



What games support the evolution of an ingroup bias?

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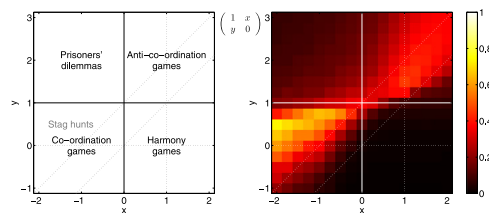
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HIGHLIGHTS

- The evolution of an ingroup bias is analysed for various symmetric two-player games.
- In some games the bias evolves even without reciprocity and kin selection.
- This does not apply to co-operation games, but to (anti-)co-ordination games.
- Certain (anti-)co-ordination games are particularly conducive to the bias.
- This includes games relying on trust, such as the stag hunt.

GRAPHICAL ABSTRACT

Both analyses and simulations show that an ingroup bias evolves in (anti-)co-ordination games. The simulations further show that the strategy becomes particularly prevalent in stag hunts. The picture depicts, to the left, the games derived from the game matrix, in the middle, for different values of x and y . The panel to the right shows the simulated proportional prevalence of an ingroup bias for the different games when there are 10 groups in the population.



ARTICLE INFO

Article history:

Received 17 September 2014

Received in revised form

27 February 2015

Accepted 4 March 2015

Available online 17 March 2015

Keywords:

Ethnocentrism

Minimal groups

Cooperation

Replicator dynamics

Assurance game

ABSTRACT

There is an increasing wealth of models trying to explain the evolution of group discrimination and an ingroup bias. This paper sets out to systematically investigate the most fundamental assumption in these models: in what kind of situations do the interactions take place? What strategic structures – games – support the evolution of an ingroup bias? More specifically, the aim here is to find the prerequisites for when a bias also with respect to minimal groups – arbitrarily defined groups void of group-specific qualities – is selected for, and which cannot be ascribed to kin selection.

Through analyses and simulations of minimal models of two-person games, this paper indicates that only some games are conducive to the evolution of ingroup favouritism. In particular, this class does not contain the prisoners' dilemma, but it does contain anti-co-ordination and co-ordination games. Contrasting to the prisoners' dilemma, these are games where it is not a matter of whether to behave altruistically, but rather one of predicting what the other person will be doing, and where I would benefit from you knowing my intentions.

In anti-co-ordination games, on average, not only will agents discriminate between groups, but also in such a way that their choices maximise the sum of the available payoffs towards the ingroup more often than towards the outgroup. And in co-ordination games, even if agents do manage to co-ordinate with the whole population, they are more likely to co-ordinate on the socially optimal equilibrium within their group. Simulations show that this occurs most often in games where there is a component of risk-taking, and thus trust, involved. A typical such game is the stag hunt or assurance game.

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1. Introduction

Human beings are often quick at dividing people into groups, implicitly or explicitly, and then let these divisions guide their

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behaviour towards them. More specifically, we tend to have an ingroup bias, meaning that we give preferential treatment to fellow group members.

The bias has been demonstrated in numerous settings, such as field studies and laboratory experiments (Brewer and Campbell, 1976; Kramer and Brewer, 1984; Yamagishi and Mifune, 2009; Balliet et al., 2014). The puzzle is that in some of these settings, people either lose in potential benefits from discriminating against outgroup members, or they take on net costs for helping out ingroup members when it would appear beneficial to abstain. Within small groups, apparently altruistic behaviour can often evolve by kin selection (Hamilton, 1964) or reciprocity (Trivers, 1971). In these groups, it would be more straightforward to use individual recognition rather than relying on weak group signals, and the ingroup bias observed would be an average preference based on whom people manage to co-operate with, rather than an evolved bias for how to behave beyond individual recognition. Meanwhile, people do display an ingroup bias also in situations where these mechanisms are not at work, and have shown to have preferences based purely on group signals. The bias can be triggered by minimal cues from arbitrary group definitions (Tajfel et al., 1971; Doise et al., 1972; Ahmed, 2007). What needs to be understood is thus how a bias that is activated among complete strangers has emerged. Co-operation can emerge as a spill-over effect from experiences from repeated interactions where it is rational (see e.g. Kiyonari et al., 2000; Rand et al., 2014), but it remains to explain the mechanisms that then lead to a bias towards strangers that is dependent on minimal signals. There is evidence that the bias works on an implicit level (Otten and Wentura, 1999) and that it is regulated by the hormone oxytocin (De Dreu et al., 2011), suggesting deep biological roots. Thus, it seems reasonable to look for an adaptationist explanation.

