早稲田大学現代政治経済研究所

Impact of altruistic behavior on group cooperation: A mechanism working in the presence of an altruist may solve the public goods provision problem

Hiroki Ozono, Yoshio Kamijo, Kazumi Shimizu

No.E1408

Working Paper Series

Institute for Research in
Contemporary Political and Economic Affairs

Waseda University
169-8050 Tokyo,Japan

Impact of altruistic behavior on group cooperation: A mechanism working in the presence of an altruist may solve the public goods provision problem

Hiroki Ozono[a], Yoshio Kamijo[b], and Kazumi Shimizu[c*]

[a] Faculty of Law, Economics and Humanities, Kagoshima University, Korimoto, Kagoshima, 890-0065 JAPAN

[b] Department of Management, Kochi University of Technology, Tosayamada, Kami-city, Kochi, 782-8502 JAPAN

[c] School of Political Science and Economics, Waseda University, Nishi-Waseda, Shinjuku-ku, Tokyo, 169-8050 JAPAN

*Corresponding Author: Tel: 81-3-5286-9818, E-mail address: skazumi1961@gmail.com

Abstract

In this paper, we propose a new mechanism to achieve cooperation in public goods provision. The mechanism is named GEM, which stands for gradualism, endogeneity, and modification, its important properties. In a public goods game with GEM, spread over 20 periods, a target contribution is presented to the players in each period. The target is gradually increased when all members reach it. If players contribute less than the target in a certain period, the minimum contribution will be treated as the next period's target. In the experiment, the GEM mechanism achieved a high level of cooperation when the participants' contributions were restricted to the target. However, when participants were allowed to contribute more than the target, cooperation was not achieved because of the presence of "excessive altruists"—participants who contributed more than the target. This is because excessive cooperation facilitated free riding by other members. Finally, we discuss the limitation and possibilities of the GEM mechanism.

Highlights

- We propose a new mechanism to solve the public goods problem without additional monetary incentive, e.g., punishment.
- The mechanism is named GEM for gradualism, endogeneity, and modification.
- The results showed that participants contributed most in the GEM mechanism.
- We demonstrated that altruistic behavior might uphold group cooperation, but "excessive" altruistic behavior might harm group cooperation.

Key words: cooperation, public goods game, altruist, experiment.

JEL Codes: C72, C91, C92, M54

1. Introduction

1.1. Public goods game and costly punishment

Many researchers have investigated how humans can achieve cooperation in a dilemma, formalized as a public goods game (PGG; Hardin, 1968). In a typical public goods game, the members of a group choose how much each member contributes to a common pool and the sum of the contributions benefits all members equally. If every member contributes the full amount, the maximum payoff for the group is accomplished. Free riders can, however, increase their own payoff if they contribute nothing and still benefit from the common pool. This results in a socially inefficient situation. This is called a free-rider problem. We humans are engaged in many instances of public goods provision every day. For example, an act to prevent a global-warming effect is a global public goods game. Cleaning streets in our town or doing our share of work at the office is a local public goods game.

Many researchers have suggested that costly punishment can promote cooperation in public goods games (Boyd and Richerson, 1992; Fehr and Gächter, 2000; Ostrom et al., 1992; Yamagishi, 1986). If people have to pay a cost as a punishment for free riding, it could be a deterrent for defection. This solution, however, engenders some problems. For example, who would be willing to punish free riders. Punishments are costly, so it is more beneficial not to punish others than to do so. This is called a “second-order free rider problem.” Some researchers suggest that multilevel selection is the key to solve this problem (Boyd et al., 2003), while others propose reputational benefits to the punisher as a remedy (Barcray, 2006). However, a fully convincing answer has not yet been presented. Another problem is that punishment is sometimes used by free riders against punishers as revenge, which reduces the motivation of punishment by cooperators (Nikiforakis, 2008). The danger of “counter-punishment” casts doubts on the suggestion that costly punishment is an ideal device to achieve cooperation in a public goods situation.

1.2. GEM can solve coordination failure

Compared to previous research that emphasized the role of punishment in promoting/maintaining cooperation in a dilemma, this paper proposes a new mechanism, called GEM, to solve public goods problems without costly punishment. The GEM mechanism consists of three driving forces to achieve cooperation: (i) gradualism, the gradual increase in the difficulty concerning the cooperation problem; (ii) endogeneity, the endogenous change in the difficulty; and (iii) modification, the difficulty modification in the case of cooperation failure. The GEM mechanism was first proposed by Kamijo et al. (2014). In their study, the mechanism produced coordination success in a minimum-effort game (Van Huyck et al., 1990), which is a variation of the coordination game.

