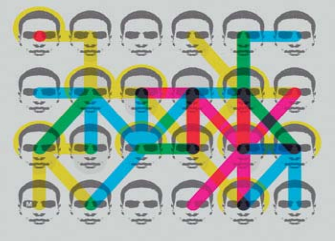
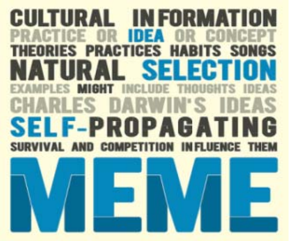
Altruistic Punishment and Human Cooperation: A Darwinian Perspective

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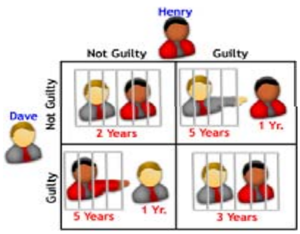
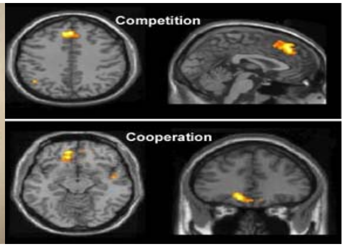




Moritz Hetzer and Prof. Didier Sornette

Chair of Entrepreneurial Risks

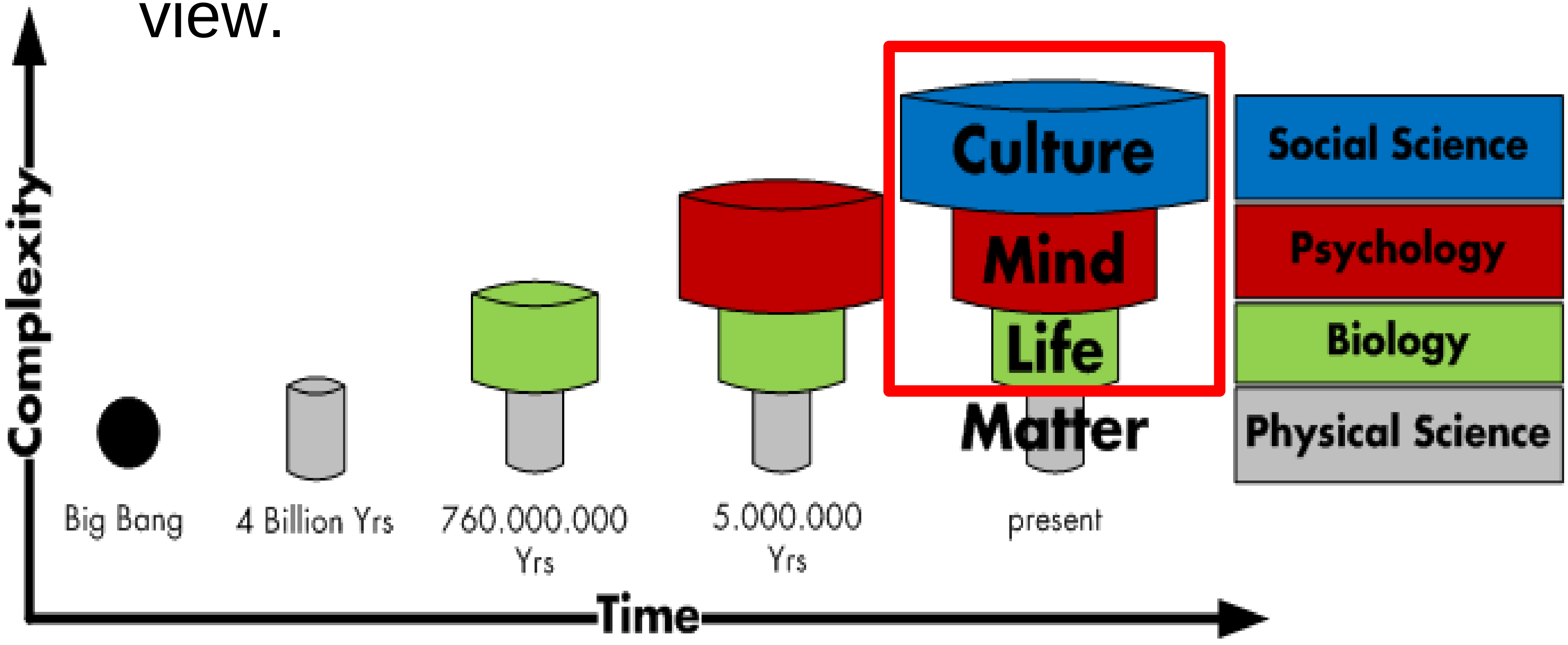
ETH Zurich

Motivation

- **Questions we want to answer:**
  - Why do people altruistically punish defectors?
  - What is the role of fairness perception and other-regarding preferences in this context?
  - How does punishment affect the emergence and maintenance of cooperation?
  - Why do we cooperate?

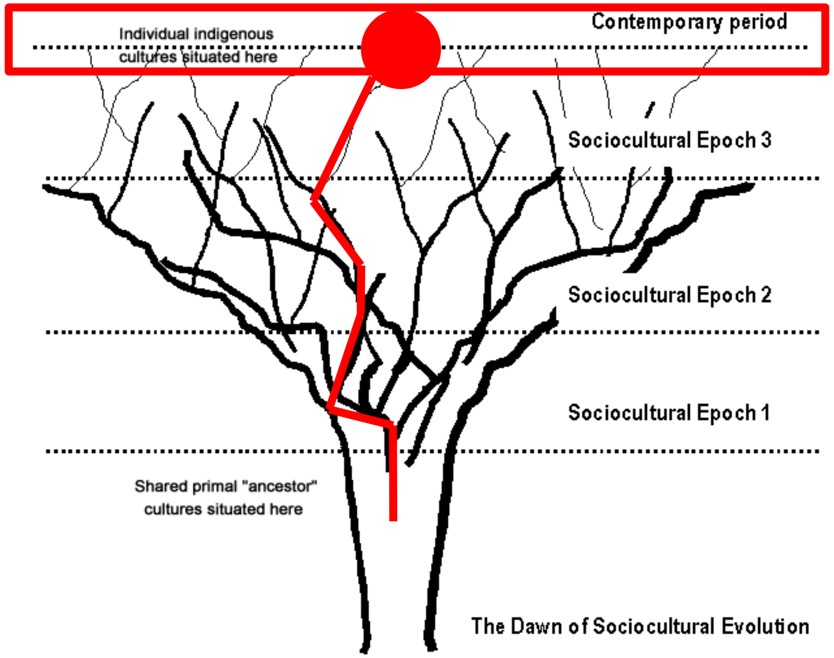
Motivation: The evolution of norms/genes

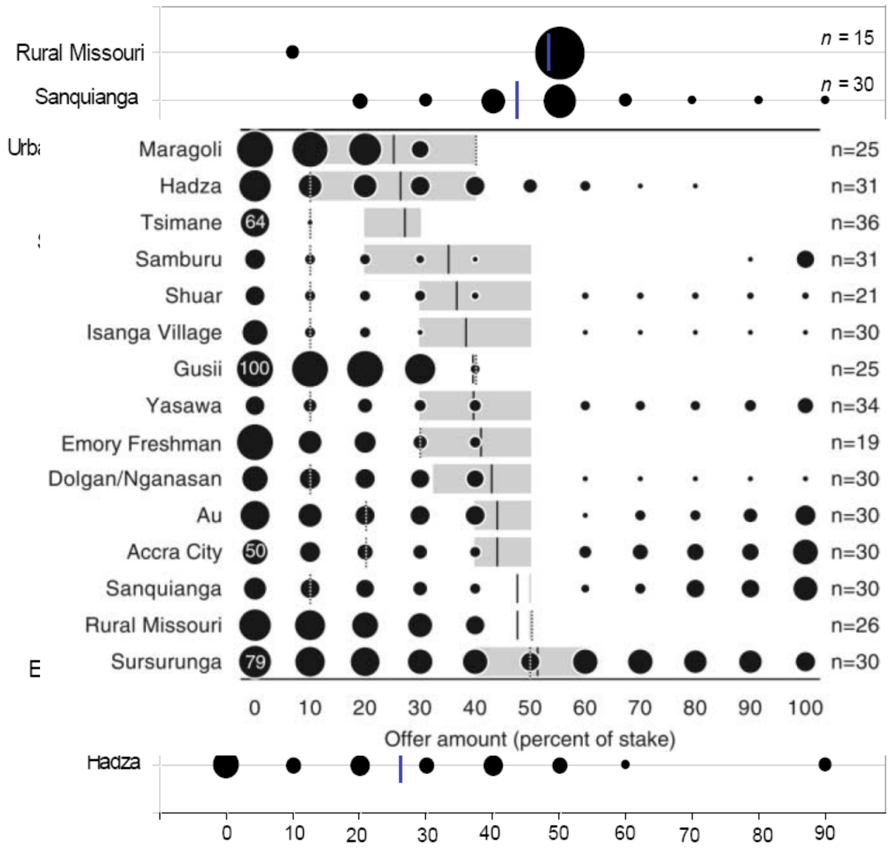
- We want to understand the roots of individual & collective behavior from an evolutionary point of view.



