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Value homophily benefits cooperation but motivates employing incorrect social information

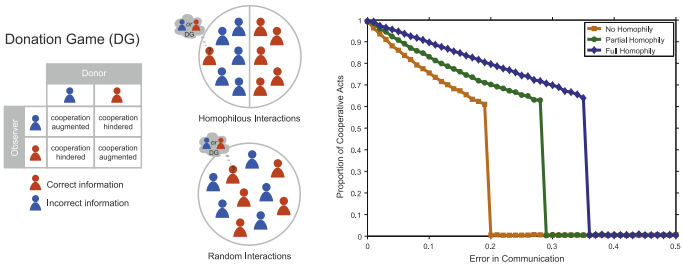
Paul Rauwolf*, Dominic Mitchell, Joanna J. Bryson

Department of Computer Science, University of Bath, Bath BA2 7AY, UK

HIGHLIGHTS

- We model the use of social norms and reputation to sustain cooperation.
- We examine the consequence of varying value-homophily in social interactions.
- Increasing value-homophily extends the potential for cooperation.
- It also creates selection pressure for ignoring accurate reputational information.
- Employing unjustified reputations is implicated in homophilous societies.

GRAPHICAL ABSTRACT



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ABSTRACT

Individuals often judge others based on third-party gossip, rather than their own experience, despite the fact that gossip is error-prone. Rather than judging others on their merits, even when such knowledge is free, we judge based on the opinions of third parties. Here we seek to understand this observation in the context of the evolution of cooperation. If individuals are being judged on noisy social reputations rather than on merit, then agents might exploit this, eroding the sustainability of cooperation. We employ a version of the Prisoner's Dilemma, the Donation game, which has been used to simulate the evolution of cooperation through indirect reciprocity. First, we validate the proposition that adding homophily (the propensity to interact with others of similar beliefs) into a society increases the sustainability of cooperation. However, this creates an evolutionary conflict between the accurate signalling of ingroup status versus the veridical report of the behaviour of other agents. We find that conditions exist where signalling ingroup status outweighs honesty as the best method to ultimately spread cooperation.

1. Introduction

It is frequently argued that the key advantage which drives the evolution of social learning compared to individual learning is that it provides more or better information at a lower cost. An individual that can benefit from what others know can draw knowledge from a wider range of experience at lower personal risk than one limited to their own immediate life events (Boyd and Richerson, 1985; Fernández-Juricic and Kacelnik, 2004; King and Cowlishaw, 2007; Magurran and Higham, 1988; Rendell et al., 2010). What happens when an individual discovers that the socially received information is false? If correctness is the paramount concern, we might expect that false socially learned information would be replaced by a more reliable source such as a first-hand experience.

There is mounting evidence that humans do not do this. Sommerfeld et al. (2008) tested the circumstances under which a participant would donate money to another individual. In each

* Corresponding author.
E-mail addresses: p.rauwolf@bath.ac.uk (P. Rauwolf), d.mitchell@bath.ac.uk (D. Mitchell), J.J.Bryson@cs.bath.ac.uk (J.J. Bryson).

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round, participants were paired and one person (the donor) was offered the opportunity to donate to the other (the recipient). Each donor was given either: (a) the directly observed history of the receiver's tendency to donate when the receiver had been a donor or (b) the gossip-spread reputation of the receiver from third parties. Significantly more variation in the tendency to donate was explained by individuals' use of reputation compared to their use of direct observation. Furthermore, Lorenz et al. (2011) showed that individuals edit their answers to questions based on other people's responses, though this often makes the average response of the group less correct. Even compared to other species of primates, humans continue to persist with inaccurate social views longer (Whiten et al., 2009).

The null hypothesis is that the above behaviours are maladaptive exceptions to what is typically an adaptive heuristic. Social learning could be the best strategy despite a high incidence of error when the full cost of accruing accurate information, including time, is taken into account (Mitchell et al., in preparation; Bryson, 2009). Further, researchers have proposed multiple heuristics by which humans bias their search for the most useful socially acquired information. Conformity bias—acting with the majority (Henrich and Boyd, 1998), prestige bias—imitating the most prestigious (Henrich and Gil-White, 2001), pay-off bias—imitating the most successful (Mesoudi, 2011) are examples. Additionally, although social information transmission may introduce error, so may individual learning. Thus, in the rare situations where correct direct observation is easily attainable (e.g. Sommerfeld et al., 2008), individuals may employ noisy social information instead of correct directly observed information, because typically direct observation is expensive or similarly error prone.

