ソシオネットワーク戦略ディスカッションペーパーシリーズ ISSN 2434-9445
第 73 号 2019 年 9 月
RISS Discussion Paper Series
No.73 September, 2019

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Experimental Evidence: Equilibrium Selection and Cognitive Ability in Infinitely Repeated Transboundary Public Goods Game*

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* We are grateful to Takanori Ida, Kazuhito ogawa, Hajime Kobayashi, Tadashi Sekiguchi, Hisaki Kono, Yohei Mitani, Masaki Aoyagi,as well 21st Experimental Social Sciences Conference, Kansai University for helpful conversations and comments. We thank Kansai University Center for Experimental Economics for the efficient use of experimental laboratories and a subject recruiting system. Research support was provided by a JSPS KAKENHI Grant Number JP 17J03485. T. Tse is also a recipient of a Grant-in-Aid for JSPS Fellows.

Abstract

We extend public goods game and design transboundary public goods game which players receive more information from the local group, and marginal return per capital (MPCR) is heterogeneous across local groups that high MPCR among local groups and low MPCR among counter groups. We experimentally investigate the relationship between the equilibrium selection and cognitive ability in infinitely repeated transboundary public goods game under the increasing probability of continuations. We also study the relationship between cognitive ability and strategy profile. We use two methods to investigate the types of strategies employed by the subjects: the strategy frequency estimation method and one period ahead strategy method. We find that fully cooperative strategies are mostly lenient and forgiving. We find that subjects with higher cognitive ability tend to be more cooperative, forgiving and lenient when cooperative strategy is supported as risk dominance. However, we cannot find the same trend among low cognitive ability groups. They behave similarly even the probability of continuations increase. These results show that subjects with high cognitive ability behave according to risk dominance, but not subjects with low cognitive ability.

JEL Classification: C72, C73, C91, C92

Keywords: cognitive ability; infinitely repeated game; risk dominance; strategy method; transboundary public goods game

1. Introduction

Carbon reduction by reducing individual carbon footprint is a global public good whose benefits cannot be restricted and does not decrease its availability for others. At the same time, they can experience different kinds of local benefits. For example, they reduce air pollutants in local area by switching to renewable energy option and reducing energy use; improve public health in local area by minimizing driving and increasing walking and biking; reduce waste in local area by minimizing the purchase of new products. Pure public goods are both non-excludable and non-rivalrous. They are also not distinguished by the geographic region in which they are produced or consumed. However, when individuals contribute to global public goods, they often simultaneously contribute to local public goods which are private to the individuals. Therefore, public goods are impure in reality.

Few experimental papers have investigated simultaneously contributing to the local group and global group in public goods game. Blackwell and McKee (2003) and Fellner and Lünser (2014) investigate the relationship of marginal per capita return (MPCR) to the contributions to local and global public goods. Both studies find that when the MPCR to the contribution to global public goods is higher than to local public goods, participants increase their global public goods contributions. As the contributions to the global public good increase, Blackwell and Mc-Kee (2003) find that participants do not reduce the contribution to local public goods, while Fellner and Lünser (2014) find that participants reallocate their contribution from local public goods to the global public goods. These literature design the public goods game which individual can contribute to local group and global group separately. It raises our interest to investigate the contribution to local public goods which simultaneously affect global public goods.

To contribute the literature on the simultaneous interaction between the local group and global group environment in public goods game (PG) game, we designed the PG game with the framework that an individual makes one decision which simultaneously affects his/her local group and global group. We call this game as Transboundary Public Goods (TPG) game. We experimentally investigate how a player contributes such that its contributions have higher positive spillover effects on local area and lower positive spillover effects in remote area. A player's payoff is affected by decisions of local area and at the same time, by decisions of remote area.

We investigate the behavioral difference between global cooperation and regional cooperation under infinitely repeated interactions by comparing PG game and TPG game. We design our parameters in TPG game based on the same threshold level for δ_{SPE} and δ_{RDE} in Kawamura and Tse (2019)'s PG game. We show that the relationship between equilibrium selection and cognitive ability in TPG game.

The rest of this paper is organized as follows. In the second section, we introduce our experimental design and propose our hypothesis based on the two equilibrium concepts (SPE and RDE) in the infinitely repeated game theory. We explain our experimental procedures in the third section. In the fourth section, we show our experimental results, in the fifth section, we discuss, and in the sixth section, we conclude our findings.

