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Social cohesion and the evolution of altruism ☆

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ABSTRACT

In this paper we propose a stylized model to study how cohesion may affect the spread and consolidation of altruism in a large population where agents are involved in a local public-good contribution game with their neighbors. We show that, if the contribution cost is moderate (neither too high nor too low), cooperation can invade and dominate the population if, and only if, group cohesion displays an intermediate value. This reflects an interesting non-monotonicity of cohesion in the evolution of altruism: while some of it is needed to internalize the benefits of cooperation, too much cohesion prevents the spread of altruism among the population at large.

1. Introduction

Local cohesion has been highlighted as a factor that can explain the rise of cooperation and altruism in large populations – see e.g. Nowak et al. (1994) or Eshel et al. (1998). The main insight gathered from the literature is that, if the population is spatially structured in relatively cohesive groups, the positive effects of cooperation can be internalized, at least partially. Hence, in that case, agents whose behavior is strictly selfish can do worse than those who are altruistic, which in turn allows cooperation to survive or even spread. But cohesion alone can only be part of the story. For, reciprocally, a society that is structured in groups with very high cohesion will tend to lack the channels required for the spread of cooperation. So even if some local "seed of altruism" can then arise somewhere in the population, it will hardly be able to grow and extend significantly if cohesion is too high.

In this paper, we address the problem and study how the former considerations impinge on the effectiveness of "social cohesion" in supporting cooperative behavior. And naturally, we find that the answer to this question depends on whether the objective is simply to have cooperation maintained (i.e. "protected" from defection) or, more ambitiously, the focus is

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on the possibility that it can spread and eventually dominate the overall population. In both cases, a key parameter in the analysis is the individual cost of cooperation – for example, it is clear that if this cost is very high, cooperation cannot possibly arise, independently of the level of cohesion.

There is, however, a range for the cooperation cost in which the cohesion of the population plays a crucial but non-monotone role. On the one hand, cohesion is *crucial* because only if it is high enough can a "seed" group of altruists be protected from the exploitation of selfish individuals in neighboring groups. Clearly, such a protection from egoists is a necessary condition for altruism to expand to the whole population. But, on the other hand, the effect is *not monotone* because, if cohesion is too high, altruism finds it impossible to spread beyond the initial group. Indeed, under very high cohesion, the original group of altruists continues to be well protected from neighboring egoists. However, as altruism starts to move *gradually* to adjacent groups, the new altruists face egoists within their own (heterogeneous) groups. And then, it is precisely very high cohesion that exposes those altruists to a severe exploitation of their egoist fellow group members and prevents a sustained expansion of altruism. Thus, in the end, we shall conclude that the level of cohesion must lie in some middle range if altruism is *both* to arise and be maintained as the overall dominant mode of behavior in the population.

Our model considers a large set of agents who are uniformly distributed in some underlying one-dimensional space and play a local public-good contribution game with their partners (i.e. the agents to whom they are connected). In this game, egoism (i.e. no contribution) dominates altruism (contribution to the public good). The population is divided into disjoint adjacent groups whose social cohesion is measured in a simple but very tractable way – roughly, it is identified with the lowest fraction of internal connections a group has. Therefore, maximal cohesion corresponds to a situation where every interaction is among agents of the same group, while cohesion is minimal when interaction is "group-blind." In this latter case, that is, every agent interacts with those who are close to her in space, independently of group affiliation. Finally, our model postulates that agents follow a simple imitation rule to adjust their behavior – specifically, they are taken to adopt the action that displays the highest average payoff among the agents with whom they interact.

In the setup just outlined, our main conclusions can be succinctly summarized as follows.

(1) If cohesion is high enough, both altruism and egoism can be maintained – i.e. they are stable and robust modes of behavior if already dominant in the population. In other words, initial conditions (be they cooperative or not) are pre-eminent in this case.
(2) When cohesion is low enough, either altruism or egoism can invade, depending on the contribution cost. If this cost is high, egoism can invade (through a single "mutant" group) an originally altruist society, while altruism enjoys the reciprocal situation if the cost is low.
(3) For any given contribution cost lying in a suitable region, there is an intermediate interval for the level of cohesion within which altruism can invade an originally egoist society. Instead, for the same costs, if the level of cohesion is low or high enough (in particular, outside the aforementioned interval), neither altruism nor egoism can invade a population displaying the opposite behavior.

We find, therefore, that when cohesion is either at the high or low ends of its domain, the struggle between altruism and egoism is resolved – depending on whether the contribution cost is high or low – in an intuitive manner. But if we consider instead how the outcome is affected by varying cohesion, there is a region for the contribution cost such that only if cohesion lies in an intermediate range, altruism receives the effective support that allows it to first gain a foothold in, and then invade, an egoist society.

To conclude this Introduction, we briefly discuss the literature that is most directly related to our approach. Besides the aforementioned branch of research that has focused on how local interaction may promote cooperation, other authors have studied how different variants of local cohesion bear on problems of coordination. For example, Young (1998) has studied how a certain measure of cohesiveness (he calls it close-knitness) affects the speed of convergence to a long-run equilibrium, while Morris (2000) highlights the role of cohesiveness in the spread of new social norms. In what follows, we briefly discuss the work of Morris, whose model displays some similarities, but also interesting contrasts, with our approach.

The main question studied by Morris is whether a more efficient action, initially present in very small frequency, can displace an alternative one that was originally chosen by most of the population. As it turns out, he finds that the key condition for such an extensive diffusion to take place is that there is no cluster of agents choosing the inefficient action that is cohesive enough in the social network. Hence, in essence, his conclusion is that too much cohesiveness is the key roadblock preventing the transition to a more efficient social state. These considerations also arise in our context, but with crucial differences. In the model studied by Morris, agents interact locally according to a pure coordination game, so that playing the efficient action generally defines a locally stable configuration. Thus high cohesion is not needed to support the efficient behavior in this case. Instead, in our context, altruism is a dominated action whose survival requires (provided its cost is moderately high) that the population structure display enough cohesion. The issue then arises of whether the level of cohesion needed to support altruism locally is consistent with its spreading globally beyond an initial seed. In this latter respect (global diffusion), cohesion plays in our case a blocking role that is quite analogous to that found in Morris' model. But since local support of altruism is equally important, a fundamental trade-off stands out: neither too low nor too high cohesion can prevail if the efficient action is to reach eventually the whole population.

As explained, our formalization of the notion of cohesion relies on the construct of groups, which is in itself another route through which the rise of cooperative or efficient behavior has been rationalized in the literature – see e.g. the papers