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Strategic complexity and cooperation: An experimental study[☆]

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ABSTRACT

This study investigates whether cooperation in an indefinitely repeated prisoner's dilemma is sensitive to the complexity of cooperative strategies. An experimental design which allows manipulations of the complexity of these strategies by making either the cooperate action or the defect action state-dependent is used. Subjects are found to be less likely to use a cooperative strategy and more likely to use a simpler selfish strategy when the complexity of cooperative strategies is increased. The robustness of this effect is supported by the finding that cooperation falls even when the defect action is made state-dependent, which increases the complexity of punishment-enforced cooperative strategies. A link between subjects' standardized test scores and the likelihood of cooperating is found, indicating that greater cognitive ability makes subjects more likely to use complex strategies.

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1. Introduction

To implement a strategy in a repeated game, a player must process and respond to information she receives from her environment such as the behavior of opponents, the state of nature, etc. Intuitively, one can say that the complexity of a repeated game strategy depends on the amount of information that must be processed to implement it. For example, consider a repeated oligopoly pricing game in which firms set a price in each stage after receiving information about demand conditions and the prices set by rivals. To use a competitive pricing strategy, a firm sets its price equal to a constant marginal cost in each stage. To use a collusive pricing strategy, a firm sets its price conditional on the demand state as well as the prices set by rival firms. Hence, the collusive pricing strategy can be called more complex because implementing it involves processing more information. If there are costs associated with this information processing in the form of management compensation, operating costs, etc., they can affect the firm's pricing strategy choice and make a relatively complex collusive strategy less likely to be used. Similarly, cognitive costs associated with information processing may influence repeated game strategy choice on the individual level, yielding important consequences for cooperation and efficiency.

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The theoretical literature suggests that strategic complexity is a practical equilibrium selection criterion in repeated games with both cooperative and selfish equilibria. Rubinstein (1986) shows that incorporating strategic complexity costs into the preferences of players in the infinitely repeated prisoner's dilemma causes the efficient cooperative equilibrium to unravel. Hence, in repeated games where efficiency depends on players adopting relatively complex cooperative strategies rather than simple selfish strategies, cognitive costs associated with implementing complex strategies may discourage cooperation and harm efficiency. Accounting for strategic complexity can also have important implications in the study of market games. Fershtman and Kalai (1993) show that collusion in a multi-market duopoly may be unsustainable when strategic complexity is bounded. Gale and Sabourian (2005) consider a market game with a finite number of sellers, which normally has both competitive and non-competitive equilibria, and show that only the competitive equilibria remain with strategic complexity costs. These results demonstrate that limitations on strategic complexity can have important consequences, but to my knowledge a theoretical model accounting for strategic complexity has not heretofore been tested empirically or experimentally.

In this paper, I present the results of an experiment designed to test how behavior in an indefinitely repeated prisoner's dilemma depends on the complexity of available strategies. Cooperation in the indefinitely repeated prisoner's dilemma has been the subject of many experimental studies,[1] but to my knowledge none has studied how strategy choice in this game might be affected by limitations on strategic complexity. I investigate this question using a design which allows manipulations of the implementation complexity of strategies by making either the cooperate or defect action state-dependent. Both of these manipulations increase the complexity of cooperative equilibrium strategies, and both make subjects less likely to use a cooperative strategy and more likely to use a simpler selfish strategy. These results provide evidence that cognitive costs associated with strategic complexity can have an impact on cooperation and efficiency.

In this experiment, the complexity of strategic implementation is increased through random switching between permutations of a three-by-three version of the prisoner's dilemma within each repeated game. Each treatment employs two payoff tables with a strictly dominated action choice added to the cooperate and defect actions, with the position of the dominated action varied between tables. Before each stage of a repeated game, one of the two payoff tables is drawn randomly and publicly announced to apply in that stage. This feature of the design can be viewed as increasing complexity by requiring subjects to condition their action choices on observable changes in the state of nature in order to use certain types of strategies.

In one treatment, the positions of the cooperate and dominated actions are permuted between the two payoff tables. Because cooperating requires subjects to account for random switching between tables in order to choose the correct action, cooperative strategies are more complex in this treatment than in a baseline treatment in which the positions of the cooperate, defect and dominated actions are the same in both tables. I find that increasing strategic complexity in this way reduces cooperation, as subjects have a greater tendency to adopt a simple selfish strategy in this treatment than in the baseline. The robustness of this effect is supported by the results of another treatment which increases the complexity of cooperative strategies in a different way. In this treatment, the dominated action is permuted with the defect action instead of the cooperate action so that defecting requires subjects to account for random switching between payoff tables. Relative to the baseline, this treatment increases the implementation complexity of strategies that support cooperation through the threat of punishment. Though the manipulation affects cooperation in a less obvious way, this treatment also reduces cooperation compared to the baseline.

The idea that cognitive costs of strategic complexity affect cooperation is further supported by data on subjects' American College Test (ACT) and Scholastic Aptitude Test (SAT) scores, which indicate a positive relationship between cognitive ability and cooperation. A correlation between average SAT scores in the subject pool and aggregate cooperation was found by Jones (2008) in a metastudy of prisoner's dilemma experiments, but to my knowledge this is the first study to find such a relationship at the individual level in a repeated prisoner's dilemma. This relationship is consistent with the idea that cognitive costs of strategic complexity affect strategy choice because cooperative strategies are generally more complex than playing selfishly, and subjects with greater cognitive ability should be more able to bear the cognitive cost associated with this complexity.

The paper proceeds as follows. Section 2 describes the experimental design, Section 3 defines the research questions, and Section 4 reports the experimental results. Section 5 concludes.

2. Experimental design

The experiment includes three main treatments. Each session of these treatments is broken into two phases. Subjects are paid their cumulative earnings from both phases at a conversion rate of $0.004 per Experimental Currency Unit (ECU), plus a

[1] Roth and Murnighan (1978), Murnighan and Roth (1983), and Blonski et al. (2011) find that cooperation in this game depends on the payoffs and continuation probability, while Dal Bo and Frechette (2011a) find that subgame perfection and risk dominance are necessary but not sufficient conditions for cooperation. Dal Bo (2005), Camera and Casari (2009), and Duffy and Ochs (2009) provide evidence that the indefinitely repeated prisoner's dilemma fosters cooperation because it allows players to use punishment-enforced cooperative strategies. Others have studied cooperation in related environments, such as indefinitely repeated oligopoly games (Holt, 1985; Feinberg and Husted, 1993) and public goods games (Palfrey and Rosenthal, 1994) as well as prisoner's dilemmas with costly punishment (Dreber et al., 2008), imperfect monitoring (Aoyagi and Frechette, 2009) and noisy implementation of intended actions (Fudenberg et al., 2012).