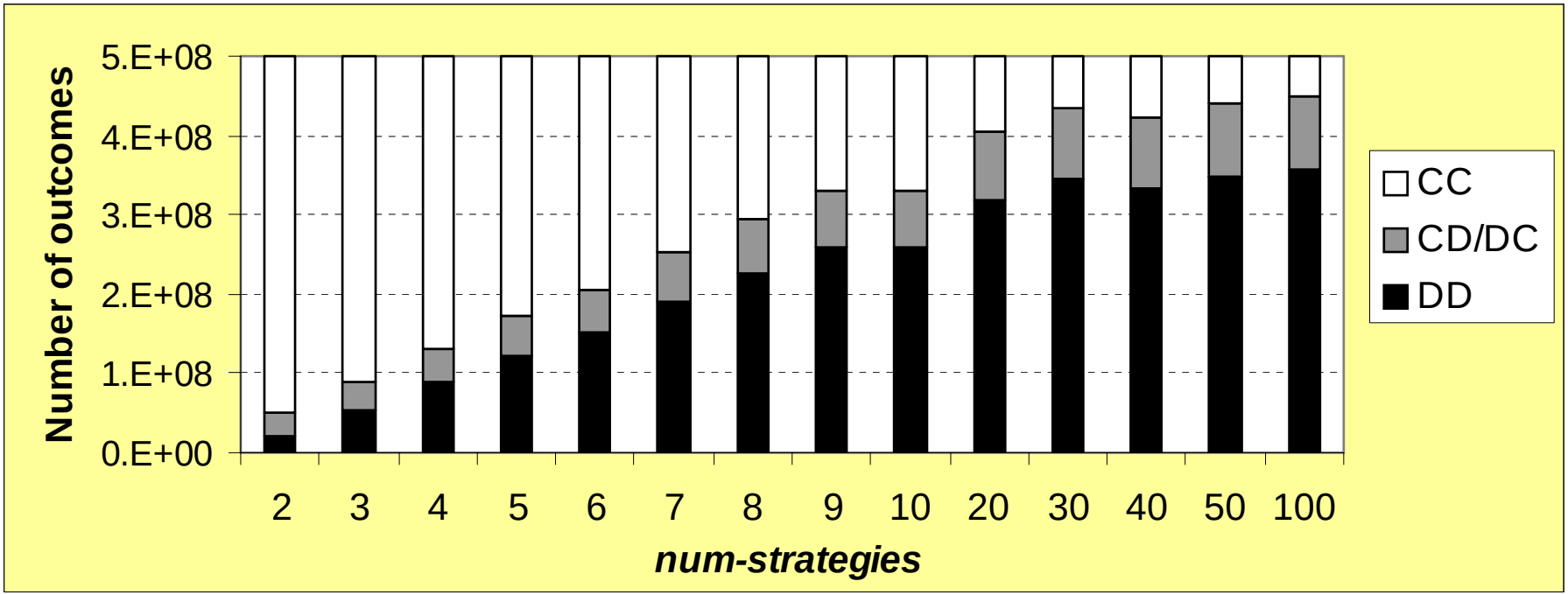

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CONCLUSIONS (1/2)

- **What type of strategies are likely to emerge and be sustained in evolutionary contexts is strongly dependent on assumptions that traditionally have been thought to be unimportant.**

- **Strategies similar to ALLD and TFT are the two most successful strategies in most contexts.**

CONCLUSIONS (2/2)

- **Strategies similar to ALLD tend to be the most successful in most environments.**
- **Strategies similar to TFT tend to spread best:**
  - **In large populations**
  - **where the individuals with similar strategies interact frequently**
  - **for many rounds**
  - **with low mutation rates**
  - **and only deterministic strategies are allowed.**

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- **Nick Gotts**
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End

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