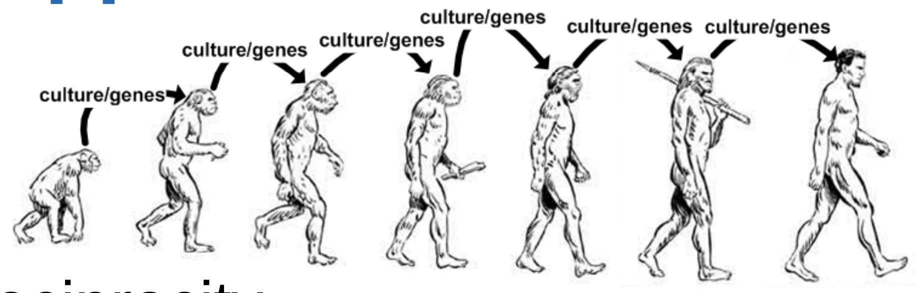
Motivation: The evolution of norms

- Experiments identify behavioral patterns
- Economic theories describe these patterns

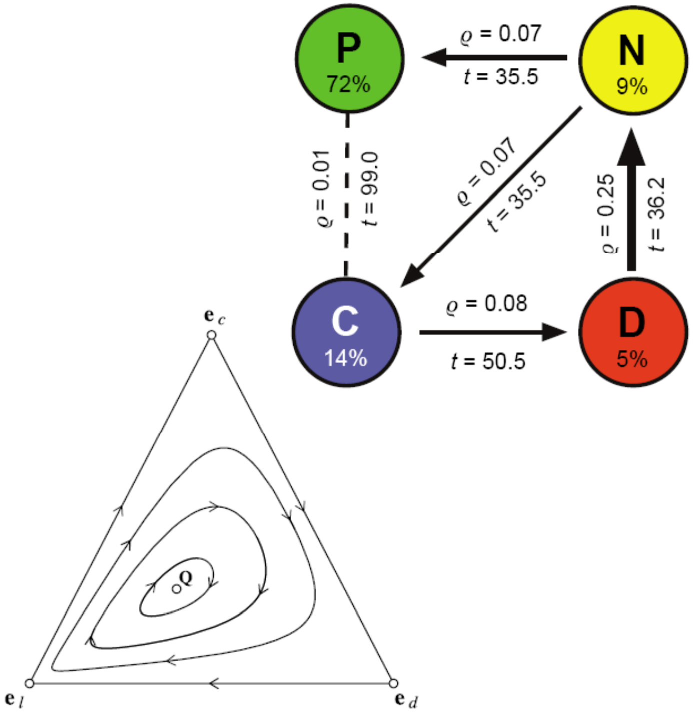

Contemporary period
Individual indigenous cultures situated here
Sociocultural Epoch 3
Sociocultural Epoch 2
Sociocultural Epoch 1
Shared primal "ancestor" cultures situated here
The Dawn of Sociocultural Evolution



Motivation - existing approaches



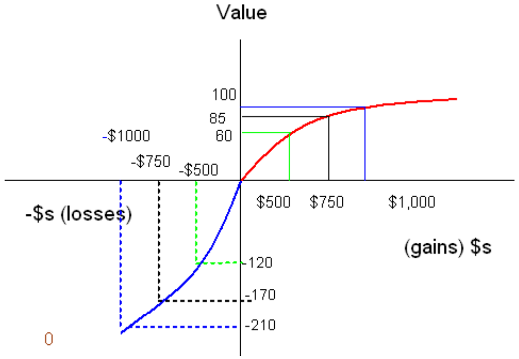
- Evolutionary theories
  - Kin selection
  - Direct / indirect / social reciprocity
  - gene-culture coevolution
- Analytic models
  - Mutual two-player interactions
  - Focus on equilibrium solutions
  - Detached from reality
  - Evolutionary game theory
    - better: Iterative Game Theory



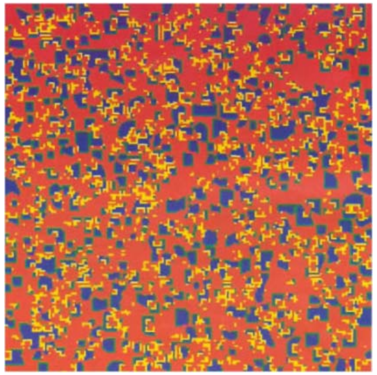
Motivation - existing approaches

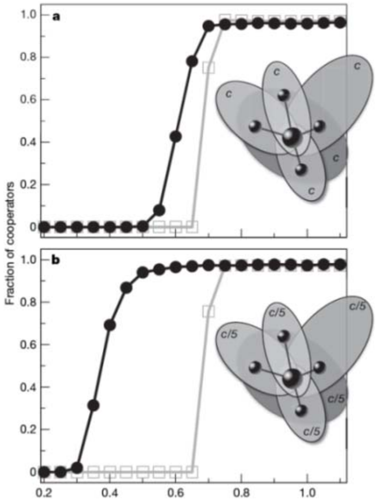
$$U_i(x) = x_i - \alpha_i \max\{x_j - x_i, 0\} - \beta_i \max\{x_i - x_j, 0\}, \quad i \neq j.$$

- Economic theories
  - Descriptive
  - Snapshot of current norms
  - Do not cover evolutionary dynamics



- Computer simulations
  - Sequential games
  - Lattice structure
  - Discrete decisions
  - Detached from reality
  - Focus on equilibrium solutions





Motivation - Our approach

- We want to answer the questions by closely integrating **experimental economics** with **agent-based modeling**.

Empirical foundation

- We use data from Fehr's & Gächter's public goods game experiments (2000/2002)

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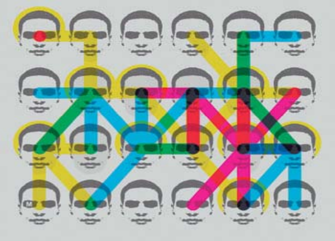
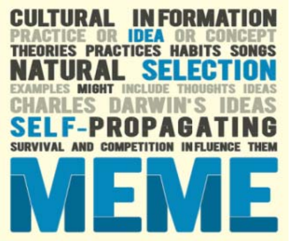
Other-Regarding preferences and altruistic punishment: A Darwinian Perspective

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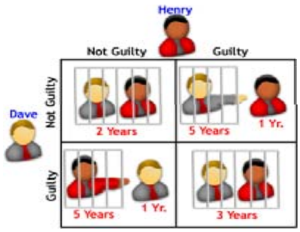

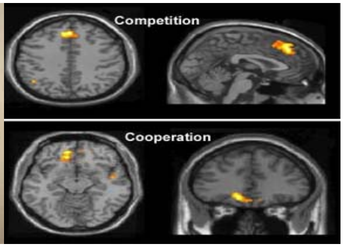

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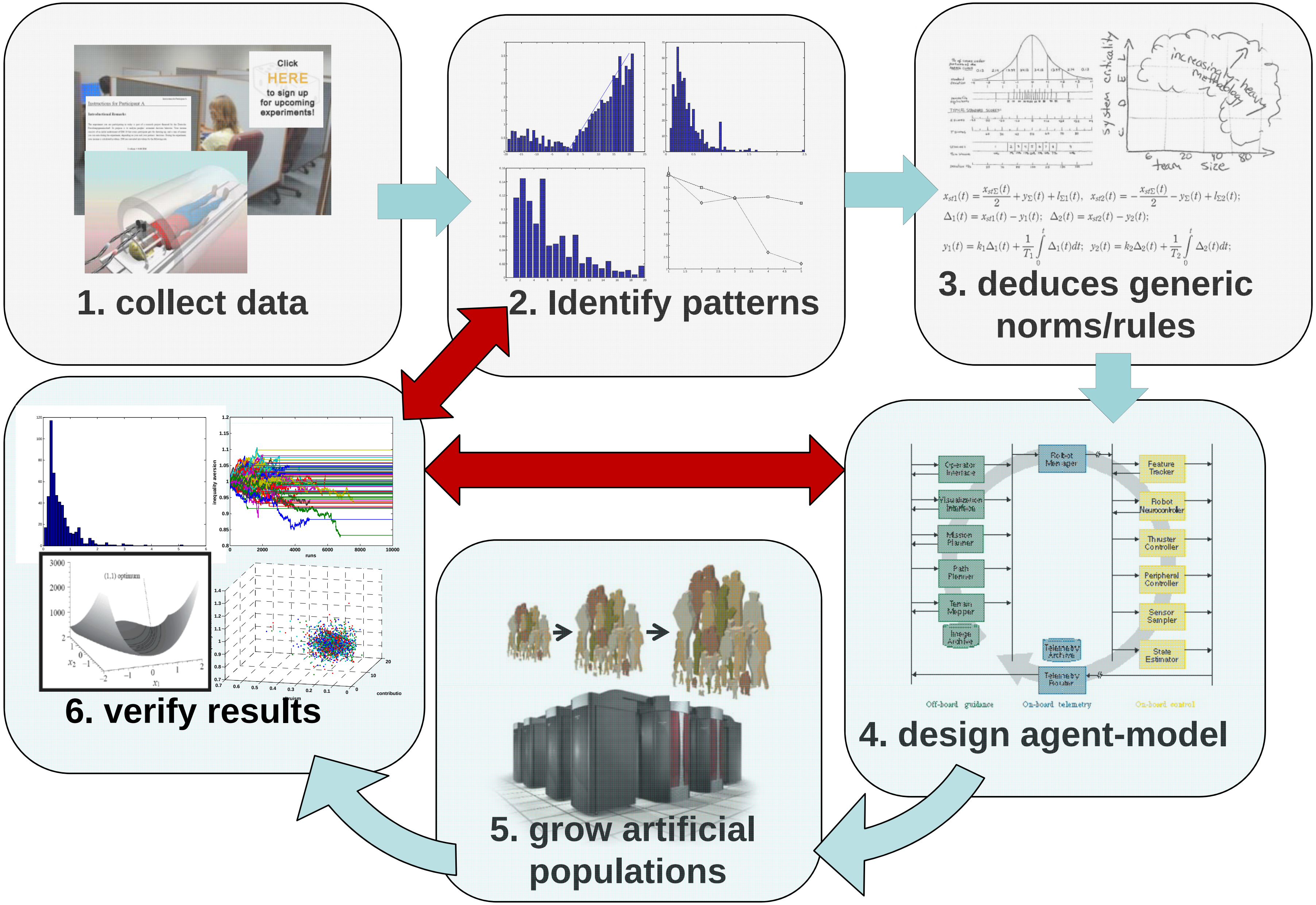


