Chaos, Solitons and Fractals 106 (2018) 76–79

Contents lists available at ScienceDirect

Chaos, Solitons and Fractals

Nonlinear Science, and Nonequilibrium and Complex Phenomena

journal homepage: www.elsevier.com/locate/chaos

Impact of strategy-neutral rewarding on the evolution of cooperative behavior

Jinzhuo Liu[a,b], Tong Li[a,b], Wei Wang[a,b,*], Na Zhao[a,b], Feilu Hang[c]

[a] School of Software, Yunnan University, Kunming, Yunnan 650200, China
[b] Key Laboratory in Software Engineering of Yunnan Province, Kunming, 650091, China
[c] Information Center, Yunnan Power Grid Co., Ltd, Kunming 650217, China

ARTICLE INFO

Article history:
Received 15 September 2017
Revised 31 October 2017
Accepted 1 November 2017

Keywords:
Cooperation
Evolutionary games
Rewarding
Network reciprocity
Social dilemmas

ABSTRACT

Social rewarding is a common but significant mechanism that promotes the evolution of cooperation. However, besides social rewarding, antisocial rewarding is also ordinary. Thus, we study the evolution of cooperation on prison dilemma game with strategy-neutral rewarding, namely a mechanism including social and antisocial rewarding. Two additional strategies, rewarding cooperators (RC) and rewarding defectors (RD), which establish union-like support to aid akin players are introduced. We show that the new mechanism greatly promotes the evolution of cooperation even in the presence of antisocial rewarding. The rewarding cooperators can enjoy both the benefits of their prosocial contributions and the corresponding rewards, thus they can form cooperative clusters to resist the aggression of defectors. On the other hand, due to their inherent greedy, rewarding defectors fail to secure a sustainable future. Our research might provide valuable insights into further exploring the nature of cooperation in the real world.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

The emergence of cooperation behavior is ubiquitous not only in nature, but also in human societies even Darwin's theory of origin of species drive their evolution and theoretically bring more benefit to defection [1,2]. Therefore, exploring the emergence and maintenance of cooperation among the population of unrelated individuals becomes an open challenge and attract the attentions of scientific researchers in a myriad of fields, such as mathematics, biology, statistical physics and behavioral science [3–14]. Among them the Prisoner's Dilemma game (PDG) is considered as a paradigm. In the PDG, two players concurrently decide to take one of two strategies: cooperation (C) and defection (D). They will receive the reward R if both cooperate and the punishment P if both defect. However, if one player defects while the other decides to cooperate, the former will get the temptation T while the latter will get the sucker's payoff S. The payoffs are ordered as $T > R > P > S$ so that in the well-mixed case defection is the best strategy regardless of the opponent strategy.

Nowak all attributed to five mechanisms that make individuals can escape from the so-called social poverty, including direct reciprocity, indirect reciprocity, kin selection, group selection, spatial reciprocity [15–18]. Spatial reciprocity, [19] introduced by Nowak and May, has attracted a great deal of attention. Thus the topology has become a determinant for the success of cooperative behavior (regular networks [20,21], small world networks [22–24] and scale-free networks [25–27]). Meanwhile, other factors have also been considered to explore their impact on the evolution of cooperation, such as environment [28–30], payoff [31–34] and so on.

Besides, the social rewarding mechanism where cooperators can receive rewards for performing prosocially as a second-stage behavior has received a lot of attention [35–40]. The mechanism is introduced into the evolution of cooperation on public goods games and 2-person games including PDG and SDG [41,42]. However, besides social rewarding, antisocial rewarding is also present in various interspecific social systems, such as the host often rewards the parasitic species of a symbiont and defectors establish a union-like support to aid akin players [43,44]. Recent works inspect what happens if both social rewarding and antisocial rewarding strategies are able to invest into a rewarding pool to support akin players on PGG [41]. Inspired by these findings, we wonder how such a strategy-neutral intervention influences the evolutionary outcome of a PDG.

In this work, we explore the impact of both social rewarding and antisocial rewarding on the evolution of cooperation on PDG. We consider a four-strategy game, where the traditional cooperators and defectors are joined by rewarding cooperators and rewarding defectors, and study how this strategy-neutral interven-

* Corresponding author at: School of Software, Yunnan University, Kunming, Yunnan 650200, China.
E-mail address: wangwei@ynu.edu.cn (W. Wang).

https://doi.org/10.1016/j.chaos.2017.11.001
0960-0779/© 2017 Elsevier Ltd. All rights reserved.

Table 1
Payoff matrix of the studied evolutionary game. The four strategies are cooperation (C), defection (D), rewarding cooperator (Rc) and rewarding defector (Rd). Here, γ stands for the cost of reward and β is the reward applied to aid akin players.

	C	D	Rc	Rd
C	R	S	R+β	S
D	T	P	T	P+β
Rc	R−γ	S	R−γ+β	S
Rd	T	P−γ	T	P−γ+β

tion affect the emergence of cooperation in structured population and if antisocial rewarding can deter the evolution of cooperative behavior.

2. Methods

In parallel to traditional version of the PDG entailing cooperators (C) and defectors (D), two additional strategies are introduced. These are rewarding cooperators (RC) and rewarding defectors (RD), who essentially establish a union-like support to aid akin players. When playing with a cooperator, the rewarding cooperators will reward the cooperator γ at a small cost β, while in interaction with a defector, the reward agent acts as a cooperator. Likewise, the rewarding defectors will also reward the defector γ at a small cost β when playing with a defector, while in interaction with a cooperator, the rewarding defector acts as a cooperator. That is to say, the rewarding agents perform as particular agents at the first stage, which is at variance with the second-stage behavior. Besides, following a common practice [45], we choose the PD's payoffs as $R=1$, $P=S=0$, and $T=b>1$, satisfying the restricted condition $T>R>P=S$. The interactions between the agents and the relative payoffs are presented in Table 1.

