Courant Research Centre
Evolution of Social Behaviour

GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

HUMANS PLAYING A SPATIAL PRISONERS DILEMMA

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INTRODUCTION

Probably the most thoroughly studied mechanism that can explain the evolution and maintenance of costly cooperation among selfish individuals is population structure. However, so far there is a significant lack of experimental data in this field. We have conducted an experimental test to address the effect of population structure on the evolution of cooperation.
For this we use the classic paradigm to study the evolution of costly cooperation among selfish individuals, the prisoner's dilemma.
The theoretical basis for this experiment was the work of Nowak and May on the emergence of cooperation on a lattice, using a cellular automaton model[1].

METHODS

- 400 students from Kiel, Cologne, Bonn and Hamburg participated from 2003-2004 in the experiment
- 16 players per group are virtually arranged 4x4 lattice with periodic boundary conditions (torus, Fig. 1).

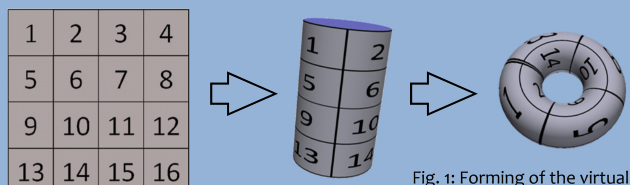

Fig. 1: Forming of the virtual torus

- Each player had four neighbors per round (von-Neumann neighborhood)
- 25 prisoner dilemma rounds with the payoff matrix in Fig. 2
- Each player made one decision per round either play Cooperate or Defect with all four neighbors

PAYOFF MATRIX

	C	D
C	0.30€	0.00€
D	0.40€	0.10€

Fig. 2

- The players solely interacted with and received information of the behavior and payoffs of their four neighbors at the end of each round.
- **Fixed treatment (15 groups):** all players had the same spot on the grid throughout the game
- **Random treatment (10 groups):** all players were randomly placed on the grid each round

PREDICTIONS

- Assuming that players switch to the strategy of the neighbor with the highest payoff (imitation dynamics):
  - With spatial structure the players can form stable clusters of cooperators and humans should quickly discover the potential benefit of cooperator clusters (Fig. 3). This should lead to a higher level of cooperation.
  - Without spatial structure stable cooperator clusters cannot be formed and therefore defection should be the preferred choice.

Fig. 3: Stable and unstable clusters of cooperators

RESULTS

- We find no significant difference in the level of cooperation between the spatial setting treatment and the random setting treatment.
- We find no stable cooperator clusters.

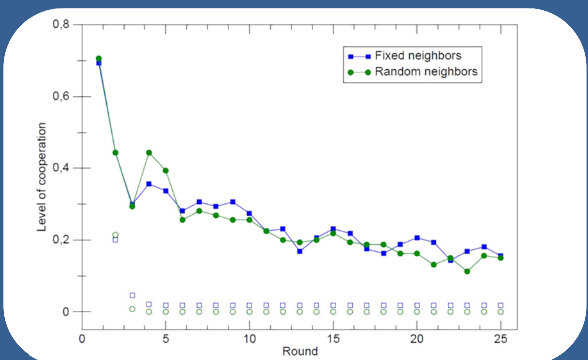

Fig. 4. Average level of cooperation in a behavioral experiment with humans (filled symbols). The dynamics in a system with 4 fixed neighbors on a spatial lattice with periodic boundary conditions is not significantly different from the dynamics in a system with random neighbors. The average level of cooperation tends to decrease, but some cooperation is maintained throughout the experiment. Since only special initial conditions lead to stable clusters, the theoretical prediction based on imitation dynamics for a fixed neighborhood (open spares) predicts only a small, but finite level of cooperation. For random neighbors, no significant level of cooperation is expected from the theory (open circles) (both experimental averages over 10 repeats with 16 players.

SUMMARY

Our analysis illustrates that there is less difference between spatial and non-spatial populations than previously conjectured. Despite the small size of our system, there is potential for cluster formation, but cooperator clusters do not persist in the behavioral experiment. Even in unstructured populations, a significant degree of cooperation is found, in contrast to theoretical considerations which typically lead to the conclusion that unstructured populations do not lead to the evolution of cooperation.

[1]Nowak, MA, May, RM (1992) Evolutionary games and spatial chaos. Nature 359:826{829.

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