2. Experimental Design

2.1 Transboundary Public Goods Game Design

A TPG game is played simultaneously by m groups of n players. Each player can observe the total contribution in his or her own and counter group. The payoff for each participant in each period is given by the following:

$$\pi_i = (E_i - x_i) + \alpha \sum_{j=1}^{n} x_j + \sum_{z=1}^{m-1}\left[\beta_z \sum_{j=1}^{n} x_{jz}\right] \text{ --------(1)}$$

where π_i is the payoff of Player i; E shows the initial endowment; x_i is the contribution level of Player i; $\sum_{j=1}^{n} x_j$ is the total contribution in Player i's own group; x_{jz} is the contribution level of Player j in the counter group z; $\sum_{j=1}^{n} x_{jz}$ is the total contribution in the counter group z; α is the MPCR from the total contribution in Player i's own group; and β_z is the MPCR from the total contribution in counter group z. We assume a positive spillover effect from the same group and counter group z, i.e. $\alpha > 0, \beta_z > 0$. Intuitively, each player represents a citizen, and a group represents a geographic region. There are m geographic regions, and each geographic region includes n citizens. The initial endowment is the income of citizens, and the payoff of citizens is affected by the total contribution of local regions and counter regions.

2.2 Parameters

To simplify the game, we considered that n=2 and m=2, which meant a TPG game was played simultaneously by two groups of two players. Each player received the same initial endowment, 10. We assumed α > β > 0, which meant the positive spillover from the same group was larger than from the counter group. The payoff for each participant in each period is given by the following:

$$\pi_{\mathrm{i}} = (10 - x_i) + 0.6 \sum_{j \in same\ group} x_j + 0.3 \sum_{j \in counter\ group} x_j \quad \text{--------(2)}$$

We set E =10, $\alpha = 0.6$, and β=0.3 to compare the PG and TPG games. We set the parameters of the TPG game according to the normalized form of the PG game in Kawamura and Tse (2019), and we followed the example in Dal Bó and Fréchette (2018) to normalize the payoff matrix. Dal Bó and Fréchette (2018) study the effect of different parameters on contribution level in infinitely repeated prisoner's dilemma game. They combine the dataset from different works of literature by normalizing the payoff matrix. Table 1 shows the payoff for each stage of the game in the PG game from Kawamura and Tse (2019). Table 2 shows the payoff for each stage of the game in the TPG game, according to payoff equation (2). In the normalized forms of both the PG and TPG games, the gain from defection when all partners cooperate is 0.5, and the loss from cooperation when all partners defect was 0.5. However, the gain from defection and the loss from cooperation in other situations are different between the PG and TPG games.

Table 1. The original and normalized payoff matrices for stages of the PG game

Original

		Partners			
		CCC	CCD	CDD	DDD
Player i	C	20	15	10	5
	D	25	20	15	10

Normalized

		Partners			
		CCC	CCD	CDD	DDD
Player i	C	$\frac{20-10}{20-10} = 1$	$\frac{15-10}{20-10} = 0.5$	$\frac{10-10}{20-10} = 0$	$\frac{5-10}{20-10} = -0.5$
	D	$\frac{25-10}{20-10} = 1.5$	$\frac{20-10}{20-10} = 1$	$\frac{15-10}{20-10} = 0.5$	$\frac{10-10}{20-10} = 0$

[a]: C means that players choose cooperation. D means that players choose defection. CCC means that all partners choose C. CCD means that two partners choose C. CDD means that one partner chooses C. DDD means that all partners choose D.

Table 2. The original and normalized payoff matrix for stages of the TPG game

Original

		Same group partner					
		C			D		
		Counter group partners			Counter group partners		
		CC	CD	DD	CC	CD	DD
Player i	C	18	15	12	12	9	6
	D	22	19	16	16	13	10

Normalized		Same group partner					
		C			D		
		Counter group partners			Counter group partners		
		CC	CD	DD	CC	CD	DD
Player i	C	$\frac{18-10}{18-10} = 1$	$\frac{15-10}{18-10} = 0.625$	$\frac{12-10}{18-10} = 0.25$	$\frac{12-10}{18-10} = 0.25$	$\frac{9-10}{18-10} = -0.125$	$\frac{6-10}{18-10} = -0.5$
	D	$\frac{22-10}{18-10} = 1.5$	$\frac{19-10}{18-10} = 1.125$	$\frac{16-10}{18-10} = 0.75$	$\frac{16-10}{18-10} = 0.75$	$\frac{13-10}{18-10} = 0.375$	$\frac{10-10}{18-10} = 0$

[a]: C means that players choose cooperation. D means that players choose defection. CC means that two counter group partners choose C. CD means that one counter group partner chooses C. DD means that two counter group partners choose D.

