

# Cooperation through the Endogenous Evolution of Social Structure

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**Abstract.** A number of recent models demonstrate sustained and high levels of cooperation within evolutionary systems supported by the endogenous evolution of social structure. These dynamic social structures co-evolve, under certain conditions, to support a form of group selection in which highly cooperative groups replace less cooperative groups. A necessary condition is that agents are free to move between groups and can create new groups more quickly than existing groups become invaded by defecting agents who do not cooperate.

**Keywords:** evolution of cooperative, agents, group selection, prisoner's dilemma, cultural evolution.

## 1 Introduction

Human society is pervaded by groups. Some are formal, such as corporations, educational institutions and social clubs. Others are informal such as youth tribes, collections of old men in a town square who discuss politics and play chess, and more recently various online forums. Some last for a long time, replenishing their membership over many generations and others are ephemeral and fleeting. Some have distinct and clear boundaries others are more diffuse – formed of overlapping networks of relationships. It would appear hard to make sense of human social behaviour without some reference to groups. Indeed, if individuals are asked to describe themselves then it is highly likely that they will refer to the groups that they hold membership of.

### 1.1 The Danger of Intuition

Although it seems intuitively clear that humans (and even other species) benefit from organising, coordinating and cooperating within groups, understanding how these might evolve from individual behaviour poses major puzzles for both political economy and evolutionary theory. If we start from individual self-interest or selfish replicators then why would individuals behave for the benefit of the group

if they can “get away” with free riding on the group - extracting the benefits of group membership without making a contribution?

One of the dangers of intuition about group processes is that it can lead one to ascribe agency to a group where none exists. Indeed the idea that if a group has interests - in the sense of something that would benefit all members - then rational or evolutionary individuals will behave in a way that promotes those interests has been debunked by careful analysis. Olson’s famous work clearly describes the folly of this intuition when considering rational agents [23] and biologists have also challenged this idea from an evolutionary perspective [39,14].

Given these results there has been a desire to understand the highly groupish phenomena observed in human societies which appears to be altruistic from the point of view of the the individual. One way to tackle this is to attempt to capture the kinds of cultural evolutionary processes that might support learned behaviour that does not conform to self-interest [4].

In this paper we follow this line by discussing recent evolutionary models that rely on a dynamically evolving population structure - that constrains interaction possibilities - that produce remarkable groupish phenomena. With only minimal assumptions these models support the endogenous formation of groups and high levels of cooperation within the groups even when there are significant incentives for individuals to free ride.

## 1.2 Recent Models

Recent evolutionary models demonstrate novel forms of group selection based on simple learning rules. They function via the spontaneous formation and dissolution of groupings of selfish agents such that altruistic behaviour evolves within their in-groups.

These social dynamics, offering an alternative to rational action theories, demonstrate several notable features of human systems such as seemingly irrational altruism, highly tribal or “groupish” behaviour, and complex dynamics of social structures over time. We overview several classes of such models - some based on evolving network structures and others based on different forms of population structures - indicating their key features and potential applications.

Recent agent-based computational simulation models have demonstrated how cooperative interactions can be sustained by simple imitation rules that dynamically create simple social structures [28,27,11,13,12,7,20,37,30]. These classes of models implement agents as adaptive imitators that copy the traits of others and, occasionally, adapt (or mutate) them. Although these models bear close comparison with biologically inspired models - they implement simple forms of evolution - the interpretation can be of a minimal cultural, or social, learning process in which traits spread through the population via imitation and new traits emerge via randomised, or other kinds of, adaption.

Often agent-based models represent social structures such as groups, firms or networks of friends, as external and a priori to the agents - see so-called “network reciprocity” results [19]. In the models we discuss in this paper the social structures are endogenous such that agents construct, maintain and adapt