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Continuous time and communication in a public-goods experiment

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ABSTRACT

We investigate the nature of continuous time strategic interaction in public-goods games. In one set of treatments, four subjects make contribution decisions in continuous time during a 10-min interval while in another they make them only at 10 discrete points of time during this interval. The effect of continuous time is muted in public-goods games compared to simpler social dilemmas and the data suggest that widespread coordination problems are to blame. When we add a rich communication protocol, these coordination problems largely disappear and the median subject contributes completely to the public good with no sign of decay over time. At the median, the same communication protocol is less than half as effective in discrete time.

1. Introduction

The provision of public goods is critical in every society, yet is typically problematic. Since by definition nobody can be excluded from enjoying public goods once they have been provided, there is the incentive to free ride—to simply allow others to provide the good and make use of it without contributing to it. Formal models of public good provision, one shot or finitely repeated in discrete time, and corresponding laboratory experiments, confirm this free-rider problem.

Our point of departure is the observation that most public goods have a real-time aspect. For example, voluntary contributions of time to neighborhood organizations (like PTA) and of money to charitable organizations (like the Red Cross) are largely asynchronous, and pledge drives for colleges and public radio proceed (all too slowly!) in real time. Team sports, such as soccer and basketball, are another example: provision of individual costly effort takes place over the course of the contest. Co-authors of research papers and co-workers in other types of team production also contribute effort in real time. Efforts to avoid over-using common pool resources (e.g., pollution abatement or using restraint in fishing in common waters) generate flow costs in real time. On the consumption side, we see a continuous flow of utility from many important public goods—national security, the internet, clean air, roads, education, sanitation, to name a few.

Nevertheless, the vast experimental and theoretical literatures (reviewed below) have, almost without exception, assumed that both provision and consumption of public goods is either one-shot or occurs in strict discrete time[1]. That

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[1] Of course, both one-shot and discrete time provision and consumption are idealizations of reality, as is our continuous time setup.

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assumption is so pervasive as to escape notice, but it may not be innocuous, because continuous time has the potential to alter the nature of strategic interaction in fundamental ways (e.g., Simon and Stinchcombe, 1989). Indeed, a recent experiment (Friedman and Oprea, 2012) shows that continuous time choices and utility flows can generate extremely high rates of cooperation in very simple (2 action) and small (2 player) prisoner's dilemma games. The logic for the result is simple. In their setup, attempts to initiate cooperation are virtually costless as unrequited attempts can be reversed nearly instantly. Likewise, once cooperation is achieved, the temptation to defect drops to nearly zero since experience shows that the other player will match a defection almost instantly. People thus establish and maintain cooperation quite consistently in a two person continuous-time prisoner's dilemma.

There is no compelling theory or evidence to suggest that such cooperative behavior will extend to more complex settings. Multi-player public-goods games, unlike two-player games, pose a difficult coordination problem. To initiate cooperation profitably in our experiment, a player must be confident that every other player will reciprocate fully and promptly; and to deter defection, the non-defectors must coordinate both the timing and severity of punishment. Absent a coordination device, cooperative strategies would seem difficult to implement in continuous-time public-goods games, and therefore continuous time alone may have less impact than in simpler settings. We therefore conjectured that without a coordination device, continuous-time public-goods games will be not much more efficient than discrete-time public-goods games.

Perhaps the most natural coordination device is to allow subjects to communicate. Non-binding free-form communication, after all, has a proven track record at encouraging Pareto-efficient outcomes in many games, as discussed in our literature review below. Of course communication may aid cooperation even in standard discrete-time public goods via moral suasion and promise-keeping. However, communication in continuous time has the added potential to coordinate the near-instant responses that support high rates of cooperation in simpler games. Ours is a very tough environment in which to generate contributions, and the possibility of immediate responses (not present with discrete time) seemed unlikely to deter low or zero contributions[2]. This led us to a second conjecture: with communication, outcomes in continuous time will be much more efficient than in discrete time.

In this paper we report the results of an experiment designed to test these two conjectures. Our 2×2 design varies the timing protocol (discrete time vs. continuous time) and the communication protocol (no communication vs. unrestricted communication)[3]. We find support for both of our motivating conjectures. Continuous time per se has only a modest effect on cooperation rates: we observe low initial contributions that decline over time in both discrete and continuous time. However, when we introduce a rich communication protocol, continuous time generates impressively high and sustained cooperation rates: the median subject quickly contributes 100 percent to the public good and this lasts to the end of the game.

The results also support our second conjecture: at the median, communication leads to less than half as much cooperation in discrete time as in continuous time, and substantially fewer people make high levels of contributions. Moreover, communication works much more slowly and less reliably across the groups (which show evidence of considerable heterogeneity) than with continuous time.

Several other points are worth mentioning. First, we use a very challenging set of parameters: our MPCR is only 0.3 with 4 players, so the payoff difference between zero contributions and full contributions is a mere 20 percent of earnings. This makes the high cooperation rates achieved in continuous time all the more striking. Second, as reported in Section 4.4, we ran a robustness communication treatment in which subjects had access to a small set of pre-programmed messages rather than free-form chat. We found that this treatment had little impact on cooperation (relative to no communication) in either continuous or discrete time. As in several previous experiments discussed below, the richness of the message space seems to be an important consideration with respect to the effectiveness of cheap talk.

We see our results primarily as a contribution to the empirical literature on public goods provision. Yet they may have additional interest to theorists, since they illustrate emerging theoretical issues regarding coordination and cooperation, and real-time strategic interaction.

The remainder of the paper is structured as follows. We review related literature in Section 2, and describe our experimental procedures and implementation in Section 3. The results are presented in Section 4, and we offer a discussion in Section 5. Section 6 concludes. Appendices collect instructions to subjects and supplementary data analysis.

2. Related literature

A well-known stylized fact is that there is an intermediate level of contributions in the beginning of standard linear public-goods experiments, but that this declines steadily to a very low contribution rate by the end of 10 periods. Many people are initially attracted to the efficiency of making public contributions, but this proves unsustainable. This is particularly true when the marginal per-capita return (MPCR) is low, as in our design. This pattern is often attributed to the presence of conditional cooperators; these people make contributions until they see that others are not doing so, so the heterogeneity

[2] We discuss this issue in greater detail in Section 5.1.

[3] We also conduct sessions where there is only a limited message space in order to see whether full free-form communication was needed to generate a high level of contribution. We report the design and results in Section 4.4.