2.3 Subgame-perfect equilibrium

We focus two SPE strategies: grim trigger (GRIM) and unconditional defection (UD) in infinitely repeated TPG game. GRIM indicates player cooperate until any partner defect and defect forever. UD indicates player always defect.

To prove that GRIM is a subgame-perfect Nash equilibrium, we need to show that no subject has an incentive to deviate from the equilibrium path.

On the equilibrium path, if player i follows GRIM, his payoff is given by:

$$\frac{1}{1-\delta}\left(0.6\sum_{i=1}^{2}10 + 0.3\sum_{j=1}^{2}10\right) = \frac{18}{1-\delta}$$

While if he deviates, he receives a one-shot gain followed by lower future payoffs:

$$(10 + 0.6\sum_{i \neq j} 10 + 0.3\sum_{j=1}^{2} 10) + \frac{\delta}{1-\delta}10 = 22 + \frac{10\delta}{1-\delta}$$

Thus, an agent has no incentive to deviate from the equilibrium path when

$$\frac{18}{1-\delta} \geq 22 + \frac{10\delta}{1-\delta}$$

$$\delta_{SPE} \geq \frac{1}{3}$$

2.4 Risk Dominance

We consider the game with two pure SPE strategies (UD and GRIM). The possible situations for a given individual are thus all combinations of that individual playing GRIM or UD against one same group partner and two counter group partners, which s same group partner and c counter group partners play GRIM and (1-s) same group partner and (2-c) counter group partners play UD, for any 0 ≤s ≤1 and 0 ≤c ≤2. We denote this payoff if individual playing GRIM against same group partner and counter group partners where (s+c) partners play GRIM by α_k and this payoff if individual playing UD against same group partner and counter group partners where (s+c) partners play GRIM by β_k.

There are six events: “Same group partner choose GRIM and two counter group partners choose UD”; “Same group partner chooses GRIM and one counter group partner chooses UD and another counter group partner chooses GRIM”; “Same group partner chooses GRIM and two counter group partners choose GRIM”; “Same group partner choose UD and two counter group partners choose UD”; “Same group partner chooses UD and one counter group partner chooses UD and another counter group partner chooses GRIM”; “Same group partner chooses UD and two counter group partners choose GRIM”.

We consider an individual playing strategy x in a population playing y. Each partner chooses GRIM with probability y_{Grim} and UD with probability y_{UD}, where $y_{UD} = 1 - y_{Grim}$. To simplify, by following Dal Bó and Fréchette (2011), we assume each partner choose GRIM and UD with equal probability, where $y_{GRIM} = \frac{1}{2}$ and $y_{UD} = \frac{1}{2}$. The probability of each event is calculated by

$$\text{Probabiliy} = \binom{1}{s} \times \binom{2}{c} \times (y_{Grim})^{s+c} \times (y_{UD})^{3-s-c} = \binom{2}{c} \times \left(\frac{1}{2}\right)^{s+c} \times \left(\frac{1}{2}\right)^{3-s-c} = \binom{2}{c} \times \left(\frac{1}{8}\right)$$

where $\binom{1}{s}$ indicates the probability of combination that select *s* partners from one same group partner which employing GRIM, i.e. $\binom{1}{s} = 1$. $\binom{2}{c}$ indicates the probability of combination that select *c* partners from two counter group partners which employing GRIM. $\left(\frac{1}{2}\right)^{s+c}$ indicates the combined probability that the multiple of individual probabilities of *(s+c)* partners employing GRIM. $\left(\frac{1}{2}\right)^{3-s-c}$ indicates the combined probability that the multiple of individual probabilities of *(3-s-c)* partners employing UD.

