Explaining Cooperative Groups via Social Niche Construction

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The Problem of Cooperation

- Cooperative behaviours: benefit others, at an apparent cost to self (weak and strong altruism).
- Public goods production, e.g., alarm calls in birds, extracellular substance production by micro-organisms.
- Problem: Selfish Cheats – individuals that reap the benefits of others' cooperation, without themselves paying the cost.

Population Structure is the Key to Cooperation

- If interactions are not freely-mixed, individually costly cooperative behaviours can evolve.
- Relatedness, or between-group variance, measures deviation from random interactions.
- Key is group structure: trait-groups, sibling groups, demes…

The Evolution of Cooperation

- Most models of cooperation assume a fixed population structure, i.e., a fixed relatedness
  - Fixed group size
  - Fixed migration rate
- They then show the level of cooperation that is evolutionarily stable given this structure.
- So cooperation is simply the adaptation of organisms' social behaviour to the social environment they find themselves in.

Does this really explain the origin of cooperation?

- Cooperation depends upon population structure, but where does this population structure come from?
- Some population structure is provided by the physical environment:
  - Viscous populations
  - Rocky shores
- But, population structure is also the product of individual genetic traits, so can itself evolve:
  - Group size preference
  - Dispersal distance
  - Degree of polygamy

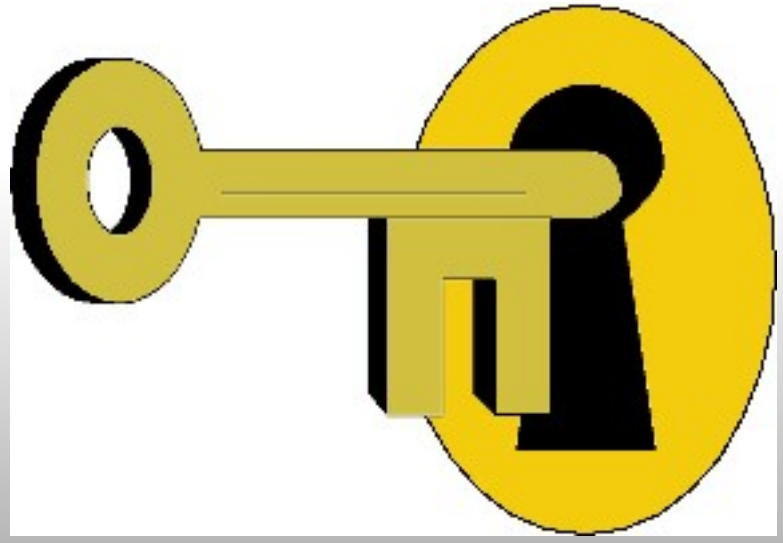
The Origin of Sociality

Pre-transition population structure	Post-transition structure
Replicating molecules	Replicators encapsulated in protocells
Independent replication of genes	Whole chromosomes replicated
Single cells	Multicellular organisms
Solitary organisms	Sociality

