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Conditional cooperation in network public goods experiments☆

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ABSTRACT

This study investigates the pattern of contribution decisions in a network public goods game. In this game, each player's payoff depends only on his own contribution and the contributions of his immediate neighbors in a circle network. As in the standard public goods game, we find substantial heterogeneity in behavior across subjects, including both unconditional free-riding and full cooperation, as well as conditional cooperation. We first examine the impact of different information conditions on conditional cooperation. At the aggregate level, we find that players who observe average payoff information about others contribute significantly less than those who observe average contribution information. We then investigate the extent to which conditional cooperators facilitate the spread of cooperation and free-riding behavior across the network. In groups with a single free-rider type, we show that individual contributions decay faster for players who are closer in the network to the free rider. On the other hand, in groups with a single unconditional full contributor type, players do not respond by converging to full cooperation. Instead, we find that proximity to the unconditional full contributor seems only to mitigate (or delay) the typical decline in contributions over time. These contrasting effects are consistent with the widespread claim that conditional cooperation is imperfect, or exhibits a self-serving bias.

1. Introduction

In many different settings, public goods are provided using the voluntary contributions mechanism. For example, local school boards often solicit contributions from families within their district to help finance ongoing programs or new facilities. Economists have long sought to understand why individuals contribute in these environments, despite facing the incentive to free ride. In repeated settings, experimental studies have consistently shown that average contributions are significant, although they decline over time (see, e.g., Isaac et al., 1984, 1985).[1]

A number of these experimental studies have demonstrated that a substantial fraction of individuals are *conditional cooperators* who contribute more when they expect others to do the same (e.g., Keser and Van Winden, 2000; Fischbacher et al., 2001; Brandts and Schram, 2001; Croson et al., 2005; Croson, 2007; Fischbacher and Gächter, 2010; Kocher et al., 2008). This result is often coupled with evidence to support the claim that conditional cooperators exhibit a downward or self-serving bias, and thus only attempt to partially match the increased contributions they expect from others (Fischbacher et al., 2001; Fischbacher and Gächter, 2010; Ambrus and Pathak, 2011).[2] At the same time, there is also a growing literature on the importance of network structure for the decisions of agents whose interactions are governed by an underlying network.[3] In this paper, we examine the spread of cooperative behavior through conditional cooperation in a network public goods game (NPGG) where each player's payoff depends only on his own

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[1] Several alternative theories have been proposed to explain this puzzle, including other-regarding preferences (Andreoni, 1990; Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Cox et al., 2007, 2008), reciprocity (Rabin, 1993; Dufwenberg and Kirchsteiger, 2004; Charness and Rabin, 2002; Falk and Fischbacher, 2006), confusion (Andreoni, 1995; Andreoni and Croson, 2008), learning (Andreoni, 1988; Anderson et al., 1998), and strategic behavior (Andreoni, 1988; Ambrus and Pathak, 2011).

[2] For a full discussion of the literature, see the surveys by Ledyard (1995) and Chaudhuri (2011).

[3] These include a comprehensive treatment by Galeotti et al. (2010), and several more targeted studies such as Bramoullé and Kranton (2007); Fatas et al. (2010); Rand et al. (2011); Carpenter et al. (2012); Boosey and Isaac (2016); Charness et al. (2014), and Leibbrandt et al. (2015).

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contribution and the contributions of his immediate neighbors in a circle network.

The circle network environment provides a particularly interesting setting for examining the issue of conditional cooperation, for at least two reasons. First, although the decisions made by players from outside my neighborhood are not directly payoff relevant, they may be important if they influence the decisions made by my immediate neighbors (as may be the case if players are conditional cooperators).[4] In turn, one might conjecture that the kind of information provided to players about others from outside their neighborhood influences behavior. For instance, observing the average payoff earned by my neighbors might convey more information than observing their average contribution, since the former reveals something about the contribution decisions made by my neighbors' other neighbors. If players are conditional cooperators, then providing different kinds of information feedback upon which to condition decisions may generate different dynamic patterns of contributions in a repeated network public goods game. Indeed, a recent study by Hartig et al. (2015) shows that using individual rather than average information can have a strong impact on conditional cooperation.