The human species is not alone in giving preferential treatment to similar individuals. In this respect, the bias resembles the green-beard effect (Hamilton, 1964; Dawkins, 1976; Gardner and West, 2009; West and Gardner, 2010) that has been observed in less complex organisms (Keller and Ross, 1998; Queller et al., 2003). Individuals have phenotypes that other individuals can condition their behaviour on, with the result being preferential treatment towards individuals with a certain phenotype. However, the human bias stretches far beyond kin recognition, is highly flexible and applies also to cultural cues (Lindenfors, 2013). While theories on green-beards are concerned with how selective altruism can withstand invasion by cheaters (with the phenotype but without the co-operative genotype), for a bias that is activated for so many various situations as the human one, we likely need to extend the question beyond conditions for altruistic behaviour and ask, in general, in what situations does group discrimination give an evolutionary advantage, also without kin selection?

Defining situations, or interactions with strategic structures with consequences for the fitness of individuals, brings us into the realm of game theory. When accounting for selective altruism, some version of the *prisoners' dilemma* is assumed. In this situation, the ingroup bias can be formally expressed as a propensity to choose the individually costly but socially optimal co-operative strategy towards fellow group members, while choosing the individually rational defective strategy towards others.

In a one-shot game, an individual with such a bias has an evolutionary disadvantage to anyone defecting in both cases. Several evolutionary models of discriminating co-operative behaviour try to solve this by introducing elements of group selection (Wilson and Dugatkin, 1997; Eshel and Cavalli-Sforza, 1982; Bowles et al., 2003) or group conflict (Choi and Bowles, 2007; Lehmann and Feldman, 2008). The former models assume high cognitive demand, small groups and high degrees of between-group selection related to selection within the groups for free-riders to be kept at stake (although some conditions have been derived for when groups may be large, see

Boyd and Richerson, 1990). As for the latter models, it is controversial whether conflict is likely to have been a major mechanism in evolving an ingroup bias (Brewer and Caporael, 2006; Brewer, 1999; Brewer and Campbell, 1976; Yamagishi and Mifune, 2009; Halevy et al., 2008; Cashdan, 2001; Mäs and Dijkstra, 2014; Balliet et al., 2014). In the end, the phenomenon under study does include preferential treatment towards the ingroup, whether or not this entails hostility towards the outgroup, and a model is more parsimonious if it can explain the former without assuming the latter.

What these models, and other models taking departure in the one-shot prisoners' dilemma, have in common, is that the aim is to find the conditions under which what is played is no longer a dilemma. For example, in an infinitely repeated version of the game, the *folk theorem* states that co-operation is an equilibrium. Given the right (and sufficiently many) assumptions, the situation can be tweaked so that people play a game where co-operation is rational within the group, while they still play the prisoners' dilemma between groups.

Before setting out to make assumptions that lead away from a social dilemma, we should know what situation to aim for. That is, what set of games support the evolution of an ingroup bias? A partial answer is those sets where we have different games for ingroup and outgroup interactions such that co-operation is rational in the former but not the latter. However, evidence suggests that the bias is activated also when the same game applies to both types of interactions. The aim here is thus to answer the question when all individuals play the same game.

Depending on the game in question, it is not always obvious how to define an ingroup bias. Let (p, q) be the probability that a random agent chooses the strategy that is most beneficial towards the partner from the ingroup (p) or the outgroup (q). We would then have group discrimination on the population level if $p \neq q$, and this would be an ingroup bias if $p > q$. Of course, what is beneficial needs to be defined, and will depend on the game. In general, this may be the socially optimal strategy, as in prisoners' dilemmas, but for other classes of games, such as *anti-coordination games*, where people are better off making different choices, it may be more reasonable to use another definition. We will return to making such a definition in Section 2.3.

First, theoretical analyses will be conducted to systematically define categories of two-person games that allow for group discrimination to evolve, and then, through simulations, we will find payoffs that optimally drive evolution towards an ingroup bias.

1.1. Previous models

Previous models of the evolution of ingroup favouritism typically focus on a specific game, commonly the prisoners' dilemma.

A well-cited model was presented by Riolo et al. (2001), where agents have a visible marker on a continuum and co-operate with sufficiently similar others. The number of offspring is determined by the success of the interactions and offspring inherit marker and tolerance level, subject to mutations. The result is that co-operation is maintained within small tolerance levels, but as tolerance levels increase due to drift, mutants with lower tolerance levels invade and form new co-operative clusters consisting of their offspring. Thus, in this model, and typical for models in its wake, preferential treatment based on the marker is successful if and only if it correlates highly with relatedness, with signals being but proxies for kin recognition. Another restriction in this model is that co-operation relies on the fact that agents are not given the possibility of co-operating with no one (Roberts and Sherratt, 2002). Similar models have been developed where groups are many and small (Traulsen and Nowak, 2007), agents have different mutation rates for tags and strategies (Antal et al., 2009), or a reputation (Masuda and Ohtsuki, 2007).

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