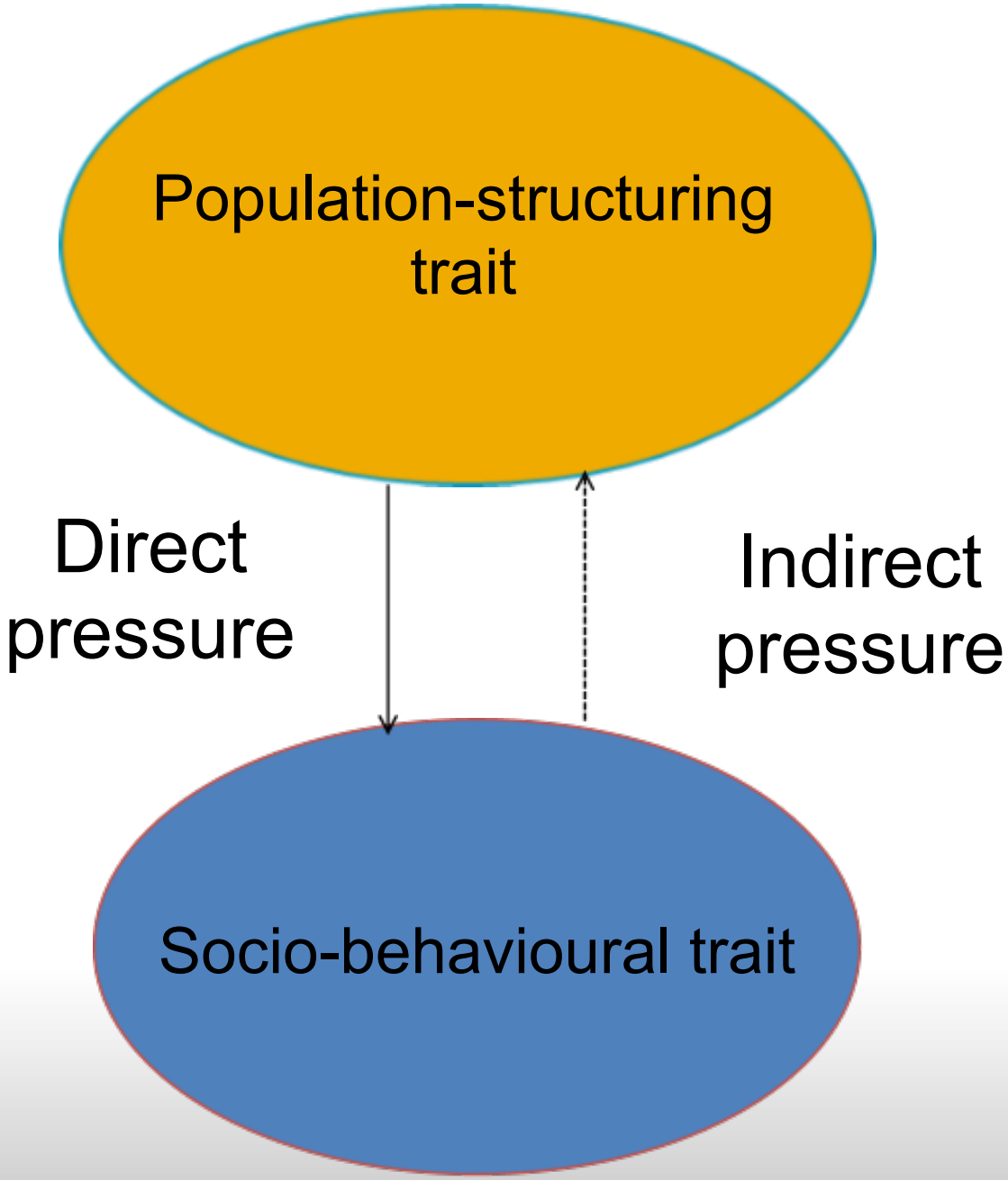
- Maynard Smith & Szathmáry's (1995) "Major Transitions"
- The origin of sociality involves a change in both social behaviour and population structure.
- How do organisms create higher levels of selection?
- So we cannot just model the evolution of cooperation on the back of a fixed structure.

Social Niche Construction

- So the strength of kin / group selection can itself evolve.
- Organisms can create a population structure that selects for cooperative or selfish behaviour: Social Nice Construction.