Table 3. Expected Payoff using the possible SPE strategies (UD and GRIM)

Same Group Partner		UD			GRIM		
Counter Group Partners		2UD	1UD 1GRIM	2GRIM	2UD	1UD 1GRIM	2GRIM
Player *i*	GRIM	$6 + \frac{10\delta}{1-\delta}$	$9 + \frac{10\delta}{1-\delta}$	$12 + \frac{10\delta}{1-\delta}$	$12 + \frac{10\delta}{1-\delta}$	$15 + \frac{10\delta}{1-\delta}$	$\frac{18}{1-\delta}$
	UD	$\frac{10}{1-\delta}$	$13 + \frac{10\delta}{1-\delta}$	$16 + \frac{10\delta}{1-\delta}$	$16 + \frac{10\delta}{1-\delta}$	$19 + \frac{10\delta}{1-\delta}$	$22 + \frac{10\delta}{1-\delta}$
Probability		$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{8}$

GRIM risk dominants UD if

$$\pi_{GRIM} = \sum_{c=0}^{2} \binom{2}{c} \left(\frac{1}{8}\right) \alpha_k \geq \sum_{c=0}^{2} \binom{2}{c} \left(\frac{1}{8}\right) \beta_k = \pi_{UD}$$

$$\frac{1}{8}\left(6+\frac{10\delta}{1-\delta}\right)+\frac{1}{4}\left(9+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(12+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(12+\frac{10\delta}{1-\delta}\right)+\frac{1}{4}\left(15+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(\frac{18}{1-\delta}\right)\geq\frac{1}{8}\left(\frac{10}{1-\delta}\right)+$$

$$\frac{1}{4}\left(13+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(16+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(16+\frac{10\delta}{1-\delta}\right)+\frac{1}{4}\left(19+\frac{10\delta}{1-\delta}\right)+\frac{1}{8}\left(22+\frac{10\delta}{1-\delta}\right)$$

$$\delta_{RDE}\geq\frac{4}{5}$$

In TPG game, the threshold level of probability of continuation δ that GRIM is supported as a subgame perfect equilibrium (SPE) δ_{SPE} is 1/3 and risk dominance equilibrium (RDE) δ_{RDE} is 4/5, which are the same as the PG game in Kawamura and Tse (2019).

Table 4. Summary of SPE and RDE strategies in the four treatments

	Treatment 1 (δ=0.4)	Treatment 2 (δ=0.6)	Treatment 3 (δ=0.8)	Treatment 4 (δ=0.9)
SPE strategies	UD, GRIM	UD, GRIM	UD, GRIM	UD, GRIM
RDE strategies	UD	UD	GRIM	GRIM

2.5 Hypothesis

Dal Bó and Fréchette (2011, 2019) finds that cooperation is more frequently observed if GRIM is supported as RDE. We show that cooperation is more frequently observed if GRIM is supported as RDE in infinitely public goods game. We can expect the same trends in our infinitely repeated transboundary public goods game experiment. Because UD risk dominates GRIM in treatment 1 and 2 and GRIM risk dominates UD in treatment 3 and 4, we have the following hypothesis.

Hypothesis 1-1: Contribution level is higher when GRIM is supported as RDE.

Hypothesis 1-2: The frequency of cooperative strategies is higher when GRIM is supported as RDE.

Proto et al., (2019) show that subjects with high intelligence find a better strategy and conceive a larger set of strategies in a given environment; and more consistent in their implementation of complex strategies. That higher intelligence subjects will achieve, in general, higher rates of cooperation. We can expect the same trends in TPG game. Thus, we propose the following experimental hypothesis regarding the risk dominance equilibrium concept.

Hypothesis 2-1: Higher cognitive ability subjects will achieve a higher contribution level when GRIM is supported as RDE.

Hypothesis 2-2: Higher cognitive ability subjects more frequently employ cooperative strategies when GRIM is supported as RDE.

3. Experimental Procedure

All experimental sessions were conducted in the laboratory at the Center for Experimental Economics (CEE) of Kansai University. Each session lasted about 90 minutes in Treatment 1 and 2, 150 minutes in Treatment 3 and 180 minutes in Treatment 4, and the same experimenter conducted all sessions.

