A few bad apples can destroy the reciprocal nature of the majority

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Introduction

Conditional cooperation is ubiquitous in human societies, but the circumstances under which evolution fosters it are not yet known. One possible explanation that has been proposed is social norms. Recently, it has been recognized that a social norm is a conditional preference that depends on 'normative expectations' and 'empirical expectations.' However, studies connecting social norms to cooperation only consider the former type of expectations while completely ignoring the latter. Against this background, we propose the first model that considers both types of expectations to explain the evolution of conditional cooperation. More specifically, we show that, in the presence of such expectations, a few good apples---unconditional cooperators---are sufficient to establish cooperation in a population of heterogeneous agents. Moreover, very few bad apples---unconditional defectors---are sufficient to destroy cooperation in such a population, even in the presence of a few good apples.

Model

Each agent i enters into a repeated public goods game (PGG) with arbitrary empirical expectation, ee_i, representing i's expectations of what the group members need to do. Agent i contributes to the public good if the past cooperation level exceeds ee_i. More formally, i contributes with a probability: $p_i = 1/(1+(\exp(-(n_C - ee_i)\beta))$, where n_C denotes the number of agents who contributed in the previous round, and β modulates the accuracy of social information about n_C. After the population makes their donation decisions in each round, the agents are rewarded or penalized according to normative expectations, i.e., the population's expectation of what an individual should do. We implement the normative expectations as follows. After each round of the PGG, each agent i is randomly paired with another agent j. If the actions of both agents match, i.e., if both reciprocate or both free-ride, then i is rewarded; otherwise it incurs a cost. Subsequently, all agents potentially update their social behavior based on their relative fitness.

Simulation parameters

Population size (N) = 100, and $ee_i \sim [0, N]$. Donation cost (d) = 0.5, non-coordination cost (nc) = 3, and coordination reward (r) = 1. We vary the accuracy of social information, $\beta \in \{0, 0.01, 0.1, 0.3, 0.5, 1. 2\}$, and the probability of norm enforcement, $p \in \{0, 0.01, 0.1, 0.5, 1\}$. Simulations ran for 20,000 generations, each consisting of PPG. We varied the percentage of good apples, $\alpha \in \{0\%, 5\%, 10\%\}$ and bad apples, $\gamma \in \{0\%, 1\%, 5\%\}$. Results for each experimental condition (N, d, nc, r, β, p, α, γ) averaged over 20 runs.

Results

High level of Cooperation is established when $\alpha > 5\%$ and $\gamma = 0\%$ (Fig. 1). Moreover, enforcing norms is much more important than the noise in empirical expectations (Fig. 2).

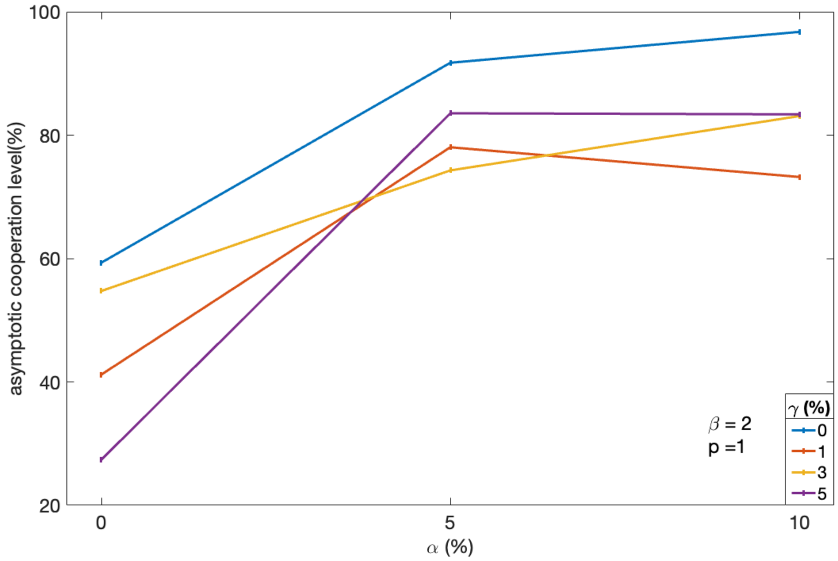

Fig. 1. Evolution of conditional cooperation for various α and γ.

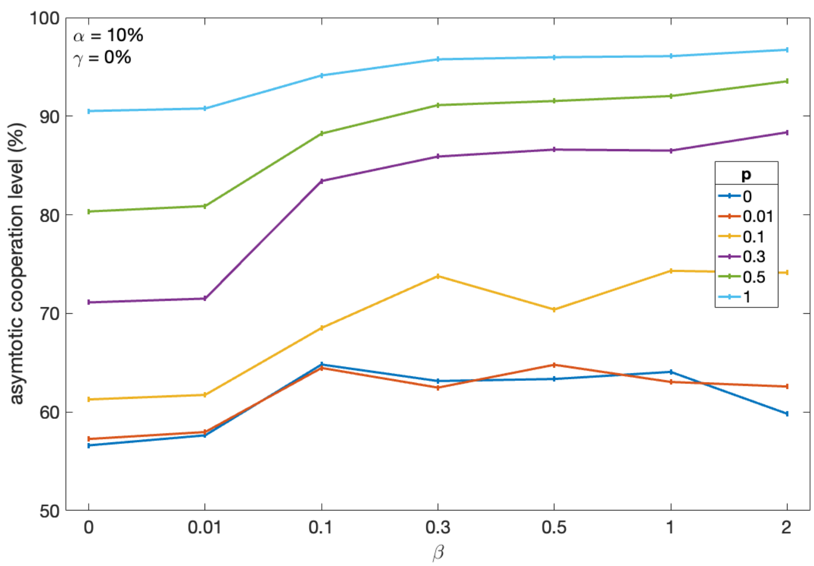

Fig. 2. Evolution of conditional cooperation for various β and p.

Conclusions

A few unconditional cooperators can influence the social learning of the population, thereby influencing the evolution of conditional cooperation.