Second, the overlap between players' neighborhoods on the circle allows us to look at the extent to which conditional cooperators can spread cooperative or free-riding behavior across the network. In the standard environment, a number of studies have demonstrated that group composition is an important factor for sustaining cooperation (Fischbacher and Gächter, 2010; Gächter and Thöni, 2005; Burlando and Guala, 2005; de Oliveira et al., 2015). For example, de Oliveira et al. (2015) show that the presence of a single free-rider type, or the colloquial 'bad apple', can significantly harm cooperation in groups.[5] Their result emphasizes the second-order effect of the free-rider type on the behavior of conditional cooperators in the group. In the network environment, we can study an additional dimension of this effect. Specifically, if conditional cooperators respond to the decay in average contributions within their neighborhood, cooperation should break down more quickly for those who are closer to the 'bad apple' in the network. Moreover, while de Oliveira et al. (2015) focus on the effect of free-rider types, we consider a similar conjecture regarding the effect of an unconditional full contributor type (whom we might refer to as a colloquial 'good egg'). That is, can a single unconditional full contributor induce others to increase their contributions, starting with his immediate neighbors and spreading across the network?

We designed an experiment to examine the pattern of contributions in the repeated network public goods game under different information treatment conditions. In all games, after each period, the subjects observed the total contributions made in their neighborhood. In addition, we varied whether subjects were shown average contributions or average payoffs, and whether the relevant average was reported for their neighborhood or for the entire group. Previous research has suggested that contributions are sensitive to the type of feedback provided, particularly given the prevalence of conditionally cooperative behavior. For example, Bigoni and Suetens (2012) find that average contributions are lower when players are provided with feedback about the individual earnings of others, in addition to information about individual contributions. Similarly, in a public goods game with costly punishment, Nikiforakis (2010) shows that the efficacy of punishment is sensitive to the feedback format. In both cases, the effect of feedback format seems to rest on the saliency of different features of the social dilemma environment. While feedback about contributions tends to invite cooperative comparisons, feedback about payoffs tends to make the benefits of free riding more salient.

We add to this existing work on feedback format by examining how both the type of feedback and the reference group about whom feedback is provided affects contribution decisions in the network public goods game. Our initial conjecture is that the broader reference group (providing feedback about the whole network rather than just the player's immediate neighborhood) may further facilitate the decay in cooperation. Consistent with Bigoni and Suetens (2012), we find that average contributions are lower in treatment conditions where payoff feedback is provided to the subjects between periods. In contrast, we find no evidence that providing information about the player's neighborhood versus information about the whole network has any effect on contributions.

In addition, the experimental data provide some interesting patterns regarding the spread of behavior across the network. Since these patterns are similar across the different information treatments, we pool together the data and concentrate our analysis on the pattern of contribution decisions across the network. Consistent with previous studies, we find considerable heterogeneity in the behavioral types of players. There are a number of pure free-rider types who contribute nothing towards the public good. In addition, we find a small number of unconditional full contributor types who always contribute close to their entire endowment. One limitation of our design is that the cooperative types were not elicited separately, as has become popular since the work of Fischbacher et al. (2001). Instead, we rely on a set of criteria applied to the subjects' decisions in the repeated network public goods game to provide a conservative measure of players' cooperative types.

After exploring the classification of subjects into behavioral types, we investigate the extent to which conditional cooperators facilitate the spread of cooperation and free-riding across the network. First, we find that in groups with conditional cooperators and a single free-rider type, the decline in contributions spreads gradually across the network. Players who are close to the free-rider decay faster and earlier than those who are positioned further away. This finding complements the 'bad apple' result reported in the non-network environment by de Oliveira et al. (2015) and suggests that in a simple network environment, the effect spreads gradually across the network.

On the other hand, in groups without any free-rider types, the presence of an unconditional full contributor does not induce a comparable increase in average contributions by the conditional cooperators. Rather, it seems that unconditional full contributors can only mitigate (and in some cases only delay) the familiar decline in contributions over time. That is, a so called 'good egg' can help to stay the breakdown in cooperation, but convergence towards full contribution does not spread across the network. This result also echoes a recent finding by Hartig et al. (2015), which suggests that conditional cooperators are more responsive to the bad example of a low contributor than the good example of a high contributor. In addition, as in the groups with only a free-rider type, we find that proximity to the unconditional full contributor is important. Players who are positioned next to the unconditional full contributor maintain average contributions at a relatively high level, although they do not increase their contributions. However, for players positioned further away, average contributions are lower and exhibit the familiar pattern of decay over time.

[4] This intuition is similar to the idea that cooperation cascades in social networks, as shown by Fowler and Christakis (2010), although the nature of cascades in their setting refers more to the transfer of behavior from one interaction to another, rather than to the evolution of behavior in a repeated setting.

[5] The notion that one bad apple can spoil the bunch has also been studied by others, including Myatt and Wallace (2008) in the context of collective action problems, and researchers in psychology, sociology, and organizational behavior. See Felps et al. (2006) for a review of the psychology and organizational behavior literatures.

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