1. collect data

2. Identify patterns

3. deduces generic norms/rules

$$x_{st1}(t) = \frac{x_{st\Sigma}(t)}{2} + y_\Sigma(t) + l_{\Sigma 1}(t), \quad x_{st2}(t) = -\frac{x_{st\Sigma}(t)}{2} - y_\Sigma(t) + l_{\Sigma 2}(t);$$

$$\Delta_1(t) = x_{st1}(t) - y_1(t); \quad \Delta_2(t) = x_{st2}(t) - y_2(t);$$

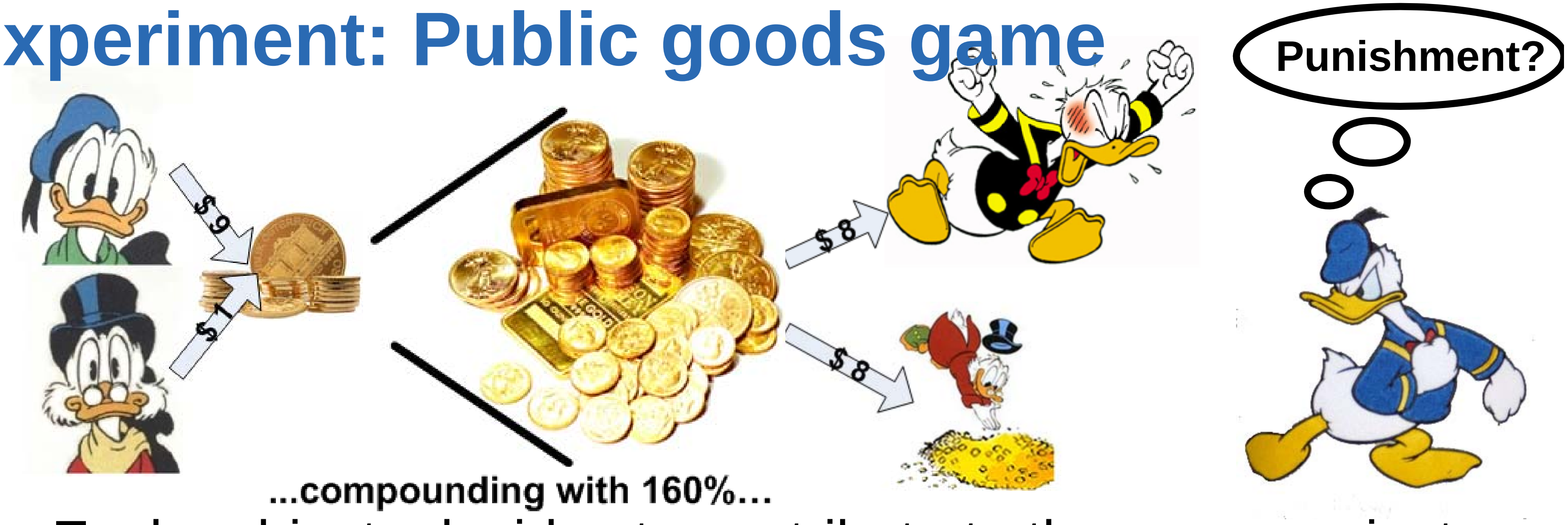
$$y_1(t) = k_1\Delta_1(t) + \frac{1}{T_1}\int_0^t \Delta_1(t)dt; \quad y_2(t) = k_2\Delta_2(t) + \frac{1}{T_2}\int_0^t \Delta_2(t)dt;$$

4. design agent-model

5. grow artificial populations

6. verify results

Experiment: Public goods game



...compounding with 160%...

1. Each subjects decides to contribute to the group project.
2. The group project pool is compounded by a factor of 1.6
3. The project return is equally redistributed to all group members.
4. Each subject gets the opportunity to punish other group members at own costs, i.e. punishment is costly to both the punisher and the punished individual.

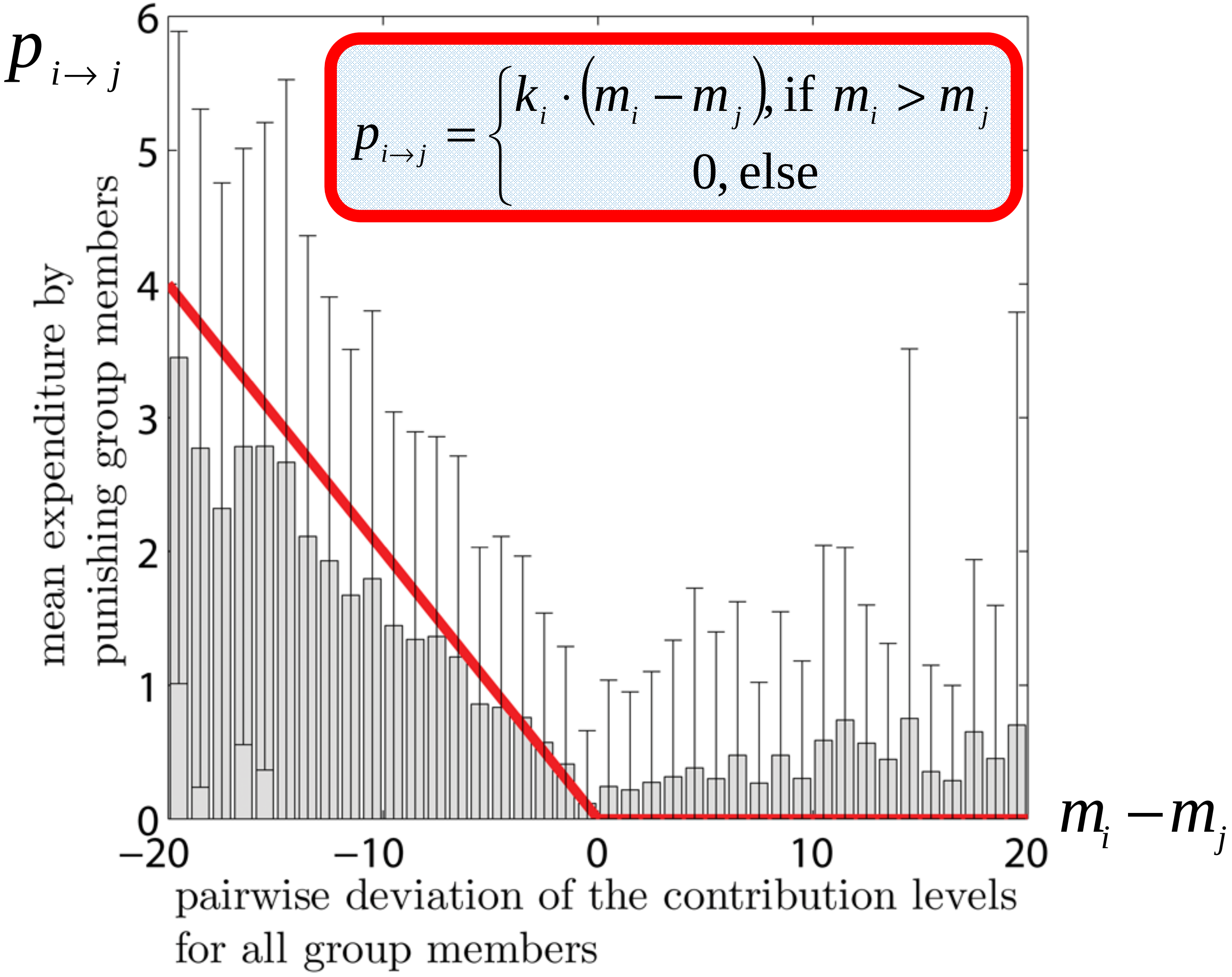
Model Design:

- **Properties of agent** i **:**
  - Level of cooperation $m_i(t)$
  - Propensity to punish $k_i(t)$
  - Wealth/Fitness $w_i(t)$

Model Design – one simulation period:

- **cooperate:** Each agent contributes m_i to the group project
- **punish:** Punishment of other group members