After the subjects are randomly assigned to seats, they are asked to sign the participation agreement sheet. After confirming that all the subjects have signed the agreement sheet, the experimenter starts the instruction. Each subject receives paper handouts of the instructions and listens to the audio instructions. The subjects could ask any questions about the experiment at any time during the instruction.

After the instruction period, there was a quiz to verify that participants understood the procedure. During the quiz, participants answered 10 questions in 10 minutes, and they earned 240 JPY when they answer all correctly. If they answer incorrectly or miss the answer, they will be deducted 10 JPY each time. The quiz is about the calculation of payoff and the elicitation of strategies. After the quiz, the experimenter conducted a follow-up session and allowed time for questions and answers.

The experiment was implemented using a z-tree (Zurich Toolbox for Ready-made Economic Experiments) (Fishbacher 2007). Every session consisted of 10 rounds, and in each round, participants repeatedly played the TPG game with their fixed partners. The number of periods in a round was determined by the given continuation probability (0.4 in treatment 1, 0.6 in treatment 2, 0.8 in treatment 3, and 0.9 in treatment 4). At the end of each period, the experimenter drew one of five cards. The five cards consisted of three (two)[one] jokers and two (three)[four] spade cards in treatment 1(2)[3]. The experimental drew one of ten cards which consist of one joker and nine spade cards in treatment 4. When the experimenter draws a joker, the round is finished, all the members are randomly re-matched, and the next round starts with new four members. The card drawing process was shown on a screen at the front of the laboratory. Therefore, each period continued at a given probability that was common knowledge.

Decision-making in the first five rounds differed from that in the last five rounds. The participants decided whether they would contribute or not in each period in the first five rounds. In the last five rounds, the participants constructed their strategy for the repeated TPG games at the beginning of each round. The participants were asked to decide whether they would contribute in all possible one-period-ahead histories as well as in the first period. The number of one-period-ahead histories was eight (two levels of one's contribution times four levels of total contribution by other players in the previous period). The 13 questions of all the possible one-period-ahead histories and the first period are shown randomly. Subjects can take notes about their strategic choices after finish constructing their strategies. Their strategies are then played automatically. The details of the strategic choices are shown in Table 5.

Table 5. Description of the strategic plan

Choice	Own Contribution at t-1	Own group partners' Contribution at t-1	Counter group partners' total contribution at t-1	What is your contribution at t?
1	0	0	0	0 or 10 ?
2	0	0	10	0 or 10?
3	0	0	20	0 or 10?
4	0	10	0	0 or 10?
5	0	10	10	0 or 10?
6	0	10	20	0 or 10?
7	10	0	0	0 or 10?
8	10	0	10	0 or 10?
9	10	0	20	0 or 10?
10	10	10	0	0 or 10?
11	10	10	10	0 or 10?
12	10	10	20	0 or 10?
13	First Period			0 or 10?

After the 10 rounds of repeated TPG games, the subjects proceed to answer the 16 questions[1] from the Raven progressive matrices test (Raven 1936) within 10 minutes. The total score of the test is 16.

The total profit in all rounds and periods is exchanged according to the rate of 3 JPY per point. The total payment is the sum of the show-up fee (1,000 JPY), the earnings in the quiz and the earnings in the game.

4. Experimental Results

[1] The selected 16 questions are commonly used in Japan and Europe (Hanaki et al. 2016; Ogawa et al. 2018).

We conducted the experiment with a total of 12 sessions between December 2018 and January, May 2019, and we implemented one treatment in each session. Therefore, each subject participated in only one treatment. We used an online billboard at Kansai University to recruit subjects who did not have any experience in PG and PD game experiments, and 216 subjects were recruited. Subjects were paid JPY1000 for showing up, plus they were paid earnings from the quiz and the repeated transboundary public goods games. The exchange rate was 1 point = JPY 3. The average payments were JPY 1775 in treatment 1, JPY 2016 in treatment 2, JPY 2846 in treatment 3 and JPY4790 in treatment 4. There was an average of 1.6 periods per round in treatment 1, 2.743 periods per round in treatment 2, 4.8 periods per round in treatment 3 and 10.158 periods per round in treatment 4.

To check the balance of cognitive ability among treatments, we conduct the one-way ANOVA to compare the average Raven scores among treatments. The average Raven scores (RS) were 11.406 in treatment 1, 11.303 in treatment 2, 11.139 in treatment 3, and 10.875 in treatment 4, with no significant difference among treatments (p-value=0.757).

