Investigations of Granularity and Payoffs in 2×2 Games under Replicator Dynamics

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Abstract. This paper describes an investigation of several 2×2 games in iterated form. Players play the games repeatedly and are limited to mixed strategies, with particular actions chosen probabilistically. The games investigated include Prisoner's Dilemma, Chicken, and Stag Hunt in various forms. The reward structure and the granularity of the games—number of games played per generation in the replicator dynamics—are the main factors investigated, with surprising results.

1 Introduction

This paper describes results of experiments on several simple games under replicator dynamics. The experiments simulate interaction within a population of relatively basic artificial agents, each defined entirely by the strategy it is programmed to carry out. The game is played for multiple generations, after each of which the proportion of every strategy is adjusted to reflect its performance relative to other strategies. If a strategy performs very poorly, it may go extinct. Similarly, there may be cases in which a strategy performs so well that it takes over the whole population.

The games that we have chosen to experiment with are all 2×2 games. Such games involve two players, who—on each round of play—can choose between two courses of action and who receive payoffs that are dependent on both their own and their counter-player's decisions. We experimented with, and report on, the Prisoner's Dilemma game, the Stag Hunt game, and variant forms of Chicken.

While our experiments on Prisoner's Dilemma tried to replicate previous work by Nowak and Sigmund [NS92], most of our other experiments involve modifications of various game and simulation parameters. We examined the number of games played per generation, representing the level of *granularity* for the simulation, to determine whether it had a significant effect on the results. We also tested the robustness of the payoff structure by varying the

relative magnitudes of payoffs while remaining within the broad definition of the game in question.

The remainder of the paper discusses several interesting results. The emergence of Generous Tit for Tat (GTFT) strategies in stochastic Iterated Prisoner Dilemma (IPD) is highly dependent on the granularity of the simulated environment, i.e., on the number of games played per generation in the replicator dynamics. Further, we found that in all three games considered—Chicken, IPD, and Stag Hunt—well-accepted findings did not withstand radical changes to the payoff structure. Also, Flag Chicken simulations demonstrated that strong group allegiance and outsider prejudice can evolve in the presence of an arbitrary identifiable feature. This finding remains robust even with uncertainty in the identification process.

To explain the experiments as clearly as possible, we proceed as follows. First, §2 presents the games, along with remarks regarding application to problems in the real world. A detailed discussion of the simulation methodology follow in §3. We give special attention to the propagation rules used and specific variations of the games implemented. Finally, we discuss the principal findings of our experiments in §4.

2 The Games

2.1 Prisoner's Dilemma

Description. After the now-standard treatment in [LR57], two criminals have been arrested and thrown into separate cells, so they cannot communicate with each other. The candid prosecutor explains to each of them their identical situations. If they both confess to having committed a crime, they will both go to jail for three years. If they both maintain their innocence, they will only stay in jail for one year. However, if one defects and testifies against his partner, the defector will walk out free while his partner in crime gets five years of imprisonment. Each prisoner has no way of observing the other's actions before choosing his own. In matrix, or strategic, form, the game looks like this :

Table 1. Prisoner's Dilemma. Canonically: R=Reward, T=Temptation, P=Penalty, S=Sucker.

	Player A pleads innocent (Cooperate)	Player A confesses (Defect)
Player B pleads innocent (Cooperate)	Reward, Reward (3,3)	Sucker, Temptation (0,5)
Player B confesses (Defect)	Temptation, Sucker (5,0)	Penalty, Penalty (1,1)