Model Design – empirical punishment:



$$p_{i\to j}=\begin{cases}k_i\cdot\left(m_i-m_j\right),\text{ if } m_i>m_j\\ 0,\text{ else}\end{cases}$$

Model Design – one simulation period:

- **cooperate:** Each agent contributes m_i to the group project
- **punish:** Punishment of other group members according to:

$$p_{i \to j} = \begin{cases} k_i \cdot \left(m_i - m_j\right), \text{if } m_i > m_j \\ 0, \text{else} \end{cases}$$

Model Design – one simulation period:

- **cooperate:** Each agent contributes m_i to the group project
- **punish:** Punishment of other group members
- **consume:** Consume avg. group welfare gained in period $t-1$

Model Design – P/L, wealth and consumption:

- **Profit & Loss:**

$$s_i(t) = \underbrace{\frac{1.6}{4}\sum_{j\in I} m_j}_{\substack{\text{project}\\ \text{return}}} \underbrace{-m_i}_{\text{contribution}} - \underbrace{\sum_{j\in I} p_{i\to j}}_{\substack{\text{punishment}\\ \text{spent}}} \underbrace{-3\cdot\sum_{j\in I} p_{j\to i}}_{\substack{\text{punishment}\\ \text{received}}}$$

- **Wealth:**

$$W_i(t+1) = W_i(t) + s_i(t) - \underbrace{c(t)}_{\text{consumption}}$$

- **Consumption:**

$$c(t) = \overline{W}(t-1) - \overline{W}(t-2)$$

Model Design – one simulation period:

- **adapt:** Change cooperation level m_i and the propensity to punish k_i

Model Design – Adaptation of m_i:

- Agents adapt their level of cooperation m_i if: profit/loss < consumption

with: $m_i(t+1) = m_i(t) + \varepsilon$

Model Design – Adaptation of k_i :

- **(A) Selfish agents:** Adapt their behavior if:

  profit/loss is less than her consumption.

- **(B) Inequality avers agents:** Adapt their behavior if:

  profit/loss < average group profit/loss (***downside***) or
  profit/loss > average group profit/loss (***upside***).

- **(C) Inequity averse agents:** Adapt their behavior if:

  contribution > group average contribution **and**
  profit/loss < group‘s average profit/loss (***downside***) *or*
  contribution < group average contribution **and**
  profit/loss > group‘s average profit/loss (***upside***)*.*

Model Design – Adaptation of k_i :

- **(D) Disadvantageous inequality avers agents:**
  Adapt their behavior if:
  profit/loss < average group profit/loss (***downside***)

- **(E) Disadvantageous inequity averse agents:**
  Adapt their behavior if:
  contribution > group average contribution **and**
  profit/loss < group‘s average profit/loss (***downside***)

Model Design – one simulation period:

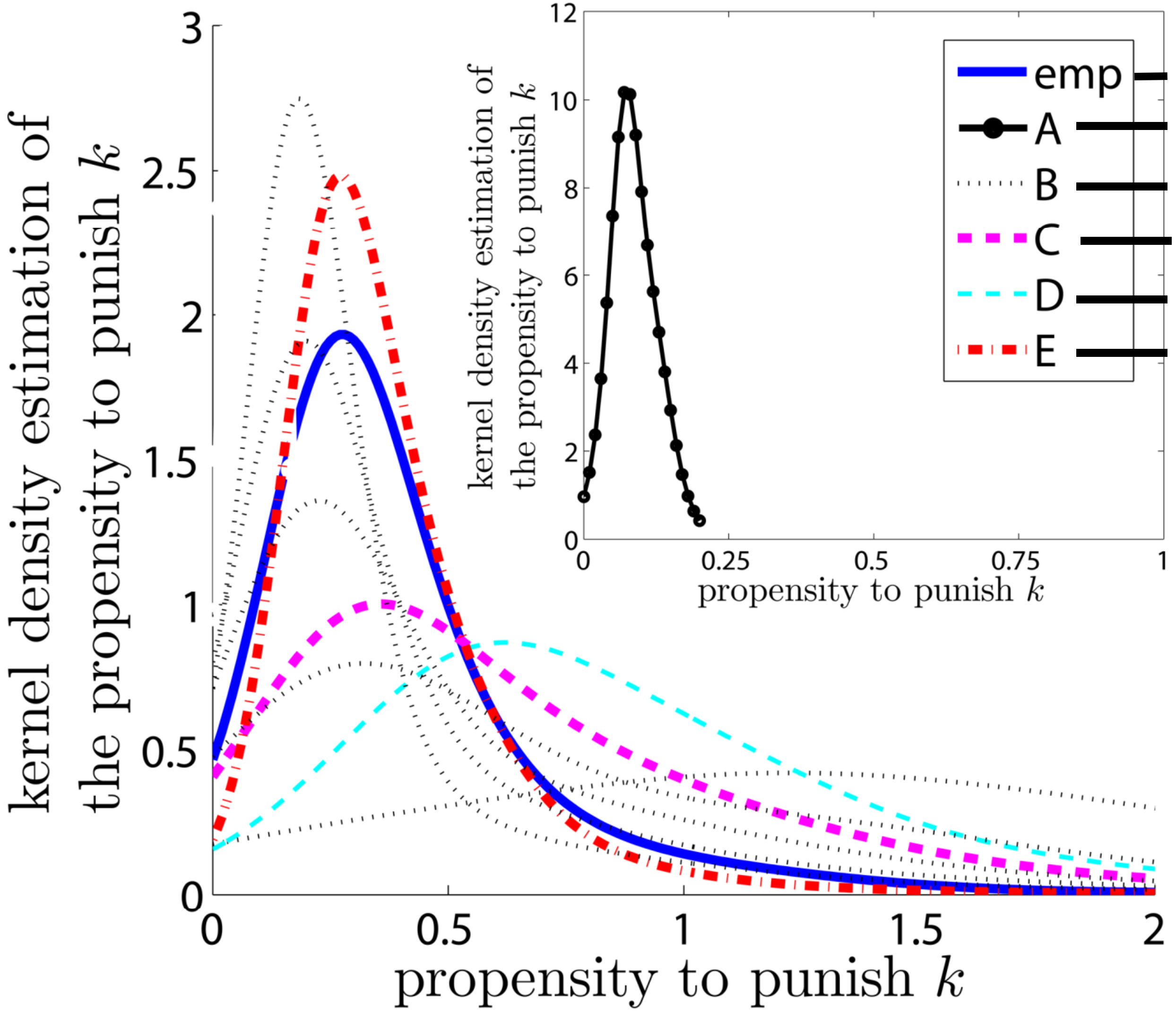
- **selection:** If the wealth of an agent drops below 0 the agent dies.
- **cross-over:** Dead agents are replaced with new ones. The level of cooperation m_i and propensity to punish k_i are initialized by the avg. values of the surviving population.

Model Design – Simulation:

- We run this model for 1 million simulation periods over 800 system realizations with
  - $m(0)_i$
  - $k(0)_i$
  - $w(0)_i$

and obtained a distribution for k_i which we compare with the empirical distribution obtained from experimental data.

Disadvantageous inequity aversion fits best!



emp – empirical data
A – selfish
B – inequality averse
C – inequity averse
D – dis. inequality averse
E – dis. inequity averse

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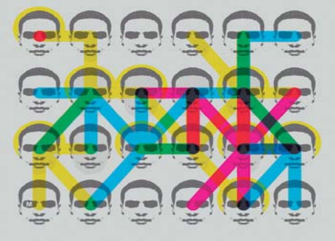
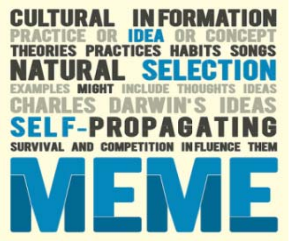
Altruistic Punishment and the Emergence of cooperation: A Darwinian Perspective

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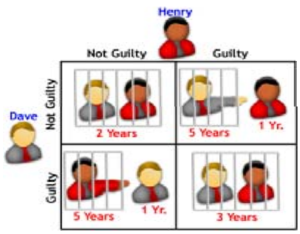
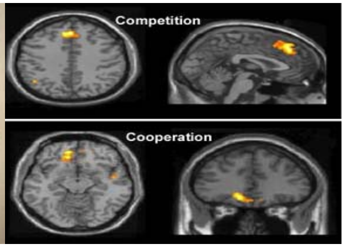
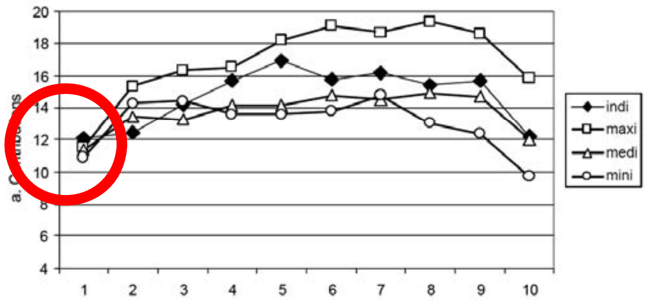


	Not Guilty	Guilty
Not Guilty	2 Years	5 Years 1 Yr.
Guilty	5 Years 1 Yr.	3 Years

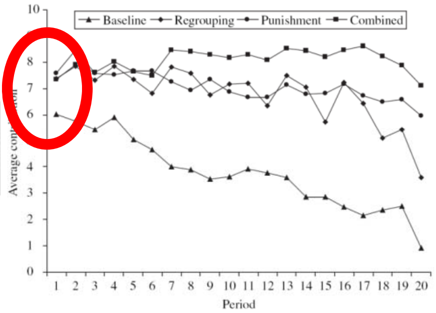


The effect of punishment on cooperation

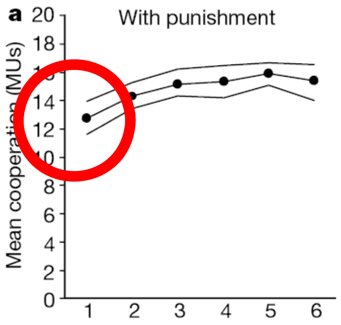
- (Altruistic) punishment is often used to explain the emergence of cooperation in social dilemmas.