Positive feedback between social behaviour and population structure

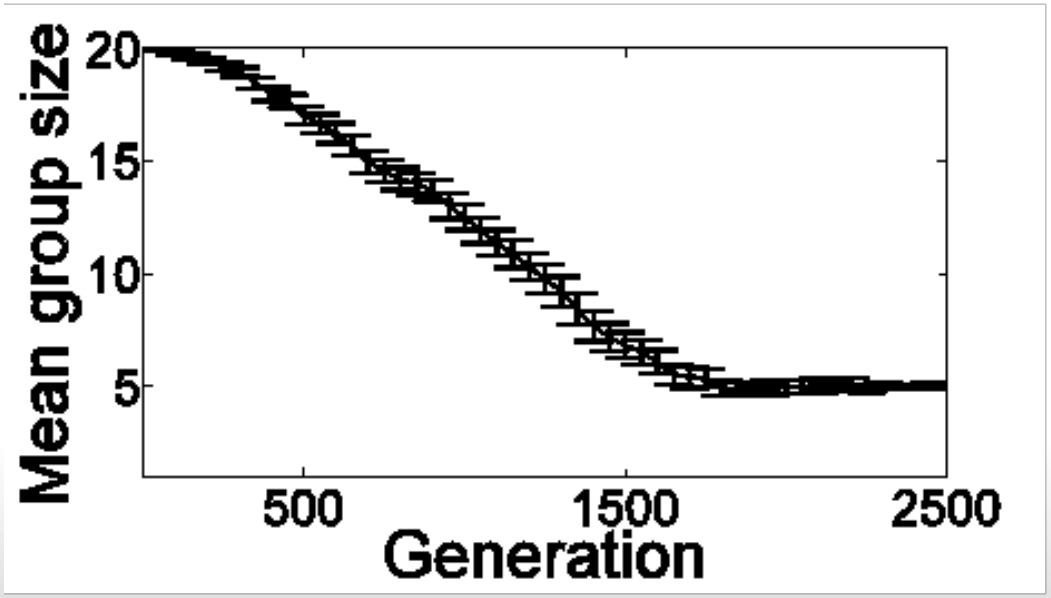


An Illustrative Model: the evolution of group size

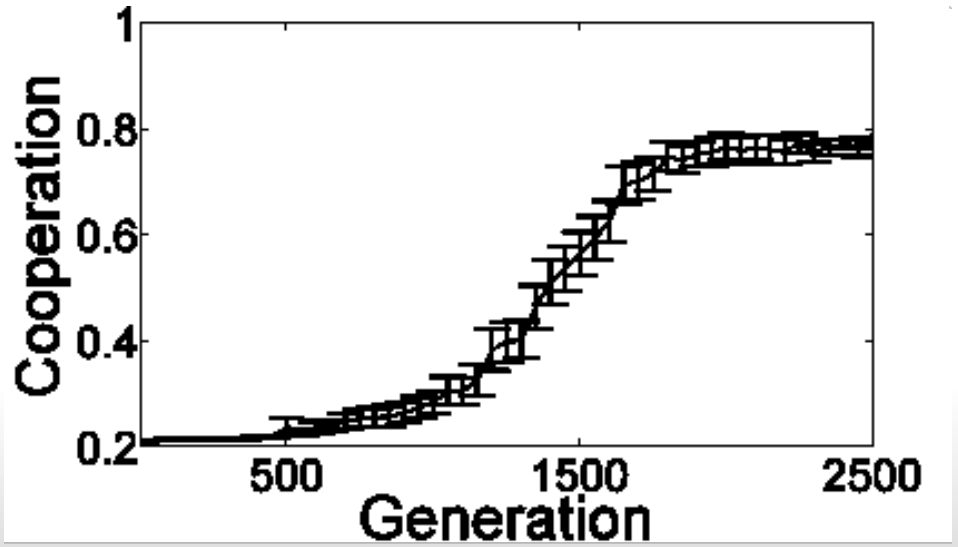
- Individuals live in social groups founded by a number of individuals sampled randomly from the global population.
- Small groups have higher between-group variance and favour cooperation.
- Large groups have lower between-group variance and favour selfish behaviour.
- Consider organisms that have genetic traits for both group size preference and social behaviour.
- No direct selection on group size preference.

The Coevolution of Group Size and Social Behaviour

Evolution of Population Structure



Evolution of Social Behaviour



Why Does Population Structure Evolve to Support Cooperation?

- Small groups select for greater cooperation than large groups.
- Because the individuals in small groups are those with the small size preference allele, positive linkage disequilibrium is generated between the cooperative and small size alleles.
- Since cooperation raises mean fitness, direct selection on social behaviour creates indirect selection for small group size.
- Positive feedback: As small groups increase in frequency, they create greater selection for cooperation.

Generality

- Argument applies to any heritable trait that affects its bearers population structure, if:
  - individuals with a heritable population structure preference are able to live in that population structure.
  - the population structures select for different amounts of cooperation.
- This component of selection on population structure, arising from social behaviour, must always favour structures that support cooperative rather than selfish behaviour.

Philosophical Implications

- Explaining within-group social behaviours becomes part of the same project as explaining the origin of the groups themselves.
- We cannot understand social behaviour in humans without understanding human population-structuring traits.
- The creation of cooperative groups by the evolving individuals parallels negotiation of a social contract.
- Multiple levels of explanation.

Conclusion: Cooperation Drives Population Structure

- Most theories of cooperation assume a static population structure.
- But to explain the origin of cooperation, we need to explain the origin of the structures that support it.
- Not only do some population structures select for cooperation, but cooperative behaviour drives indirect selection for the structures that support it.

References

- Powers S.T. (2010), Social Niche Construction: Evolutionary Explanations for Cooperative Group Formation, Ph.D. thesis, University of Southampton
- Powers S.T. and Watson R.A. (2009), Evolution of individual group size preference can increase group-level selection and cooperation, Proceedings of ECAL 2009, Springer.