



# Belief heterogeneity and contributions decay among conditional cooperators in public goods games



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## ABSTRACT

It is well-established that in finitely repeated linear public goods games, contributions decay over time with increasing free-riding. Prior researchers have appealed to notions of conditional cooperation coupled with self-interest to explain this phenomenon. We explore a complementary explanation for contributions falling over time. We show that there can be considerable heterogeneity in the distribution of initial beliefs among conditional cooperators, with subjects holding either optimistic or pessimistic beliefs regarding their peers' cooperativeness. Therefore, what is often perceived as purely self-regarding behavior may well be "conditional free-riding" by pessimistic reciprocators. These differences in prior beliefs, and subjects' contribution choices in response to those differing priors, can also generate a process of decay over and above self-serving biases or the interaction between reciprocators and free-riders.

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## 1. Introduction

The experimental literature using voluntary contribution mechanisms to understand private provision of public goods is extensive.<sup>1</sup> In one-shot public goods games, average contributions range from 40% to 60% of endowments, with wide variations in individual contributions, ranging from 0% to 100%. If the game is repeated finitely, average contributions in the first round typically lie between 40% and 60%, but then decline as some participants start "free-riding," though the strong free-riding hypothesis of zero contributions is rarely borne out (Ledyard, 1995, chap. 2). Much research has been devoted to understanding the mechanisms behind such decay, which, in turn, can help in the design of institutions to promote pro-social behavior, particularly in "field" settings, as in Ostrom (1990), where the focus is on the management of natural resources.

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<sup>1</sup> Bohm (1972), Bohm (1983) and Marwell and Ames (1979, 1980, 1981) undertook some of the earliest experimental work in this area. In economics, notable early contributions include Andreoni (1988, 1990, 1995), Isaac and Walker (1988a), Isaac and Walker (1988b) and Isaac, McCue, and Plott (1985). Dawes, McTavish, and Shaklee (1977), Dawes (1980), Dawes, Orbell, Simmons, and van de Kragt (1986), Ostrom (1990), Ostrom, Gardner, and Walker (1994), Ostrom, Walker, and Gardner (1992) and Yamagishi (1986), Yamagishi (1988) are noteworthy early studies from other social sciences. Ledyard (1995, chap. 2) provides a comprehensive review.

Recent research has honed in on two possible explanations for declining contributions, both based on the idea of “conditional cooperators”.<sup>2</sup> Players who are conditional cooperators make contributions that are positively correlated with their beliefs about the contributions of others (see Fischbacher, Gächter, & Fehr, 2001).<sup>3</sup> One strand of this literature, and indeed the broader literature on social dilemma games, assumes that any population is composed of at least two types of players: cooperators and free-riders. Cooperators start out making high contributions, but over time recognize the presence of free-riders, and reduce their contributions in retaliation, leading to the oft-seen pattern of decay.<sup>4</sup> Ambrus and Pathak (2011) provide a formal theoretical model along these lines.

The other strand of the literature is based on the idea of self-serving biases. Fischbacher and Gächter (2010), for example, report that a “self-serving bias” in conditional cooperation, where each agent attempts to contribute slightly less than the group average, leads to contribution decay.<sup>5</sup> Neugebauer, Perote, Schmidt, and Loos (2009) provide further evidence on self-serving biases. They examine subjects’ own contributions and their beliefs about others’ contributions when subjects get feedback about others’ contributions and when they do not. Contributions decline only when feedback is provided. The authors report that overall contributions and beliefs are higher in the treatment without feedback, and that contributions are positively correlated with beliefs. Smith (2013, 2015b) extends this line of work by addressing the issue of beliefs being endogenous to contribution decisions. Using instrumental variables estimation, he estimates the causal effect of beliefs on contributions.

While readily conceding the validity of these models, we wish to explore a third channel for declining contributions over and above the two above-mentioned factors. We do this by drawing attention to the fact that even conditionally cooperative actors may possess heterogeneous prior beliefs about the potential cooperativeness of their peers. Consider an optimistic conditional cooperator who expects others to contribute 80% and a pessimistic conditional cooperator who expects others to contribute 20%. If each chooses a contribution level commensurate with these prior beliefs, then to the optimist, the pessimist will appear as a free-rider, even though the latter’s free-riding is “conditional” on pessimistic prior beliefs.