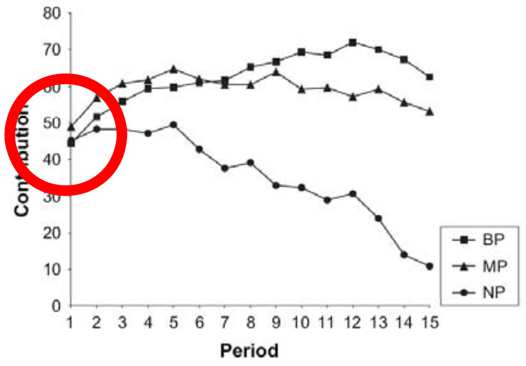
Decker, Stiehler, Strobel, 2003



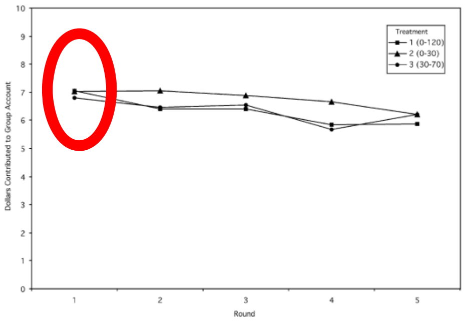
Page, Putterman, Unel, 2005



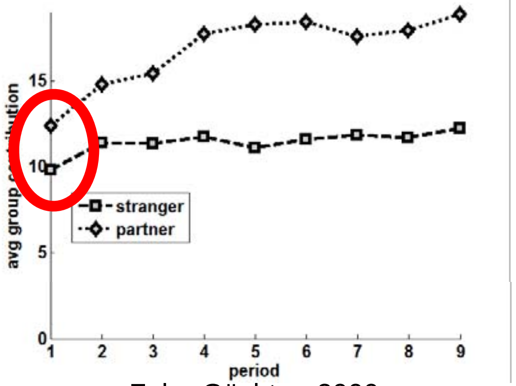
Fehr, Gächter, 2002



Noussair, Tucker, 2005

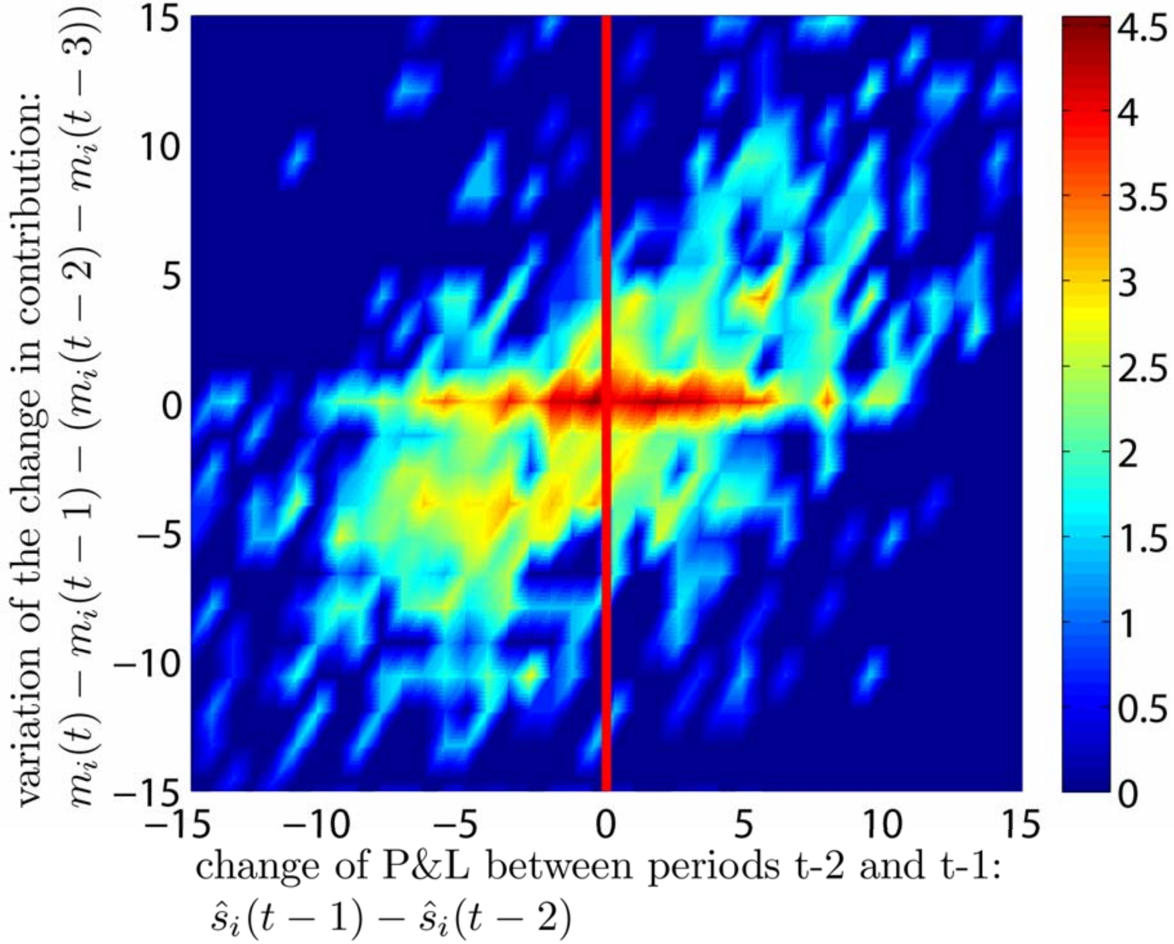


Anderson, Putterman



Fehr, Gächter, 2000

Evidence for short term persistence in period-by-period decision process:

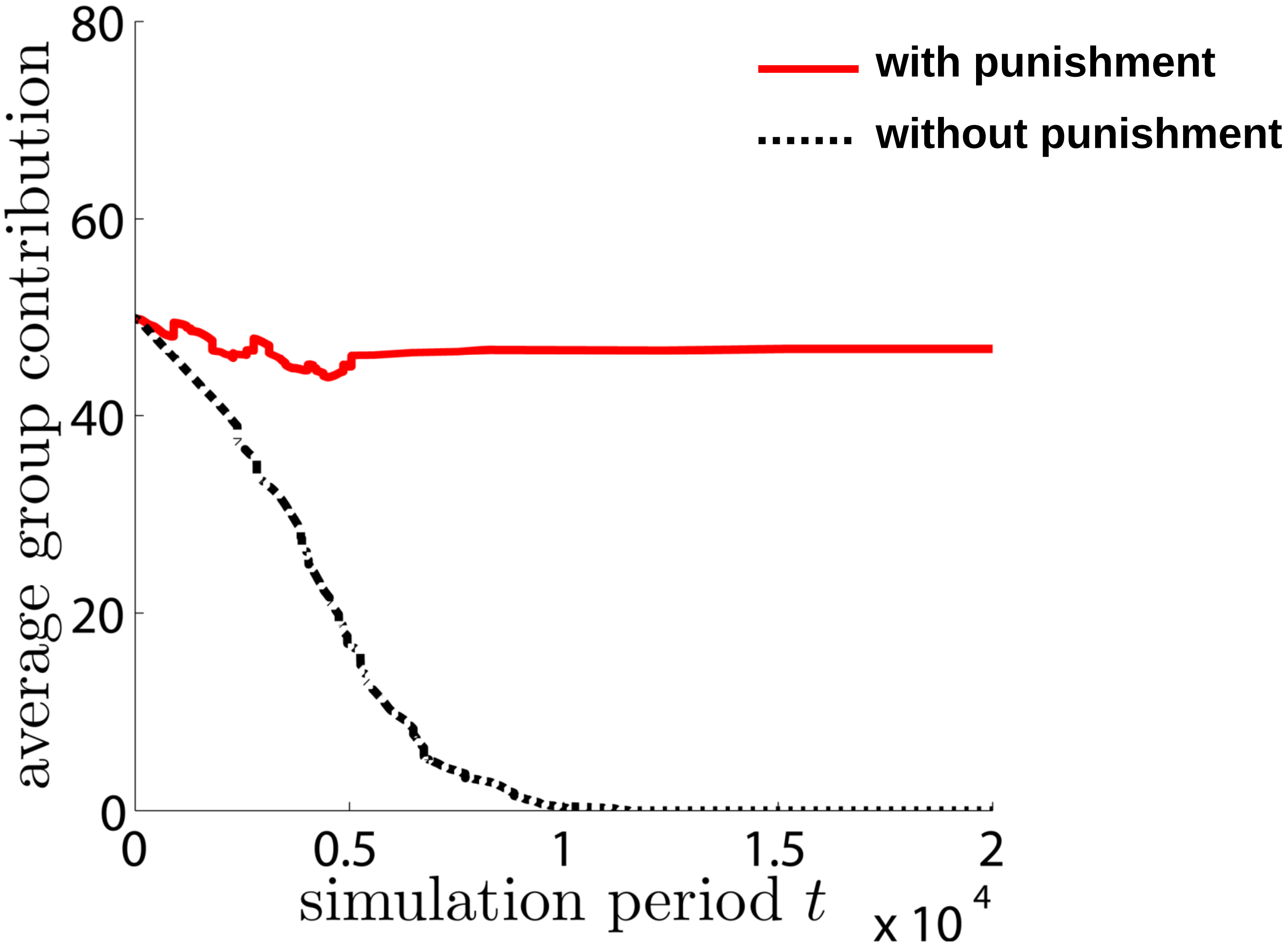


- Subjects seem to follow a trend in their updates of the individual contributions.
- If profit/loss in period (t) is larger than in period (t-1)