In the minimum-effort game, each player of a group chooses his or her contribution, and all the players benefit equally according to the minimum contribution in the group. In their experiment, the upper contribution limit is set at the lowest level in the first period, and this gradually increases by period when and only when coordination succeeds, that is, all the players choose the upper contribution limit, in the previous period (gradualism and endogeneity). If coordination fails, the upper amount in the next period is set at an easier level, that is, the minimum amount among the group's contributions in the previous period (modification). Kamijo et al. (2014) reveals that the GEM mechanism is effective in achieving coordination success.

A public goods game is similar to a minimum-effort game in some ways. For example, players choose their contribution, their benefits are determined according to the other players' choices, and the maximum payoff for the group is achieved if everyone contributes the full amount. There is, however, a definitive difference between them. In the minimum-effort game, a player is best off with full contribution when all the other players contribute in full. In contrast, a player is best off with null contribution regardless of the other players' contributions in the public goods game. In other words, the free-rider problem does not occur in the minimum-effort game, but does occur in the public goods game. Thus, it is more difficult to achieve cooperation in a public goods game than a minimum-effort game.

1.3. Why can the GEM mechanism solve the public goods provision problem?

In fact, even under the GEM mechanism, if players participating in a repeated public goods game have a self-regarding preference that is common knowledge, the standard game-theoretic prediction is that they free ride in every stage game, which is why cooperation fails in the finitely repeated prisoners' dilemma. However, replacing a kind of technical assumption of "every player being a rational egoist" by a more realistic assumption of "there being at least one altruistic person," which is consistent with the findings from laboratory (Fishbacher et al., 2001) and field (Frey and Meier, 2004) studies, we obtain a completely different theoretical prediction under the GEM mechanism: people cooperate for public goods provision.

Why can the GEM mechanism work in the presence of an altruist whose existence is common knowledge? The reason is informally stated as follows. The altruist is never willing to free ride. In such a case, the egoistic player's best way to maximize his or her long-term profit is to choose the upper-limit contribution until the period before the final and free ride to the altruistic player at the final period. This is because if the egoistic players free ride in an earlier period, the "modification" of the GEM mechanism resets the upper limit to a lower value, which will reduce their future profit. This can be considered a punishment embedded in the GEM mechanism. When the payoff reduction by this systemic punishment is large enough, the rational egoistic players intend to cooperate except for the final period. Therefore, the GEM mechanism sustains cooperation in the group that consists of egoistic and altruistic players (for the formal proof, see Appendix).

It should be noted that the GEM mechanism resembles the raise-the-stakes (RTS) strategy (Roberts and Sherratt, 1998). Conducting a continuous-choice repeated prisoners' dilemma experiment, Roberts and Renwick (2003) find that some participant pairs maintain a high cooperation level by using a kind of RTS strategy in which a player raises the stake (contribution) when mutual cooperation is achieved in the previous period and reduces it to a level equal to the other player's contribution in the previous period when the other player's contribution is lower than his or hers. The RTS strategy includes gradualism, endogeneity, and modification. However, even such an RTS strategy is not expected to work in public goods situations that are characterized by more than two participants. With more group members, it becomes increasingly difficult to maintain a high cooperation level—even under a reciprocal strategy—as the range of personality types (e.g., egoistic, altruistic, or reciprocal) expands (Dawes 1980).

The GEM mechanism can guide people to use a kind of RTS strategy in two directions. First, it can suggest how to behave in repeated public goods situations. Second, it can create a shared belief that other people use an RTS strategy. In other words, the GEM mechanism internalizes the behavioral properties of the RTS strategy in society and forces society members to use a reciprocal strategy.

1.4. Conditions of our experiment

To avoid confusion, we clarify the terminology before explaining the aim of this study. Hereafter, we refer to the aforementioned GEM mechanism as standard GEM (S-GEM). We now introduce another type of GEM mechanism: the “no limit” GEM (NL-GEM). In the standard GEM mechanism, the player’s contribution is bounded by an upper limit at each period. The no limit GEM mechanism is identical to the standard one except that, in the no limit GEM mechanism, players can freely choose their contribution regardless of the target contribution. Now let us return to the purpose of our research.

In the present study, we conducted repeated multiple-choice public goods games and investigated whether the GEM mechanism could solve the public goods problem. First, we verified if the PGG with the standard GEM mechanism would achieve higher cooperation than the typical PGG (the bound is constant for every period) and, as a result, the total profit would be greater for participants with GEM than those without the standard GEM, i.e., the typical PGG.

Second we compared the performance of the standard GEM and no limit GEM in the PGG. We introduce the no limit type of GEM for two reasons. The first is a practical reason. As the purpose of present study is to propose a feasible mechanism that enables people to cooperate in a social dilemma, it will be worth examining whether the GEM mechanism can work under a more general condition, that is, if each period player's contribution is not bounded by an upper limit.