We implement the evolutionary dynamics in the following way. As initial conditions, we assign to each individual, with equal probability, one of the four available strategies: cooperation (C), defection (D), rewarding cooperators (RC), or rewarding defectors (RD). Then, at each time step, each player i in the network obtains the payoff P_i by playing with all its neighbors. Next, all the players synchronously update their strategies by picking up at random one of their neighbors, say j, and comparing the respective payoffs P_i and P_j. If $P_i > P_j$, player i will keep its strategy for the next step. On the contrary, if $P_i < P_j$, player i will adopt j's strategy with the probability:

$$W = \frac{1}{1 + \exp\left[\left(P_i - P_j\right)/K\right]}$$

where K stands for the amplitude of noise [46–49]. Without loss of generality, we use $K = 0.1$ for the PD. To assure that the system has reached a stationary state we make the transient time t equals 100,000. Then we can obtain the presented results by using $L = 100$ system size. Moreover, each data were averaged over up to 20 independent runs for each set of parameter values in order to assure suitable accuracy.

3. Result

Two additional strategies, rewarding cooperators (RC) and rewarding defectors (RD), are introduced into the PDG to explore the hybrid influence of social and antisocial rewarding on the emergence of cooperative behavior. In the interaction with an akin agent, the rewarding agent will reward his opponent γ at a small cost β with the effect of increasing the effective payoff gained by the opponent. In contrast, when the rewarding cooperator meets

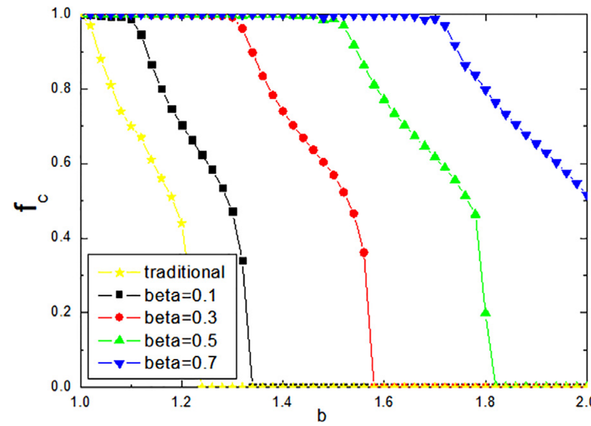

Fig. 1. Fraction of cooperative agents (cooperators and rewarding cooperators) $\langle\rho\rangle$ as a function of b for different values of γ. All the results in Fig. 1 have been obtained for $N = 400^2$ nodes, $\langle k\rangle = 4$, and $\beta = 0.01$.

a defective agent(defector and rewarding defector), the former one acts as cooperators only earning the sucker's payoff S, meanwhile, the rewarding defector gains the temptation T when meeting a cooperative agent (cooperator and rewarding cooperator). In the model, we fix $\beta = 0.01$ and change γ from 0.1 to 0.7 assuring that only a small cost is needed for rewarding and cooperation is promoted more obviously. In the methods section we summarize the interactions between players and their corresponding payoffs.

We start by examining the hybrid effect of the social rewarding and antisocial rewarding on the emergence of cooperation. The results obtained for different values of b are shown in Fig. 1 where the average fraction of cooperative agents is defined as the total fraction of cooperators and rewarding cooperators presented at the equilibrium state. In the traditional formulation (i.e., neither social rewarding nor antisocial rewarding) the fraction of cooperators at the stationary state suddenly decreases as $b > 1$ and becomes zero soon afterwards for very small values of the temptation b. Interestingly, even a small reward ($\gamma = 0.1$ or 0.3) can radically change the dynamics of the system that cooperation can survive even for big values of the temptation b. It is observed that the larger the γ value, the higher the critical value of b where the fraction of cooperative agent starts decreasing, which indicates that vehement rewarding is more effective in promoting cooperation.

To explore why the mechanisms promote cooperation, we analyze a series of snapshots for different values of γ and fixed temptation to defect b ($b = 1.3$). For $\gamma = 0$, the model returns to the traditional case, on which defectors occupy the whole lattice as shown in Fig. 2(a). However, as the social rewarding and antisocial rewarding are introduced into the game, even for a small $\gamma = 0.1$ (Fig. 2(b)), it can be observed that a few cooperators (rewarding ones) survive in the equilibrium state. The reason is that cooperators which interact with defectors become rewarding cooperators and form clusters to prevent the exploitation of defectors. As illustrated in Fig. 2(c), when the level of reward becomes higher (say $\gamma = 0.3$), cooperators tend to become rewarding cooperators, therefore form a series of compact C + Re clusters to resist the spreading of defectors. When the value of γ is further increased ($\gamma = 0.5$), an interesting phenomenon can be observed: the pure cooperative strategy emerges in the system. The reason can be explained as follows. With the increasing of reward level, C + Re clusters become larger and larger which means the threat of defective agents has diminished greatly. Thus, cooperators emerges in the C + Re clusters by comparison between cooperator strategy and rewarding cooperator strategy. These demonstrative snapshots indicate that the rewarding mechanism can greatly promote the

Download English Version:

https://daneshyari.com/en/article/8254309

Download Persian Version:

https://daneshyari.com/article/8254309

Daneshyari.com