$$m_i(t+1) = 2 \cdot m_i(t) - m(t-1)$$

- Previous results are **ROBUST** to this addition

The effect of punishment on cooperation



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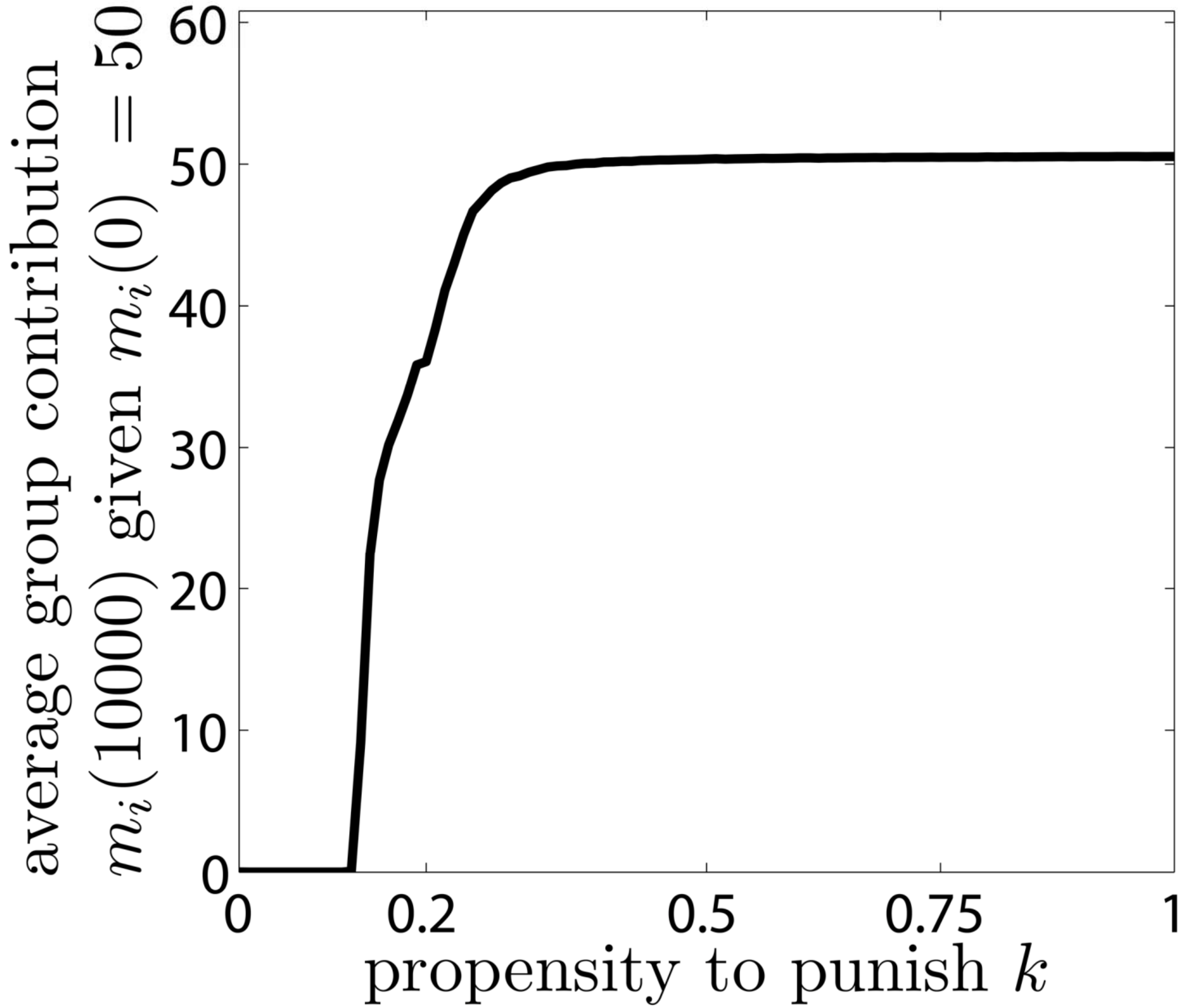
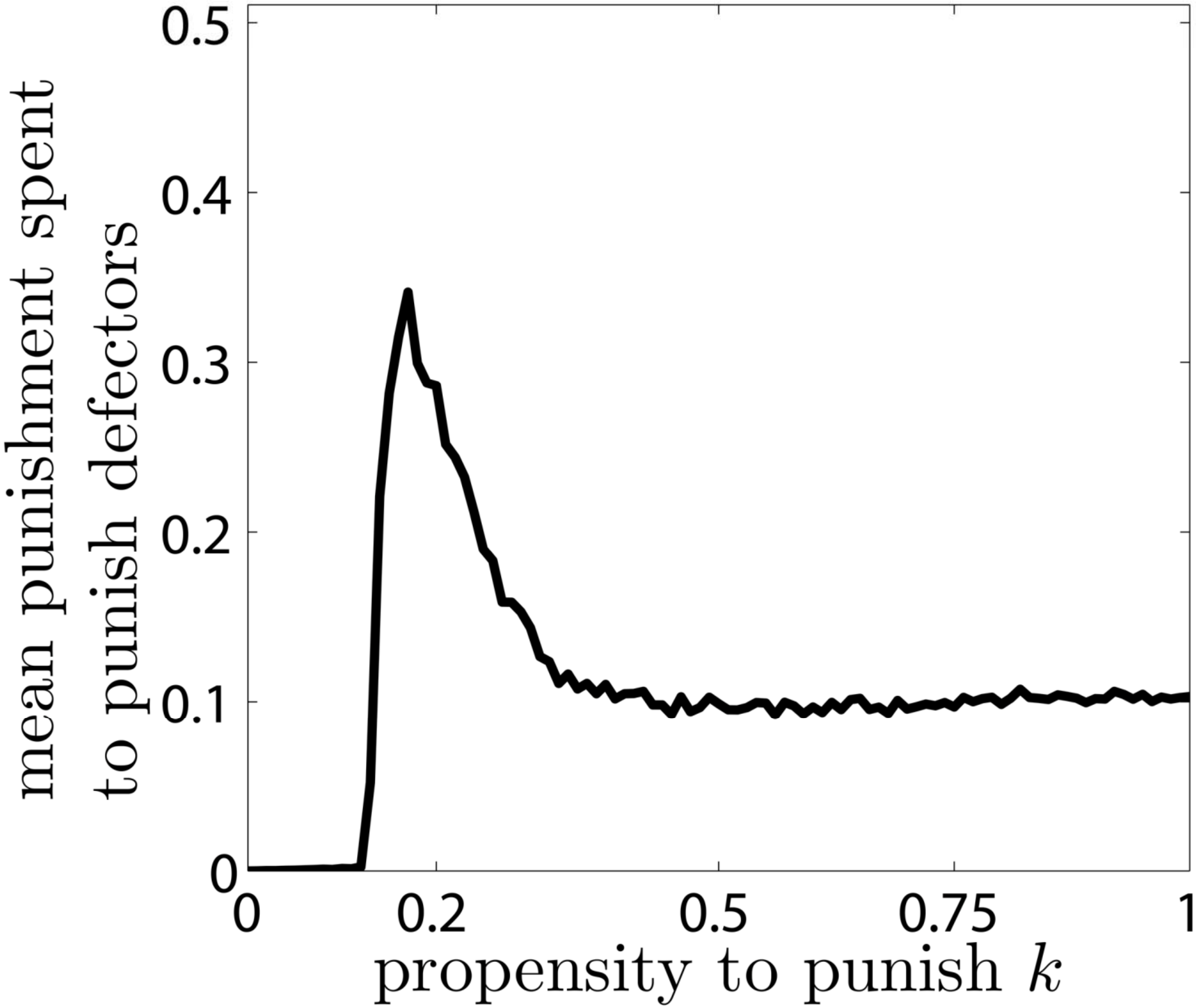