The second reason is a theoretical one. We have deductively shown that cooperation can be maintained under the standard GEM mechanism if the existence of the altruist is common knowledge (see Appendix). We can also predict that the existence of the altruist will harm cooperation in the no limit condition. To see this, let us distinguish two types of altruists: the "obedient" altruist and the "excessive" altruist. An "obedient" altruist chooses a contribution just equal to, and an "excessive" altruist higher than, the target. Assume that the altruist is obedient and the fact becomes common knowledge. The GEM mechanism in this case will work in the same way as with an upper-limit condition. Alternatively, assume that the altruist is excessive and this fact becomes common knowledge or that egoistic players believe that the altruist is excessive. The GEM mechanism will not work in this case. This is because the free riding does not necessarily reduce, but may increase, the future profits of free riders. Under the no limit GEM, the altruist can still contribute more than the target even though the target is reset to a lower value after the free riding. In other words, a systemic punishment embedded in the standard GEM mechanism hardly works in the no limit GEM mechanism.

From the above discussion, we can predict that a PGG with the no limit GEM mechanism will realize lower cooperation than a PGG with the standard GEM mechanism and, as a result, the total profit of participants will be lower in the former than in the latter.

Lastly, we can suppose that rational egoistic players will free ride as soon as they notice the existence of "excessive altruists" in their own group. Thus, we can expect the group's minimum contribution to fall below the previous period's minimum at a later period under the standard GEM compared to the no limit GEM.

The next section describes the methodology employed in the study. Section 3 provides the analytical results. Section 4 presents a detailed discussion of the findings and concludes the study.

2. Method

2.1. Treatments

We conducted three types of public goods game experiments. These experiments are labeled S-GEM, NL-GEM, and CON (for the control condition: typical repeated PGG where players can choose their contribution levels without a strict constraint, actually between 0 and 100). In every treatment, the public goods game was repeated 20 times; thus, each treatment was spread over 20 periods.

Let us introduce a four-person public goods game. In this game, each player simultaneously chooses his or her contribution from {0,10,20,…,90,100}, which will be extracted from his or her endowment of 100 points. The contributions are multiplied by 1.6 and split evenly among the four group members. In the beginning of every period, the target contribution was presented. In CON, the target contribution was always 100 points. In NL-GEM and S-GEM, the target contribution changed according to the GEM mechanism. In the first period, the target contribution was 10 points. After the second period, the target contribution increases 10 points only when all the players choose more than the target contribution in the previous period. Otherwise, the target contribution is adjusted to the minimum contribution by the group players in the previous period. In CON and NL-GEM, all the players could choose from 0 to 100 points in every period, while players in S-GEM were not allowed to choose more than or equal to the target contribution.

Each participant was assigned randomly to one of the three conditions. Sixty participated in S-GEM, 64 in NL-GEM, and 44 in CON. Participants were separated into groups of four, and group members were fixed throughout the duration of the experiment according to a partner-matching design. Thus, there were 15 independent groups for S-GEM, 16 for NL-GEM, and 11 for CON.

2.2. Participants

We recruited 168 (= 60 + 64 + 44) undergraduate students from various disciplines. All participants were recruited from Waseda University via its portal. Written informed consent was obtained from all participants. We conducted the experiment from November 2012 to January 2013.

2.3. Procedures

In all treatments, participants were randomly assigned to laboratory booths at the beginning of the experiment. These booths separated participants in order to ensure that every individual made his or her decision anonymously and independently. Participants were provided with written instructions that explained the game, payoffs, and procedures. In particular, we explained that the target of contribution would vary across periods. The instructions used neutral wording, as is common practice in experimental economics. After reading the instructions, participants were tested to confirm that they understood the rules and knew how to calculate their payoffs. We did not start the experiment until all participants had answered all questions correctly. Therefore, all participants completely understood the rules of this transaction and were able to calculate their payoffs.

Participants were then randomly and anonymously allocated to groups of four, and these groups played the public goods game. Group composition remained the same throughout the 20 periods in order to retain statistically independent groups. Each group member had to determine his or her contribution level on the computer screen simultaneously. After their decisions, feedback was provided to participants, such as their current payoff and the contribution by each member of the group in this period. After each experiment, all participants answered a demographic questionnaire.

We used the z-Tree software (Fischbacher, 2007) to conduct the experiments. Each session took approximately 1 hour to complete on average. Participants' earnings were the sum of points gained over all 20 periods exchanged at a rate of 10 points = 5 yen. Participants were also paid a participation fee of 500 yen. The mean payment per participant was 1276 yen (≒$12.76, evaluated at $1 = 100 yen). The maximum was 1784 yen (≒$17.84), and the minimum 781 yen (≒$7.8).