Table 6. Summary of the experiment

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Number of sessions	4	4	2	2
Number of subjects	64	76	36	40
The average number of rounds[2]	10	8.75	10	9.5
The average number of periods per round	1.6	2.743	4.8	10.158
Number of males	45	46	20	23
Number of females	19	30	16	17
Average age	21.539	21.171	20.083	20.025

[2] We set the time for the experiment at 90 minutes. Due to the time constraint, we only conducted 7 rounds and 8 rounds in the two sessions in treatment 2. We only conducted 9 rounds in one session in treatment 4.

Number of students from the Faculty of Economics and Business and Commerce	9	10	8	19
Average Payment (JPY)	1775	2016	2846	4790
Exchange Rate (JPY/point)	3	3	3	3
Raven Score	11.406	11.303	11.139	10.875

4.1 Average Contribution Levels

We examine our hypothesis that the contribution levels are higher in treatment 3 and 4 than in treatment 1 and 2, in which subjects behave according to risk dominance. We use first-period decision making, before any effect of other partners' decision. Table 7 shows the summary of first-period average contribution levels among treatments in high and low cognitive ability groups. Table 8 shows the odds ratio estimates and average marginal effect of logistic regression of treatments on contribution, with standard error clustered by session[3]. It derives the significance level on the comparison of first-period contribution level among treatments in overall, high and low cognitive ability groups.

For overall, the first-period average contribution levels are 24% in treatment 1, 25% in treatment 2, 32% in treatment 3 and 45% in treatment 4, which is higher in treatment 4 than in treatment 1, 2 and 3 (T1 vs. T4: p-value<0.001; T2 vs. T4: p-value<0.001; T3 vs. T4: p-value=0.024) and no significant difference among treatment 1, 2 and 3 (T1 vs. T3: p-value=0.118; T2 vs. T3: p-value=0.198). Hypothesis 1-1 is partly supported.

For high cognitive ability group, the first-period average contribution levels are 21% in treatment 1, 22% in treatment 2, 38% in treatment 3 and 61% in treatment 4, which the frequency is higher in treatment 3, 4 than in treatment 1 and 2 (T1 vs. T3: p-value=0.012; T2 vs. T3: p-value=0.028; T1 vs. T4: p-value<0.001; T2 vs. T4: p-value<0.001), and also higher in treatment 4 than in treatment 3 (T3 vs. T4: p-value<0.001).

[3] By following Fréchette (2012), we use the standard errors clustered by sessions.

For low cognitive ability group, the first-period average contribution levels are 27% in treatment 1, 29% in treatment 2, 26% in treatment 3 and 32% in treatment 4, with no significant difference among treatments (T1 vs. T3: p-value=0.913; T2 vs. T3: p-value=0.725; T1 vs. T4: p-value=0.392; T2 vs. T4: p-value=0.600; T3 vs. T4: p-value=0.570). Hypothesis 2-1 is supported.

Table 7. Summary of first-period average contribution levels (%)

	Treatment 1		**Treatment 2**		**Treatment 3**		**Treatment 4**	
	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.
Overall	23.75	640	25	742	32.222	360	45.213	376
	(1.683)		(1.672)		(2.466)		(2.570)	
High cognitive ability group	21.143	350	21.842	380	37.895	190	61.047	172
	(2.186)		(2.122)		(3.529)		(3.729)	
Low cognitive ability group	26.897	290	29.110	292	25.882	170	31.863	204
	(2.608)		(2.663)		(3.369)		(3.271)	

[a]: The unit of observation is decision-making in the first period in every round. The total number of observations is the number of subjects × the number of rounds.

[b]: The standard errors are in parentheses.