The effect of deterrence



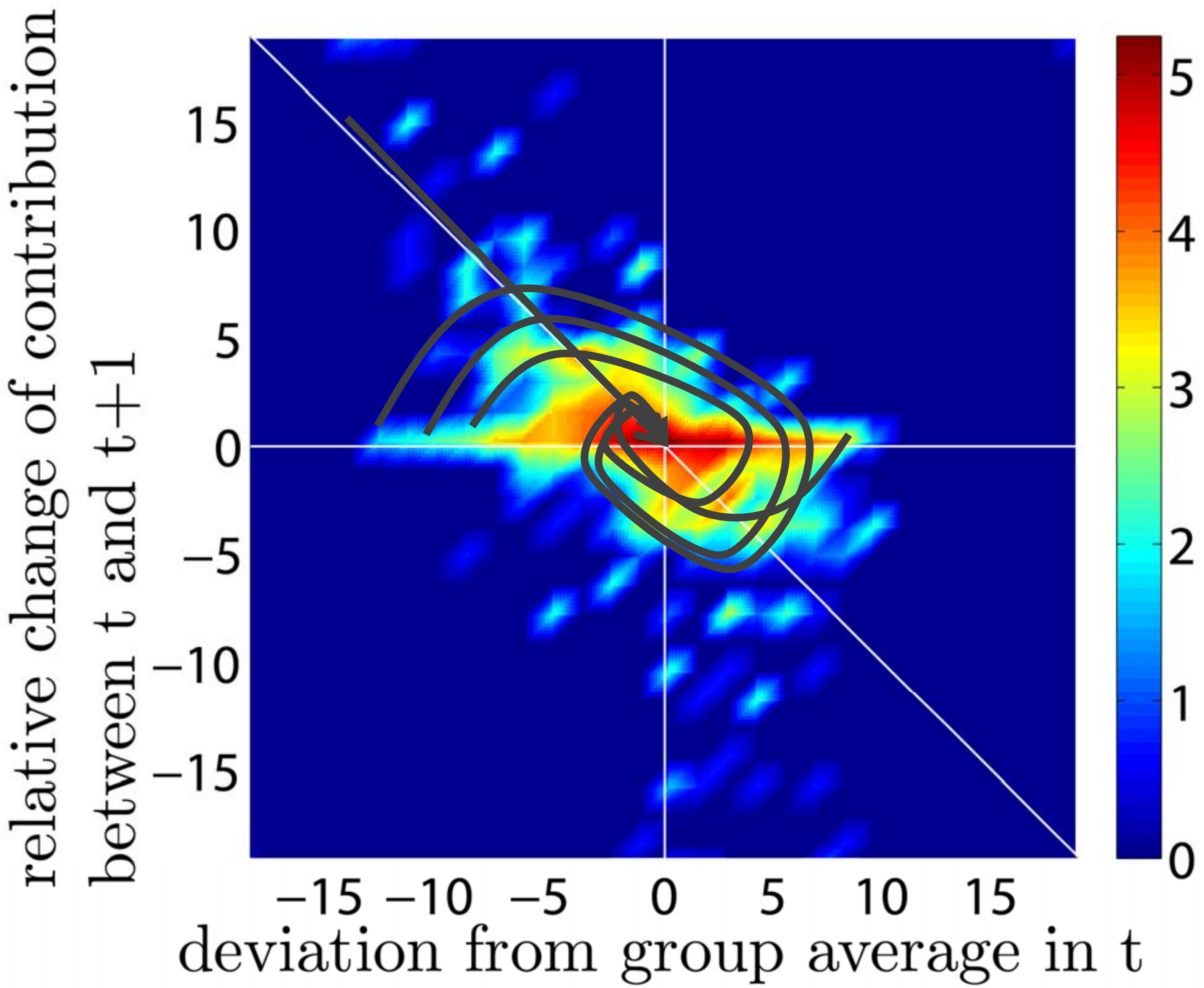
Altruistic punishment and cooperation

- Is altruistic punishment sufficient to **sustain** cooperative behavior …

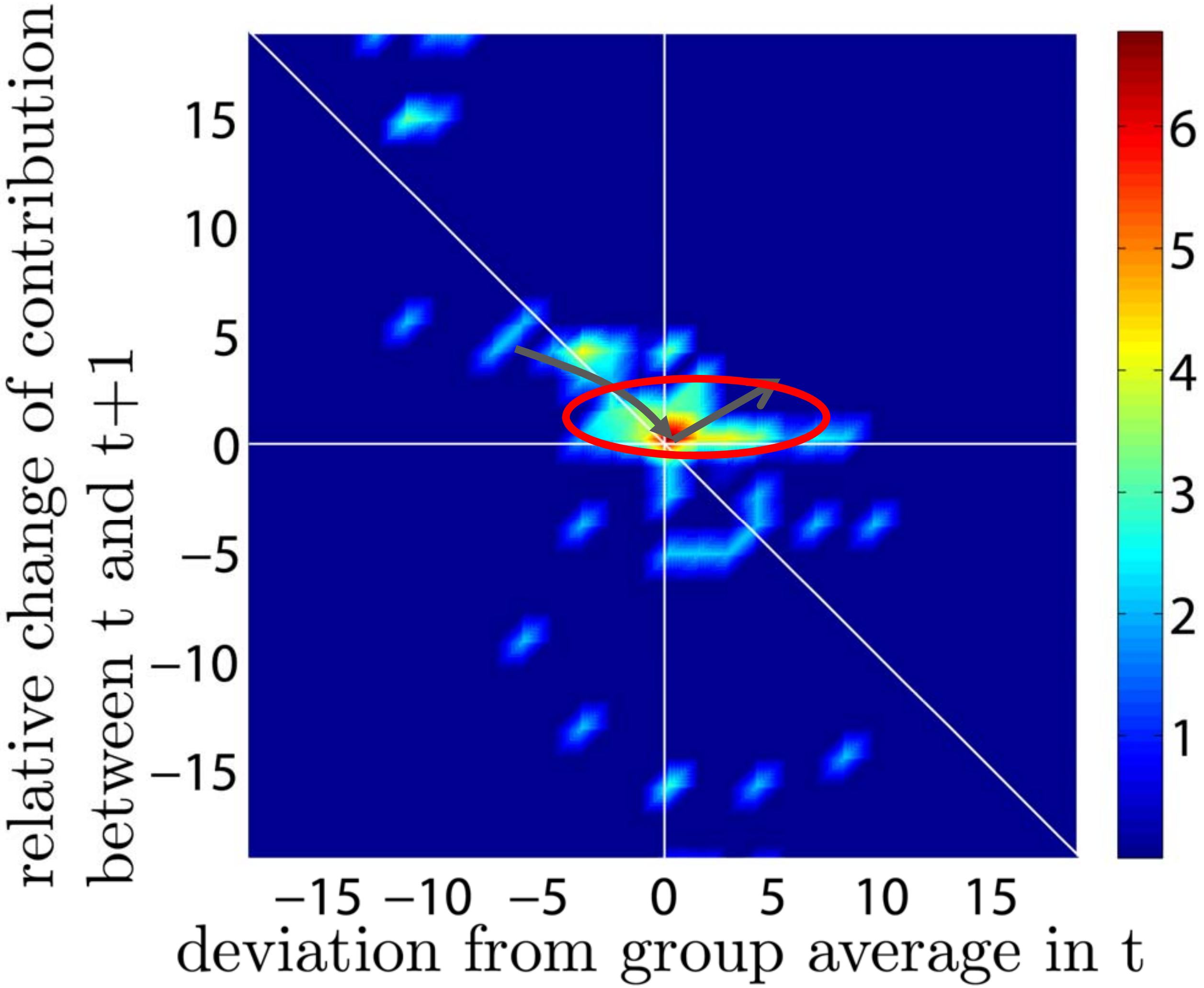
  …between related (partners) and unrelated individuals (strangers)?

- Is altruistic punishment sufficient to **promote** cooperative behavior …
  - **Partners:** group composition stays constant
  - **Strangers:** group composition changes