2.4. Hypothesis development

The following hypotheses about cooperation success and failure in our three experimental treatments are based on the discussion in the introduction.

Hypothesis 1. For $t \geq 10$, the contribution level per participant in a certain period is greater for S-GEM compared to (a) CON and (b) NL-GEM [1].

Hypothesis 2. The total profit per participant is greater for S-GEM compared to (a) CON and (b) NL-GEM.

---

[1] After the 10th period, the theoretical maximum contribution is identical across the three treatments, at 100 points.

Hypothesis 3 (effect of deterrence or sustainability of cooperation). The event of a decrease in a group's minimum contribution from a previous period to the subsequent period occurs first under NL-GEM and later under S-GEM.

3. Results

3.1. Analysis of contribution level

First, the transition of participant contribution levels in each treatment is reported in Figure I. We see that the contribution increased and remained at a higher level except for the final period in the S-GEM condition, whereas in NL-GEM and CON, the contribution level did not increase or weakly decreased across periods. These results are consistent with hypothesis 1a and 2a, which implies that only the S-GEM condition, but not the NL-GEM and CON, has the power to uphold cooperation in PGG.

[Place Figure I Here]

We further investigate hypothesis 1a and 1b using individual-level analysis. The individual is nested in the group, and group in the treatment. Thus, individual variation in contribution is relative to not only treatment differences but also group differences. Thus, we use a nested analysis of variance (nested ANOVA) model in each period, as well as for all 20 periods, to attribute the amount of variance in contribution explained by treatment variations. A nested ANOVA allows us to measure the explanatory power of treatment variation for contributions by considering group influences. Table I summarizes the statistical analysis using the nested ANOVA for certain periods (1st, 5th, 10^{th}, 15^{th}, and 20^{th}). [2] This table shows the following results:

(a) The difference between S-GEM and CON is highly significant in every period; and

(b) The difference between S-GEM and NL-GEM is highly significant after the 10^{th} period.

[Place Table I Here]

3.2. Analysis of profits

As for hypothesis 2, we examine the difference in profits among conditions. First, we analyzed the total profit per participant in each treatment across the 20 periods. The last column of Table II reports the average total profit. We performed one-way ANOVA, and multiple comparisons showed that the total profit in S-GEM is greater than that in NL-GEM and CON with Bonferroni

---

[2] Owing to space limitations, we only show the data for certain important periods. All results are presented in the web appendix. This also holds for Table II.

correction (p values is < .001). Thus, we confirmed hypotheses 2a (S-GEM > CON) and 2b (S-GEM > NL-GEM) regarding the total profit of the groups.

We also conduct a nested ANOVA model (Table II) for contributions. In short, the results are consistent with those on the contributions for the three treatments:

(a) The difference between S-GEM and CON is highly significant for all latter periods; the total profit difference between the two is also highly significant;

(b) The difference between S-GEM and NL-GEM is highly significant for all latter periods; the total profit difference between the two is highly significant as well.

[Place Table II Here]

3.3. Analysis of deterrence effect

Regarding hypothesis 3, we investigated when contributions deteriorated, or dropped below the target. The first deterioration occurred at periods 20,19,2,13,15,18,20,12,2,11,1,1,8,20 and 20 in each group of S-GEM and at periods 1,1,1,1,3,1,12,1,1,8,6,1,5,3,3,and 1 in each group of NL-GEM. The Wilcoxon rank sum test thus shows that deterioration occurs significantly later in S-GEM than in NL-GEM (p value = 0.0012), lending support to hypothesis 3.

3.4 Do excessive altruists harm group cooperation?

Now we examine the impact of the excessive altruist on the participant's cooperation. As we have discussed in the introduction, the excessive altruist may harm cooperation because free riders can exploit his or her excessive contribution. This was the main reason behind our prediction that S-GEM's performance would be better than NL-GEM's. Actually, in the NL-GEM condition, 29 of 64 participants contributed higher than the target contribution (= 10) at the first period. In addition, there was at least one excessive altruist in 15 of 16 groups in the NL-GEM condition at the first period. The following statistical analysis may reveal that the excessive altruist produces a negative effect on others' cooperation, provided the presence of the excessive altruist becomes common knowledge in almost all groups.

To examine the excessive altruist's impact, we employ a regression model with fixed and random effects, a form of generalized linear mixed model (GLMM) with a restricted maximum likelihood (REML) method, using individual data. The individual is nested in the group. A GLMM allows us to measure the explanatory power of independent variables for individual efforts by considering group influences. Our principal aim is to examine how the excessive altruist affects the individual effort of each period by removing a possible "group effect" as a random effect.

