Stability of Arbitrary Genes: a New Approach to Cooperation

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Abstract

We describe a model to explain how an arbitrary gene may persist in a population of self-interested agents even when it is detrimental to the individual. Since the arbitrary gene may code for a cooperative behavior, disadvantageous to the owner but advantageous to the whole population, the model may be used to explain the persistence of cooperative behaviors in societies of selfish agents.

THE MODEL

Explaining the persistence of cooperative behaviors is particularly difficult when cooperation is not directly beneficial to the individuals fitness and when it involves more than a handful of agents, weakening any mechanism based on reciprocity. We consider an iterated cooperation opportunity whose advantage is shared between all individuals of the population, whether they are cooperators or not. Also, in our simple model the cooperative behavior is the same for all cooperating agents. In such a case, the gene that codes for cooperation tends to disappear, since defectors share the advantages of cooperation without sharing the costs. A widespread gene coding for a retaliation against defectors may support cooperation. Unfortunately, since the punishment of the defectors is a cooperative effort itself, the vengeful gene tends to disappear in its turn.

In our model each agent can attack any other, determining symmetric penalties. The gene that codes for the vengeful behavior, though, does not code for a direct attack against defectors. It triggers, instead, an attack against each agent that behaved differently from the owner agent in the previous step. To determine the targets of its attacks, each agent maintains a succinct representation of the events that took place at the previous step consisting for each other agent of the simple information "did the other agent behave the same as me?"

In the experiments we considered a population of 100 individuals. At each time step the fitness of all the agents is increased by $4n$ points, where n is the number of cooperators. Further, the fitness of each agent is decreased by 1 point for each attack involving the agent and is decreased by 3 points if the agent is cooperating. After 100 time intervals the population reproduces with binary tournament selection. The results of the experiments are shown in Figure 1. The starting point of each arrow corresponds to the initial frequencies of the two genes, while the ending point corresponds to the frequencies of the next generation. Each arrow is obtained averaging ten experiments with the same initial gene frequencies. Our experiments show that if the frequency of the vengeful gene is high enough, the population is pushed towards uniformity, and any gene that is widespread into the population (the vengeful gene itself, a cooperative gene, or an arbitrary gene whatsoever) gains stability.

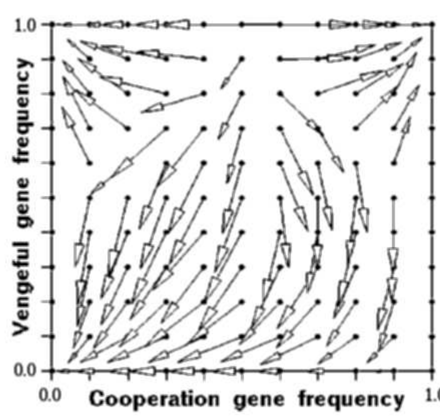

Figure 1: The results of the experiments.