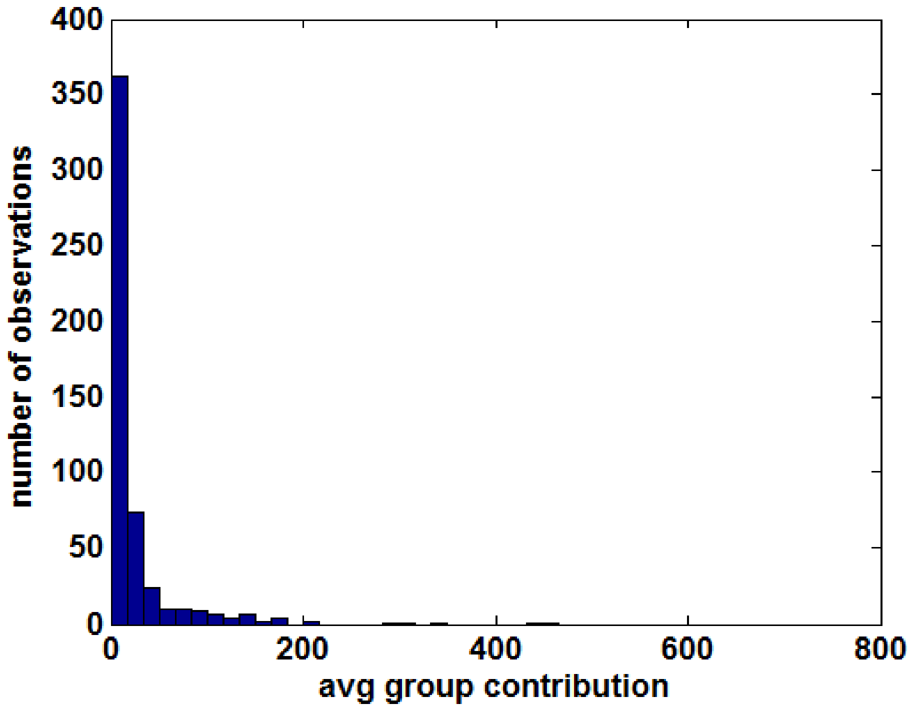
First-order dynamics among strangers



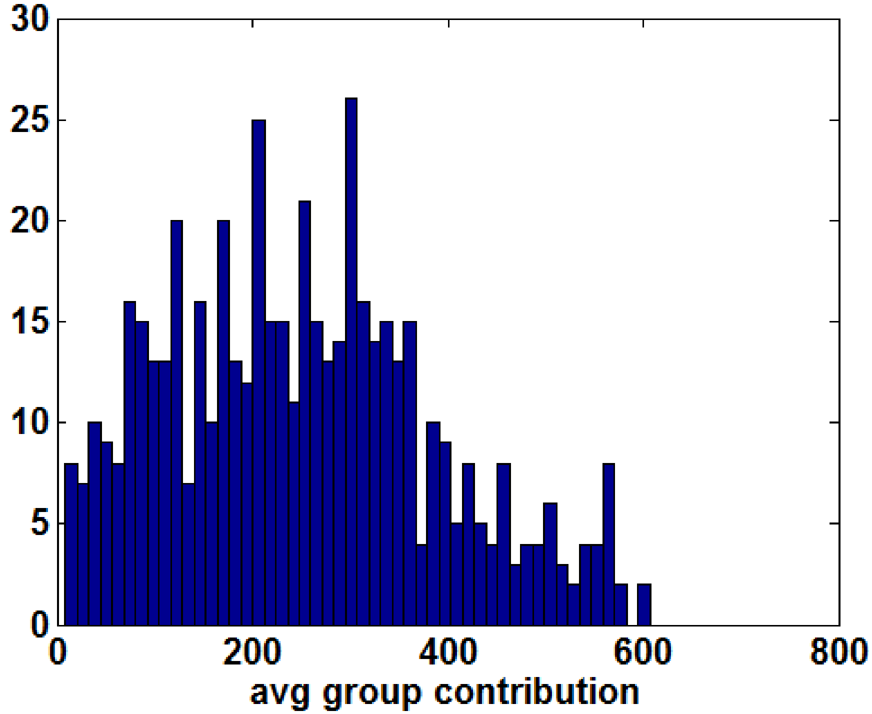
First-order dynamics among partners



Feedback by punishment + group migration promotes cooperative behavior



avg group contribution punishment only



avg group contribution group migration + punishment

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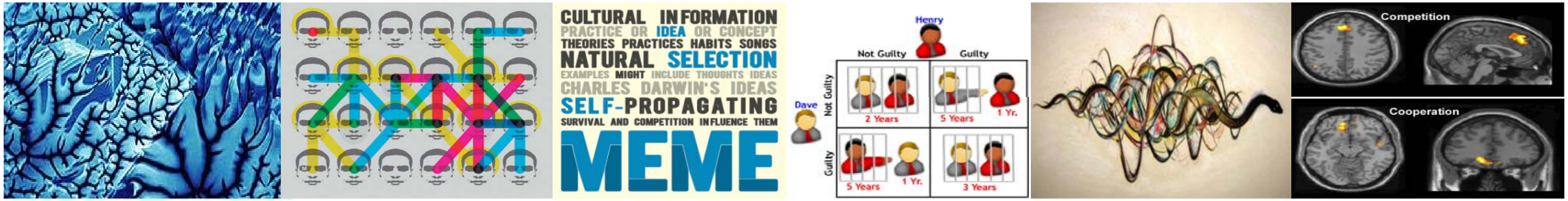
Conclusion



Conclusion

- The evolution of altruistic punishment can be explained by **disadvantageous inequity aversion**
- Punishment can promote cooperation among social-related individuals (partners)
- Punishment acts as a coordination mechanism among unrelated individuals (strangers)
- To promote cooperation among unrelated individuals, additional mechanisms are required (heterogeneity).

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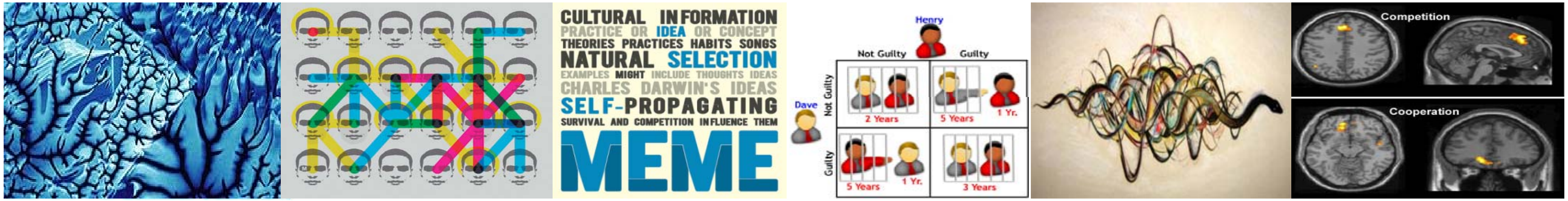
Outlook: Behavioral Mechanism Design and Social Engineering



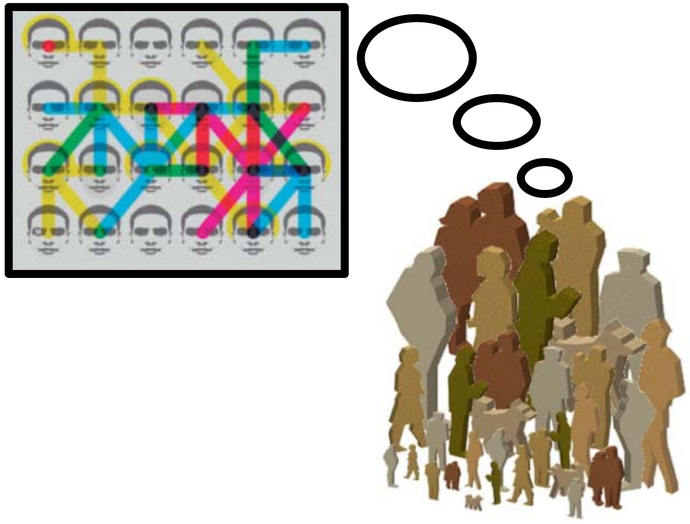
Outlook: Behavioral Mechanism Design

- Mechanism design and contract theory base on the homo economicus assumption.
- They aim at controlling a social system by means of monetary incentive schemes / selfishness assumptions.

Outlook: Social capital

- Mechanism design/contract theory should also consider
  - … the impact and the dynamics of social norms
  - … reciprocal effects
  - … altruistic behavior
  - … fairness perception, and many more…

The value of "social capital" is underrated!



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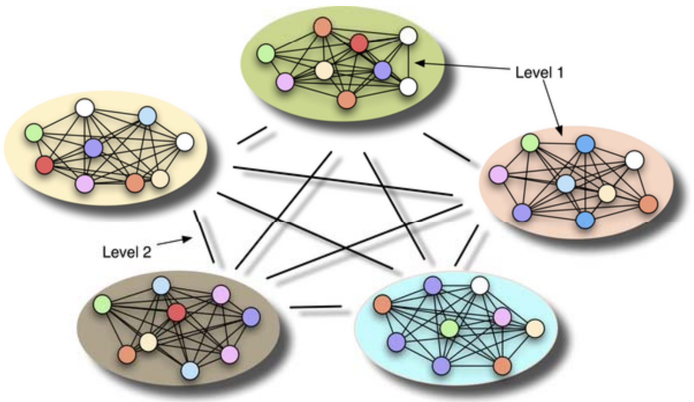

reciprocity/feedback mechanism

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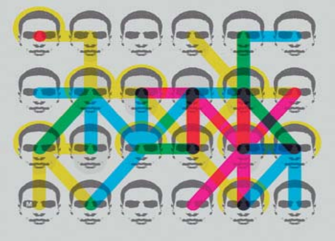
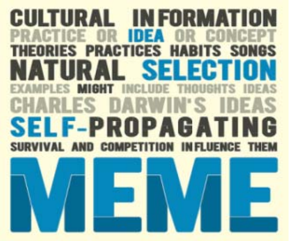
Thanks for your attention!

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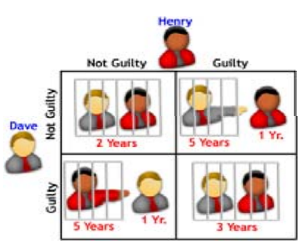

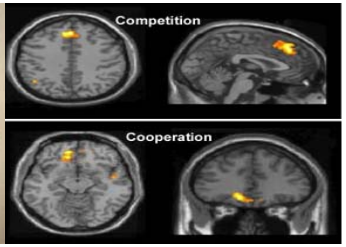

Questions, comments and criticism are very welcome!

Conclusion

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