We start from model 1, which includes one independent variable for the number of excessive altruists and three control variables. Let the dependent variable be the effort of the i^{th} subject of the j^{th} group of period t (Effort_{ijt}). The explanatory variable is the number of excessive altruists in each group at one period before the effort period, period t - 1 (N_EA$_{jt-1}$). The control variables are period in which an individual decides his or her effort level (Period), Self_EA degree $_{ijt-1}$ and N_FR$_{jt-1}$, Self_EA degree $_{ijt-1}$ is the deviation of the individual effort of the ith subject of the jth group from the target at one period before the effort period; the greater the deviation, the more altruistic the person was. This variable considers the participant's own attribute as excessive altruism. It is possible that altruistic people have a propensity to cooperate regardless of the other's behavior. N_FR$_{jt-1}$ is the number of participants in each group whose contribution is below the target at one period before the effort period. Not only the number of excessive altruists in each group but also the number of free riders in each group may affect individual behavior. The statistical model (model 1) is as follows:

$$\text{Effort}_{ijt} = \beta_{0j0} + \beta_1 \times \text{N\_EA}_{jt-1} + \beta_2 \times \text{Period} + \beta_3 \times \text{Self\_EA\_degree}_{ijt-1} + \beta_4 \times \text{N\_ER}_{jt-1} + e_{ijt}$$ [3]

(i=1,2,3,4; j=1,2,…,16; t=1,2,..,20)

$$\beta_{0j0} = \gamma_{000} + u_{0j0}$$

where β_1, β_2, β_3, and β_4 are the fixed-effect coefficients, which are identical among the groups, e_{ijt} is an individual-level error, γ_{000} is the average outcome for the population, and u_{0j0} is the j group's specific effect.

[3] A tolerance test does not reveal multicollinearity among the four independent variables.

[Place Table III Here]

Table III shows that the number of excessive altruists in a group produces a negative effect on individual cooperation. This negative effect is consistent with our prediction. The period has a negative effect as well. Since a free-riding incentive always exists in public goods provision, the fact that participants are more likely to free ride in later periods is understandable. While the participant's own excessive altruism has a positive effect on his or her effort, the number of free riders in the group has a negative effect.

To test the robustness of the excessive altruist's impact, we add two more control variables that can indicate the relative cooperative degree of the i^{th} subject of the j^{th} group. The first is the difference between the maximal effort in the j^{th} group and the subject's own effort at period t - 1, $\text{Supra\_Difference}_{ijt-1}$[4]. The second is the difference between the minimal effort in the j^{th} group and his or her own effort at period t - 1, $\text{Infra\_Difference}_{ijt-1}$[5].

Thus, the model 2 we have estimated is as follows:

---

[4] Supra_Difference is calculated as the maximal effort of the subject's own group minus his or her own effort. Thus, Supra_Difference is always equal to 0 or more than 0.

[5] Infra_Difference is calculated as the minimum effort of the subject's own group minus her or her own effort. Thus, Infra_Difference is always equal to or less than 0.

$$\text{Effort}_{ijt} = \beta_{0j0} + \beta_1 \times \text{ N\_EA}_{jt-1} + \beta_2 \times \text{Period}_t + \beta_3 \times \text{Self\_EA\_Degree}_{ijt-1}$$
$$+ \beta_4 \text{N\_FR}_{jt-1} \times + \beta_5 \times \text{Supra\_Difference}_{ijt-1} + \beta_6 \times \text{Infra\_Difference}_{ijt-1}$$
$$+ e_{ijt}$$ [6]

(i=1,2,3,4; j=1,2,…,16; t=1,2,..,20)

$$\beta_{0j0} = \gamma_{000} + u_{0j0}$$

From the result shown in Table III, we can state that the effect of the "excessive" altruist is stable.

4. Discussion and conclusion

4.1. Can GEM solve the public goods provision problem?

We have demonstrated that the standard GEM condition could uphold cooperation in a public goods game. This result is consistent with our theoretical prediction based on the assumption that an altruist is present in a group. Many previous studies have suggested that costly punishment is the solution to the cooperation problem in public goods provision. However, the GEM mechanism can be a new, alternative, and probably more efficient solution for public goods provision, since it does not depend on costly punishment. In addition to its efficiency, the GEM mechanism has two strong points.

[6] A tolerance test does not reveal multicollinearity among the six independent variables.

First, it is versatile. The GEM mechanism can achieve cooperation in PGG either when all players are obedient altruists or rational egoists, who expect other players to be obedient altruists, or when obedient altruists and rational egoists coexist in a group. Thus, there are multiple patterns to achieve high cooperation. This means the GEM mechanism is robust to various types of players. Furthermore, it is a useful mechanism. As mentioned before, the GEM mechanism can realize high cooperation in a minimum-effort game (Kamijo et al., submitted), which means it can solve not only the public goods problem but also the coordination problem. The usability of GEM is established by the fact that the same mechanism can be applied to two different types of cooperation failure.

