Cooperation in Harsh Environments: The Effects of Noise in Iterated Prisoner's Dilemma

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Abstract. Interactions in the real world are subject to mistakes and miscommunications. The presence of this noise challenges cooperation, as one party cannot determine whether the other party did not cooperate on purpose. Prisoner's dilemma strategies like Tit-for-Tat (TFT) perform badly once noise is present. Recent studies that harsh environments promote cooperation do not take noise into account. We show that the adversity of the environment benefits cooperators and can make cooperation more robust against mistakes. Harsher environments also encourage greater generosity to cope with noise. Yet when uncertainty is substantial due to higher probability of mistakes or more potential defectors in the environment, contrite behaviours are the most successful.

1 Motivation and Experimental Design

When environmental adversity is high, cooperation in many species counter-intuitively increases [1]. In spatial prisoner's dilemma (PD) games with simulated harshness, defecting strategies benefit the most at first, but in the long run cooperating strategies recover and later dominate the game [3]. Information in real-world interactions is not perfect, however, and errors occur. Strategies that perform well in a normal PD setting often fail when even occasional mistakes happen [5]. While various works have studied the effects of noise in spatial PD, it is unknown how these strategies fare in a harsh environment.

In order to simulate communication errors, we introduce an extra parameter for noise, E, into a spatial iterative PD simulation. E is the probability that the desired action of an agent actually results in the opposite action. Under different levels of cost-of-life, we study 12 different strategies: 9 'classical' strategies (ALLC, ALLD, RAND, GRIM, TFT, TFTT, STFT, TTFT, Pavlov) [2] and 3 strategies adapted to handle noise: *Generous Tit for Tat* (GTFT) and *Generous Pavlov* (GPavlov), and *Contrite Tit for Tat* (CTFT) [5].

2 Results and Discussion

The success of generosity in noisy environments has been widely supported [5]. We find that the importance of generosity is emphasized when the harshness of the environment increases. This contrasts with the reported success of less

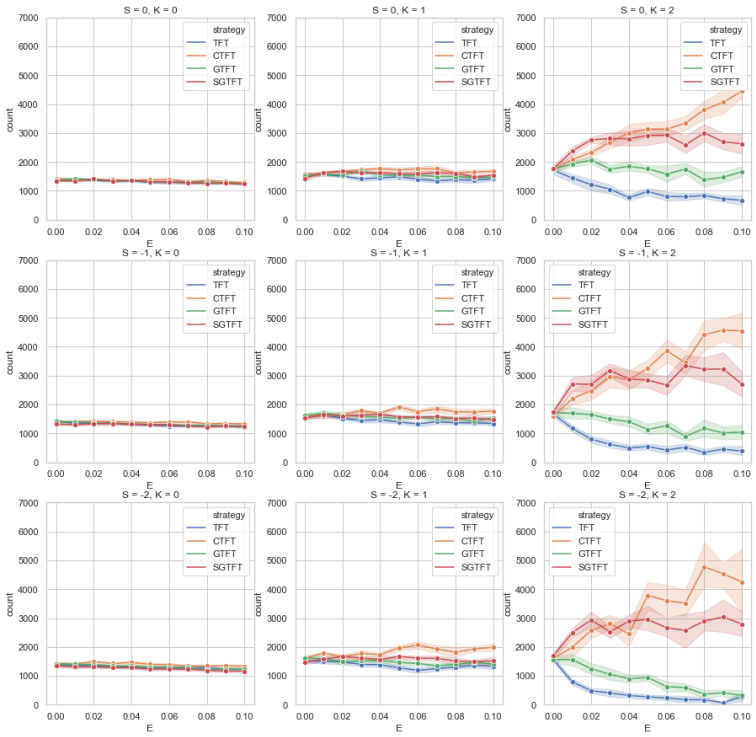

Fig. 1: Influence of noise in a tournament of TFT variants with varying harshness. S = sucker's payoff, K = cost of life, E = level of noise.

generous strategies such as GRIM in harsh environments [4], which confirms the importance of studying the PD with noise. Second, under higher noise, contrition is found to outperform generosity. The same phenomenon can be observed in the classic IPD [5]. The advantage of CTFT is that it works well in overtaking environments with defectors, while generous strategies rely on the presence of other cooperating strategies to succeed.

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