In our experiment, prior to the start of play, we elicit beliefs from each subject about the average contributions of others in the first round. We find that there is considerable heterogeneity in beliefs and subsequent contributions are strongly related to these beliefs. We show that in the absence of any feedback about what others are doing, each type of conditional cooperator persists in contributing an amount commensurate with prior beliefs; optimists contribute a lot, while pessimists contribute little for extended periods.

However, when feedback is provided, so that subjects can see what others are contributing, the pessimists’ low contributions instigate retaliation from optimists in the form of reduced contributions. Pessimists, once informed about the presence of more optimistic subjects, sometimes increase their contributions relative to those of others. But, in keeping with models of inequity aversion, any increases from pessimists are smaller in magnitude than reductions in contributions from optimists, resulting in the familiar pattern of decay. Here, the decay is caused by a mismatch in prior beliefs among conditionally cooperative players and exacerbates the decay due to the presence of free-riders or self-serving biases.<sup>6</sup>

We are certainly not disputing existing explanations, such as different preference types or self-serving biases, behind contributions decay. In fact, our experimental design cannot rule out the presence of free-riders or self-serving bias and indeed, we will find evidence in favor of both of these factors. But where this study adds value is to highlight that prior literature has treated conditional cooperators as a particular “type”, but even within this group there may be considerable heterogeneity in terms of prior beliefs.<sup>7</sup> At times, what appears as free-riding may be conditional behavior by pessimistic reciprocators. This heterogeneity in prior beliefs can lead to similar dynamics in behavior and add to the process of decay. Even if the population did not contain free-riders, as long as there is sufficient heterogeneity in the prior beliefs of conditional cooperators one would expect to see a process of adjustment where the reduction in contributions from optimists are larger than any increases from pessimists, leading to contributions decay.

This, in turn, may imply different policy responses. If contributions decay is caused primarily by self-regarding behavior on the part of free-riders, then we might need to resort to either centralized or decentralized (“altruistic”) punishments (Fehr

<sup>2</sup> Early writing in experimental economics identified a number of different factors that might cause this pattern of decay. These included kindness on the part of some and confusion on the part of others (Andreoni, 1995), the “warm glow” of giving (Andreoni, 1990), a combination of learning to play the dominant strategy and strategic play by self-interested players (Andreoni, 1988) and decision errors of various types (Anderson, Goeree, & Holt, 1998; Palfrey & Prisbrey, 1997).

<sup>3</sup> Other contributions to the literature on conditional cooperation include Sonnemans, Schram, and Offerman (1999), Keser and van Winden (2000), Brandts and Schram (2001), Kurzban and Houser (2005), Burlando and Guala (2005), and Chaudhuri and Paichayontvijit (2006), among others. Chaudhuri (2011) provides an overview.

<sup>4</sup> See Gunnthorsdottir, Houser, and McCabe (2007) for an example of this kind of argument. Smith (2015a) empirically examines the relationship between contribution heterogeneity and the path of average contributions, finding that contributions decline faster when there is more contribution heterogeneity, all else equal.

<sup>5</sup> Smith (2012) presents a re-examination of the Fischbacher and Gächter (2010) data, and reports that only partially matching one’s own previous contributions is also a factor underlying contribution decay.

<sup>6</sup> Our work is closely related to Neugebauer et al. (2009), who also study the effect of feedback on the path of contributions. But we extend the Neugebauer et al. (2009) results by classifying subjects according to their prior beliefs and by examining the asymmetry in responses between optimists and pessimists. Chaudhuri, Graziano, and Maitra (2006) and Ashley, Ball, and Eckel (2010) examine asymmetric adjustment by high and low contributors from one round to the next and the process of convergence to the group average over time, but neither of the two studies attempts to connect those responses to prior beliefs.

<sup>7</sup> We wish to add a caveat about our use of the word “type”. It is possible to think of conditional cooperators and free-riders as two different types of players. However, within the rank of conditional cooperators, it is also possible to think of those with optimistic or pessimistic beliefs about their peers as being different types (in terms of their differing prior beliefs). In what follows we will use the word “type” interchangeably but we believe that the actual meaning will be clear in the context in which the word is used.

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