Second, GEM is tolerant to errors. We have explained that the mechanism internalizes the behavioral properties of the RTS strategy in society and forces society members to use a reciprocal strategy. If the internalization of the behavioral strategy is essential, the internalized mechanism of other strategies such as the trigger strategy (Ostrom et al., 1994; Watabe and Yamagishi, 1994) can also uphold cooperation in a public good situation [7]. Theoretically, the trigger mechanism can work like GEM, but we argue that the latter might be more practical in the actual society. The GEM mechanism includes modification, so the cooperation level will recover after one member contributes lower than the targets for some incidental reasons. In contrast, the trigger mechanism must be weaker to such noises. Furthermore, the GEM

---

[7] The trigger strategy consists of two actions: player *i* chooses *C* at the start of the game and after a history in which every previous action of player *j* was *C*; *i* chooses *D* after any previous action of player *j* was *D* and continues to choose *D*.

mechanism performs the function of trust construction among members. The target contribution increases gradually and endogenously in the GEM mechanism, so the members can confirm the other's trustworthiness gradually [8].

4.2. How to restrict contributions to the target

To be fair, although we think that the GEM mechanism is equipped with the good properties discussed above, we should notice that it worked under the condition in which players could not contribute more than the target level. This suggests that the GEM mechanism needs to restrain participants from contributing more than the target. In some cases, we can easily suppose this sort of restraint. For example, tax, pension, or fees for public services should be paid as they are determined institutionally. Here, the problem of excessive cooperation is avoided in advance. When administrative restraint does not exist, the following three ideas can be considered as candidates to achieve a necessary restraint.

The first idea concerns punishment to players who contribute more than the target. The punishment will certainly raise another question: Who will pay the cost of punishment? However, it is worth pointing out that the punishment is directed only to excessive altruists and not to free riders. Actually, excessive altruists are much fewer than free riders in the public goods provision case.

---

[8] These advantages of the GEM mechanism were discussed by Kamijo et al. (2014), who used a minimum-effort game.

Therefore, the actual cost of punishment to excessive altruists should be quite low. Thus, the cost might not be a serious problem.

The second idea consists of an announcement or recommendation of the target contribution by a leader or an authority. The leader's (authority's) effect is a natural topic in psychology; a major study in social psychology has revealed that people tend to obey a leader or an authority even if his or her command is seemingly cruel (Milgram, 1963). Leadership studies in economics show that a non-binding contribution suggestion by a leader can influence a member's cooperation rate in voluntary contribution settings. For example, in Levy et al. (2011), the leader made an initial non-binding announcement to the group about what amount should be contributed, and this weak form of leadership exerted a positive impact on members' cooperation. Based on their study, we can conclude that players, including excessive altruists, follow the leader's announcement of target contributions, and the GEM mechanism will work.

The third idea is about communication among the members of a group. Communication facilitates sharing expectations in a group (Cooper et al., 1989, 1992). If members can communicate with each other and share the belief that all the other members will honor the target contribution, excessive cooperation might be avoided because members would understand that excessive cooperation is not more profitable than obedient cooperation. Solution by communication, however, would be applicable to a small group where the members can communicate with each other. Although we think these candidate ideas are feasible and will produce the expected effect, whether they can restrain excessive cooperation and uphold high-level cooperation in a public goods game needs to be examined.

4.3. Altruists may break group cooperation

To conclude this study, we should clarify one point that can shed light on the further possibilities of this research: the altruist’s influence on cooperation. Recall that in contrast to S-GEM condition, high cooperation was not achieved or maintained in the NL-GEM condition. This was because excessive altruists facilitated free riding by other players. Whether the altruists may sometimes cause cooperation to collapse is a counter-intuitive and interesting question.

This paradox has been mentioned in studies on evolutionary game theory. Some theoretical studies have suggested that the spread of unconditional cooperators (altruists) permit the invasion of free riders because altruists raise the benefits of free riders (Nowak and Sigmund, 1993; Panchanathan and Boyd, 2003). Besides, a recent study in social psychology has revealed that the unselfish person, who contributes more to the group pool but uses less from the pool, was disliked more than a fair person, whose contribution and use were almost the same (Parks and Stone, 2010). The participants in their study regarded the unselfish person as a norm violator who sometimes causes turbulence in group harmony. Along the same line of reasoning, Nettle et al. (2013) suggest, by a meta-analysis of “the watching eyes effect in the dictator game,” that watching eyes make people more resistant to extreme strategies (such as giving nothing or giving an oddly large amount) and cause them to follow norms.