These explanations argue for error prone social learning as the 'least-worst' option, and that the human tendency to employ social information in contexts where it is not useful is merely a local exception to a generally adaptive heuristic. However, the underlying assumption is that the utility of information (whether gossip or asocial) rests upon the accuracy of the information. Here we propose an alternative explanation for ignoring accurate personal experience in favour of social information. If social information comes with social prescriptions as to the employment of that information, then the factors influencing one's decision to utilize the information may extend beyond accuracy alone.

We demonstrate that ignoring veridical personal experience can facilitate the cooperative exchange of information more generally. In particular, the mechanisms that generally facilitate cooperation can create a dilemma between two levels of information: (a) information about the transmitter and (b) information to be transmitted. We begin with a model of society where cooperation is regulated via reputation. Agents decide whether to donate to other agents and the reputation of the agent is spread throughout the population. We show that when homophily (the tendency to act with others who share similar beliefs) is added to this model, the robustness of cooperation is increased against error in communication. However, as a consequence, it becomes adaptive to employ incorrect social information even when an individual agent has access to correct information. In conditions where the pay-offs for group unanimity outweigh the costs of acting based on inaccurate information, there is selective pressure for norm-following.

Our examination employs both computer simulations and formal analysis and proceeds as follows. First, we briefly introduce the literature on homophily and the evolution of cooperation. Next, we model the Donation game to examine the effects of error on the evolution of cooperation. The Donation game has been utilized as an existence proof for the evolution of cooperation in highly mobile societies (Nowak and Sigmund, 2005). It can be described as a specific instantiation of the Prisoner's Dilemma (Suzuki and Kimura, 2013; Masuda, 2012; Uchida and Sigmund, 2010) and continues to be used for studying cooperation both theoretically (Tanabe et al., 2013; Masuda, 2012; Hilbe et al., 2013; Stewart and Plotkin, 2013; Uchida and Sasaki, 2013; Marshall, 2011, 2009; Nakamura and Masuda, 2012) as well as experimentally (Angerer et al., 2014; Sommerfeld et al., 2008). We confirm that the Donation game and the spreading of reputation can be used to sustain cooperation (Panchanathan and Boyd, 2003; Nowak and Sigmund, 2005). This result is employed as a baseline for measuring cooperation.

Next, we analyze the effects of value homophily (the propensity to interact with those who share your beliefs) on cooperation. We find that as interactions become biased toward shared beliefs, cooperation becomes increasingly robust to error. Finally, we allow individuals to discover in isolation whether the social information they have received is incorrect. We test the consequences of acting on this information. We find that in homophilous societies, agents employing correct information are invaded by agents communicating known error. This demonstrates that honest signalling about own-group membership can outweigh the importance of honest signalling about others' behaviour. We discuss some of the consequences of the results for the literature on self-deception.

2. Model and context

2.1. The problem of cooperation

In order to explore these issues, we need a context which meets certain requirements. First, the agents must learn valuable information socially. Second, that information must be subject to error. And finally, individuals must possess the ability to overrule what they socially learn, but in doing so breach a social norm. For our model, we implement a version of the Prisoner's Dilemma, called the Donation game (Marshall, 2011). This game has been used to show that cooperation can be established in a society when individuals exchange social information about the reputations of others (Nowak and Sigmund, 1998, 2005). We will give more details of the model in the following section, but first we review the problem of cooperation.

A cooperative society is defined as one in which individuals benefit from the collective absence of defection (Axelrod and Hamilton, 1981). However, it is often the case that for any individual member, defection is advantageous when others are cooperative. Several mechanisms have been hypothesised to overcome this problem of defection, notably reciprocal altruism (Trivers, 1971). In reciprocal altruism, an agent behaves prosocially with another so that the other will reciprocate at some later date. However, mobile societies, such as human ones, are often seen as vulnerable to free-riders (Enquist and Leimar, 1993 though see Schonmann et al., 2013). Individuals might defect opportunistically and move on before the consequences of their behaviour can catch up with them. In such cases, a different mechanism may be required to explain cooperation.

Indirect reciprocity (Nowak and Sigmund, 1998) solves this problem as an agent behaves prosocially with another because it is likely to subsequently receive a benefit from a different agent. This can be achieved when individuals observe each other, judge behaviour according to a norm, and pass on the resulting reputation via social transmission. Defectors can no longer free-ride, however mobile they are, so long as for every interaction they are likely to be preceded by their reputation and suffer a cost.

It should be clear that accuracy of information can be measured: for example, how closely an individual's reputation matches their actual behaviour. But to test the hypothesis described above,