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Evolution of Social Behaviour

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Self-organization & cooperative behaviour in dynamic social networks

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Introduction

Cooperation in human societies is ubiquitous, though natural selection should favour defectors over cooperators. Network reciprocity is one theoretical mechanism where certain spatial network structures allow cooperation to evolve. Moreover, cooperation can be enhanced by making networks dynamic, i.e. behaviour and network structure co-evolve.
By active linking [1,2] individuals can control their social interactions, i.e. to break existing links and to form new links. Based on this theoretical work, we investigated in an experimental study the cooperative behaviour of groups organized on dynamic networks and the influences of an active link breaking mechanism on the network topology.

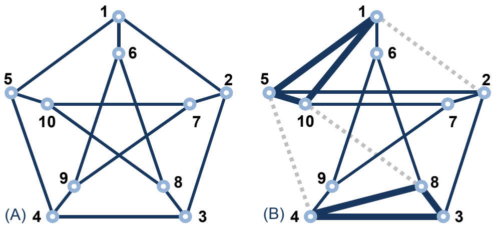

Fig. 1 Network topology
Circles represent individuals and lines are links between individuals. *(A)* Initial network topology. *(B)* Example of active link breaking (dotted lines: former links; bold lines forming a triangle: cluster).

Method

The game:
Ten groups of 10 participants (♀=55, ♂=45) played 30 rounds and with 3 partners simultaneously (though independently). Interactions were defined by the network structure.

Stage 1: Prisoner's dilemma
For each partner participants decided whether to cooperate (C) or defect (D) (cf. payoff matrix to the left).

Stage 2: Active linking
Participants could refuse to keep playing with a partner; then the link was broken and both received new partners, randomly chosen (cf. Fig. 1).

		partner C	*partner* D
focus player	C	0.25 €	-0.10 €
	D	0.40 €	0.00 €

The network:
In the initial network (Fig. 1A) two linked participants never share a partner, i.e. there are no clusters. Random re-linking decreases the chances of cluster formation (cf. Fig. 1B), as players from very different corners of the network can be linked and do not necessarily have shared partners.

Results

Cooperation level:
- Participants cooperated on average 59.7% (s.d.: 9.4)

Social links:
- Partner defected → participant was more likely to cut the link (logistic regression: $\beta = 3.47$, s.e. = 0.10, $p < .001$)
- Cooperative participants meet → link lasted longer than if either of them defected in the first prisoner's dilemma (Fig. 2)

Clustering within the network:
- Participants classified as net-cooperators and net-defectors → higher clustering scores for net-cooperators (Fig. 3)

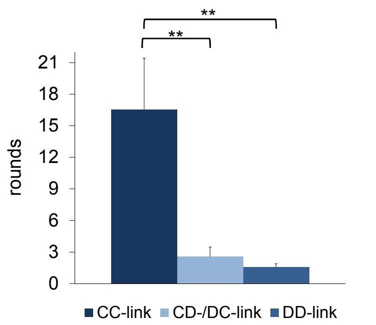

Fig. 2 Duration of links (± s.d.)
Participants cooperated, C, or defected, D. Accordingly, they either formed a CC-link, a CD-link (DC-link, respectively), or a DD-link.

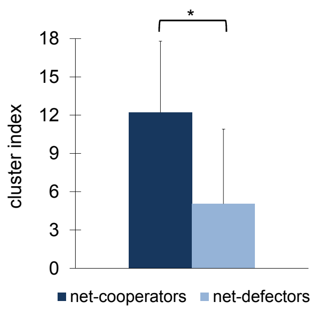

Fig. 3 Cluster scores (± s.d.) for on average more cooperative and more defective participants.

Main Conclusions

- Assortment of cooperative participants into clusters generates a social environment that can protect them from exploitation.
- Surprisingly, participants sorted into clusters with no knowledge of their partners' partner's behaviour or any information on the network topology.

→ Clustering (global level) emerged through self-organization from local interactions (prisoner's dilemma and linking decisions).

- Participants' linking decisions are influenced by the prisoner's dilemma outcome, leading to changes in the network.
- Changes of the network structure (e.g. cluster formation) feed back on how participants choose their behaviours.

→ Thus, generating a feedback loop between local dyadic interactions and the global network level, i.e. the ecological context of participants.

⇒ This highlights the importance of the interaction between the ecological context and selective pressures on cooperation.

[1] Pacheco, JM, Traulsen, A & Nowak, MA (2006). Active linking in evolutionary games. *J. Theor. Biol.*, 243, 437-443.
[2] Pacheco, JM, Traulsen, A, Ohtsuki, H & Nowak, MA (2008). Repeated games and direct reciprocity under active linking. *J. Theor. Biol.*, 250, 723-731.

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