By contrast, some researchers have proposed “competitive altruism (Barclay, 2004; Hardy and Van Vugt, 2006; Robert, 1998)”. In this idea, altruistic behavior can evolve and accelerate when reputations of altruists widely spread in a society and altruists can benefit enough. Barclay (2011) also shows by simulation that an evolutionarily stable level of helping increases with the size of the biological market and the degree of partner choice.

Intuitively, the role of the altruist and her/his impact on people’s cooperation are yet unsure. When and how altruists harm or favor people’s cooperation can be a very interesting research question as we have little knowledge about it. We think an extension of our study, which has experimentally demonstrated the collapse of cooperation due to altruists, can help shed light on this topic.

ACKNOWLEDGMENTS We gratefully acknowledge financial support from the Grant-in-Aid for Scientific Research on Priority Areas (19046002) provided by the Japanese Ministry of Education, Culture, Sports, Science and Technology.

References

Barclay, P., 2004. Trustworthiness and competitive altruism can also solve the ”tragedy of the commons’’. Evolution and Human Behavior 25,209–220.

Barclay, P., 2006. Reputational benefits for altruistic punishment. Evolution and Human Behavior 27, 325–344.

Barclay, P., 2011. Competitive helping increases with the size of biological markets and invades defection. Journal of Theoretical Biology 281, 47–55.

Boyd, R., Richerson, P., 1992. Punishment Allows the Evolution of Cooperation (or Anything Else) in Sizable Groups. Ethology and Sociobiology 13, 170-195.

Boyd, R., Gintis, H., Bowles, S., Richerson, P.J., 2003. The evolution of altruistic punishment. Proceedings of the National Academy of Scienve of the United States of America 100. 3531–3535.

Cooper, R., DeJong, D.V., Forsythe, R., Ross, T. W., 1989. Communication in the battle of the sexes game. Rand Journal of Economics 20, 568–587.

Cooper, R., DeJong, D.V., Forsythe, R., Ross, T. W., 1992. Communication in coordination games. Quarterly Journal of Economics 107, 739–771.

Hardin, G., 1968. The Tragedy of the Commons. Science 162, 1243.

Dawes, R. M., 1980. Social dilemmas. Annual Review of Psychology 31, 169–193.

Fehr, E., Gächter, S., 2000. Cooperation and Punishment in Public Goods Experiments. American. Economic Review 90, 980-994.

Fischbacher, U., 2007. Z-tree. Zurich toolbox for readymade economic experiments. Experimental Economics 10, 171–178.

Fishbacher, U., Gachter, S., Fehr, E., 2001. Are people conditionally cooperative? Evidence from a public goods experiment. Economic Letters 71, 397–404.

Frey, B. S., Meier, S., 2004. Social Comparisons and Pro-social Behavior: Testing "Conditional Cooperation" in a Field Experiment. The American Economic Review 94, 1717-1722

Hardy, C., Van Vugt, M., 2006. Nice guys finish first: The competitive altruism hypothesis. Personality and Social Psychology Bulletin 32, 1402-1413

Kamijo, Y., Ozono, H., Shimizu, K., 2014. A mechanism that overcomes coordination failure based on gradualism, endogeneity, and modification, Working Paper Series, Institute for Research in Contemporary Political and Economic Affairs, Waseda university, No.E1401.

Levy, D. M., Padgitt,K., Peart, S. J., Houser, D., Xiao, E., 2011. Leadership, cheap talk and really cheap talk, Journal of Economic Behavior and Organization 77, 40–52.

Milgram, S., 1963. Behavioral Study of Obedience. Journal of Abnormal and Social Psychology 67, 371–378.

Daniel Nettle, D., Harper, Z., Kidson, A., Stone, R., Penton-Voak, I.S., Bateson, M., 2013. The watching eyes effect in the Dictator Game: it's not how much you give, it's being seen to give something, Evolution and Human Behavior 34, 35–40.

Nikiforakis, N., 2008. Punishment and Counter-Punishment in Public Good Games: Can We Really Govern Ourselves. Journal of Public Economics 92, 91-112.

Nowak, M., Sigmund, K., 1993. A Strategy of Win-Stay, Lose-Shift That Outperforms TIT FOR TAT in the Prisoner's Dilemma. Nature 364, 56-58.

Ostrom, E., Gardner, R., Walker, J., 1994. Rules, games, and common-pool resources. Ann Arbor: University of Michigan Press.

Roberts, G., 1998. Competitive altruism: from reciprocity to the handicap principle. Proceedings of the Royal Society B: Biological Sciences 265, 429-430.

