Behavioral differences and the evolution of cooperation in adaptive social networks

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Abstract

Cooperation is essential in every society, but puzzling from an evolutionary perspective. Here, we discuss the work published in [11], where we address the role of behavioral differences — ubiquitous among Humans — in the evolution of cooperation. We study a model in which individuals interact along the edges of a complex network, engaging in social dilemmas of cooperation. The structure of the network changes in time, as new interactions arise whereas old ones disappear. Interactions may last long or brief, depending on the behavior of the individuals involved. When dissatisfied about a partner, some will try to break contact as soon as possible, whereas others will remain in touch. We adopt the framework of evolutionary game theory (EGT) and show how diversity in response to unwanted social interactions boosts cooperation. Moreover, diversity remains once cooperation sets in, providing the means to establish cooperation as a robust evolutionary strategy.

1 Summary

Cooperation has recently been proposed as the third major force of evolution, next to mutation and selection [6]. Understanding its viability under natural selection does, however, remain an intriguing quest [2], with a wide range of implications in areas like artificial intelligence research. The problem has been conveniently formulated using EGT [3], implying the famous prisoner's dilemma. We consider a population of individuals who may act either as cooperators or as defectors. Cooperators pay a cost (c) in order to provide a benefit ($b > c$) to their partners. Defectors refuse to pay any costs, but still rip the benefits provided by others. When two individuals meet, three scenarios are possible: both cooperate, both defect, or one cooperates whereas the other defects. Whenever anyone in the population is equally likely to be your partner, the mathematics of cooperation (EGT) shows that cheaters (defectors) win the evolutionary race, as the cooperator trait goes extinct in the population [3]. Hence, evolution leads to a scenario of defection, where no-one pays any costs but no-one receives any benefits either, unlike in a society of cooperators where everyone is better off. During the last decades, several mechanisms have been uncovered which provide an escape hatch to cooperators [5]. It has for instance been recognized that the adaptive nature of social networks plays a crucial role in increasing the viability of cooperators [7, 8, 12, 11]. Indeed, the fact that in modern human societies people do not only change their behavior, but also their social contacts, constitutes an efficient mechanism to support cooperative behavior. In this context, we investigate the relevance of behavioral diversity in partner fidelity to the conundrum of cooperation [11].

We study a model in which individuals interact along the edges of a social network, every interaction being represented as a prisoner's dilemma. Each individual can either cooperate or defect upon interaction. The structure of the network changes in time, as individuals regularly engage in new social interactions while abandoning old ones. Some interactions may last long, whereas others are short-lived, which depends on the behavior of the individuals involved. Those interactions that satisfy both parties will most likely last longer than those that do not. Furthermore, individuals also differ in the way they treat unwanted interactions (behavioral diversity in partner fidelity). Some will try to break contact as soon as possible, whereas others

remain in touch even though they are dissatisfied with the situation. In [11], we show how cooperation blooms — and society as a whole benefits — the larger the behavioral diversity in responding to adverse social ties.

This supports the idea that diversity, on a grand scale, is instrumental in shaping us as the most sophisticated cooperative entities on this planet (see also [10]). Indeed, cooperation evolves in the advent of behavioral diversity, even when individuals behave according to their own myopic preferences and without any need for norms, punishment or any other community enforcing mechanism. In more technical terms, differences in behavior combined with adaptive social dynamics make individuals perceive differently the same social dilemma [7, 11]. On static [13, 9] or co-evolving [7, 8, 12, 11] networks, all individuals behave as if they engage in a transformed game — yet everyone perceives the same game. Individual diversity, on the other hand, enables those who engage in the same game to perceive that game differently; in doing so society as a whole benefits. Moreover, it is rewarding that behavioral diversity remains once cooperation sets in, providing a robust means to prevent invasion by defectors.

The developed framework is general and can be applied to other problems of interest such as the spreading of infectious diseases or computer viruses [1, 4]. Here, individual diversity can be associated with variability in response to drug treatments, vaccines, immune responses, etc. The co-evolution of network topology and individual's epidemiological state may, just like in [11], introduce feedback mechanisms that drastically affect the overall dynamics of the system, calling for a coevolutionary process as the one discussed here.

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