Panchanathan, K., Boyd, R., 2003. A tale of two defectors: The importance of standing in the evolution of indirect reciprocity. Journal of Theoretical Biology 239, 435-444.

Roberts, G., Renwick, J. S., 2003. The development of cooperative relationships: An experiment. Proceedings of the Royal Society B: Biological Sciences 270, 2279–2283.

Van Huyck, J., Battalio, R., Beil, R., 2000. Tacit cooperation games, strategic uncertainty, and coordination failure. American Economic Review 80, 234-248.

Watabe, M., Yamagishi, T., 1994. Choice of strategies in social dilemma supergames. In: Schulz, U., Albers, W., Muelle, U. (eds.). Social dilemmas and cooperation, New York: Springer-Verlag, 251-267.

Yamagishi, T., 1986. The provision of a sanctioning system as a public good. Journal of Personality and Social Psychology 51, 110-116.

<<Appendix>>

A1. PGG with GEM

We formulate a linear public goods game among n players as follows. Each person i has E units of resources as an initial endowment at each period, and the resource can be apportioned between a private use and a provision for the public account. Let c_i denote i's contribution to a public account and $c = (c_1, c_2, \dots, c_n)$ denote the profile of contributions of n players. The payoff of player i is the sum of the utility from the private use and that from the public account, and the latter is assumed to be a linear function of the total amount of n players' contributions. Thus, $u_i(c) = E - c_i + \beta \sum_j c_j$, where β is the marginal per capita return of the public project.

A PGG with GEM is a finitely and repeatedly played PGG that adjusts the contribution's upper limit in each stage game depending on the contribution profile of the previous stage game. Let T be the number of repetitions of the PGG, and M_t be the upper limit of the contribution at stage $t\,(1 \le t \le T)$. Let ${c_m}^t$ be the minimum amount among the contributions at period t. In a PGG with GEM, the upper limit of the contribution varies because of the following rule:

$$M_1 = 1$$

$$M_t = \begin{cases} \min\{E,\ {c_m}^{t-1} + 1\} \text{ if } {c_m}^{t-1} = M^{t-1} \\ {c_m}^{t-1} \text{ if } {c_m}^{t-1} < M^{t-1} \end{cases} \quad \text{for } t \ge 2$$

The characteristics of this rule are as follows: (i) the upper limit is gradually changed (gradualism), (ii) the limit is changed if players succeed (endogeneity), and (iii) the limit is modified to a lower level if they fail (modification).

A2. Prediction from "behavioral" game theory

We analyze the PGG with GEM by using an equilibrium concept of game theory. Assume that the group of players is a mixture of $n\,(n \geq 2)$ rational egoists and $m\,(m \geq 1)$ altruistic persons. Assume further that an altruist is a person who always contributes the upper limit of the stage game. Then, the following theorem holds true.

Theorem A. Assume $\beta \geq \frac{1}{m+1}$. In a PGG with GEM, there exists a subgame-perfect equilibrium where every rational egoist contributes the upper limit except for the final period.

Thus, the PGG with GEM can attain full cooperation for the finitely repeated public goods provision situation in almost all periods.

To prove the theorem, we introduce an additional notation. Let $G(M,T)$ be a PGG with GEM where the upper limit of the first stage is M and the number of repetitions is T. We first show the following lemma for the final two periods.

Lemma B. Assume $\beta \geq \frac{1}{m+1}$. In $G\,(M,2)$, there exists a subgame-perfect equilibrium where every rational egoist chooses M in the first period and 0 in the second (final) period.

It is obvious that the rational egoist chooses 0 in the second (final) period. Thus, all we have to do is show that when the other $n-1$ players choose M in the first and 0 in the second period, the best course for a rational egoistic player is to follow the same strategy. The payoff of a rational player when he or she follows this rule is at least

$$(E - M + \beta(n+m)M) + mM$$

On the other hand, if the person chooses k $(0 \leq k \leq M-1)$, his or her payoff is

$$(E - k + \beta(n-1+m)M + \beta k) + mk$$

Calculating (1) – (2), we have

$$\big((m+1)\beta - 1\big)(M-k) \geq 0.$$

Thus, a rational egoist cannot be better off by choosing k less than M in the first period. Thus, choosing M in the first period is the best option if other rational egoists choose M in the first period. Thus, the lemma is proved.

Finally, we prove the theorem. To prove the theorem, all one needs to do is consider the following grim-trigger strategy: choose the upper contribution limit if all players choose the upper limit of the stage game in every previous period and the current period is not the last period; choose 0 otherwise. By induction from $T = 2$ (this is the case considered in Lemma B), the strategy profile in which every rational egoist uses the grim-trigger strategy is a subgame perfect equilibrium for $G(M,T)$ for any finite integer T.