Table 8. Odds ratio estimates and average marginal effect of logistic regression of treatments on contribution, with standard error clustered by session

	(1)		(2)		(3)	
VARIABLES	Contribution		Contribution		Contribution	
	Odds ratio	Average marginal effect	Odds ratio	Average marginal effect	Odds ratio	Average marginal effect

Treatment dummy						
Treatment 1	-0.068	-0.013	-0.041	-0.007	-0.110	-0.022
	(0.201)	(0.037)	(0.484)	(0.082)	(0.164)	(0.033)
Treatment 3	0.355	0.072	0.781**	0.161**	-0.162	-0.032
	(0.276)	(0.058)	(0.356)	(0.061)	(0.461)	(0.089)
Treatment 4	0.907***	0.202***	1.724***	0.392***	0.130	0.028
	(0.162)	(0.032)	(0.399)	(0.075)	(0.248)	(0.054)
Constant	-1.099***		-1.275***		-0.890***	
	(0.147)		(0.355)		(0.071)	
Observations	2,048	2,048	1,092	1,092	956	956
Cognitive Ability Group	Overall	Overall	High	High	Low	Low
Clusters	12		12		12	
Wald chi2	61.506		37.788		0.929	
Prob > chi2	0.000		0.000		0.819	
Pseudo R2	0.024		0.076		0.002	

[a]: Treatment 2 dummy = 1 for treatment 2 and 0 for other treatments. Treatment 3 dummy = 1 for treatment 3 and 0 for other treatments. Treatment 4 dummy = 1 for treatment 4 and 0 for other treatments. The default is treatment 2. We also confirm the same result when we set the default as treatment 1.

[b]: The unit of observation is the decision making in the first period in every round. The total number of observations is the number of subjects × number of rounds.

[c]: The standard errors clustered by session are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table 9 shows the odds ratio estimates of logistic regression of RDE on contribution, with standard error clustered by session. We make RDE dummy which equals to 1 when GRIM is supported as RDE in treatment 3 and 4, and equal to 0 when GRIM is not supported as RDE in treatment 1 and 2. We control the RDE dummy in Model (4) to determine whether contribution level increase when GRIM is supported as RDE. We control the learning effect by adding the experience variable (i.e., reciprocal of the round number) to determine how the method effect or/and learning effect affects decision making in Model (5). In Model (6), we study how cognitive ability affect contribution levels when GRIM is supported as RDE by adding the variable standardized Raven score and the cross term of RDE dummy and variable standardized Raven score. We standardize the variable Raven score (i.e., standardized Raven score = (Raven score – Mean) / standard deviation).

Model (4) shows that the coefficient of the RDE dummy is 0.678, with a 1% significance level, while Model (5) shows that the coefficient of the RDE dummy is 0.685, with a 1% significance level. Model (6) shows that the coefficient of the RDE dummy is 0.694, with a 1% significance level. For all models, the RDE dummy is positive, with a 1% significance level, indicating that the subjects more frequently contribute when GRIM is supported as RDE.

In Model (5), the coefficient of the method dummy is -0.081, with no significance level (p-value=0.516), and the coefficient of experience is 0.415, with no significance level (p-value=0.236). This result indicates that subjects contribute similarly in both stages. At the same time, the subjects keep their contribution over the rounds after learning over time.

In Model (6), the coefficient of standardized Raven score is -0.189, with 1% significance level and the coefficient of RDE dummy × standardized Raven score is 0.669, with a 1% significance level, which indicates that subjects more (less) frequently contribute when their Raven score increases in the treatments that GRIM is (not) supported as RDE. These results show evidence that the subjects with high cognitive ability more frequently behave according to the riskiness of cooperation than the subjects with low cognitive ability. Thus, Hypothesis 2-1 is supported.

Table 9. Odds ratio estimates of logistic regression of RDE on contribution, with standard error clustered by session

	(4)	(5)	(6)
VARIABLES	Contribution	Contribution	Contribution
RDE dummy	0.678***	0.685***	0.694***
	(0.217)	(0.215)	(0.224)
Method dummy		-0.081	-0.080
		(0.125)	(0.128)
Experience		0.415	0.425
		(0.351)	(0.357)
Standardized Raven score			-0.189***
			(0.060)
RDE dummy × Standardized Raven score			0.669***
			(0.236)
Constant	-1.131***	-1.225***	-1.225***
	(0.103)	(0.211)	(0.224)
Observations	2,048	2,048	2,048
Clusters	12	12	12
Wald chi2	9.744	36.345	94.938
Prob > chi2	0.002	0.000	0.000
Pseudo R2	0.019	0.022	0.040

[a]: RDE dummy = 0 for treatment 1 and 2 and 1 for treatment 3 and 4. Method dummy = 0 for direct-response-method stage and 1 for strategy-method stage. Experience = 1/Round.

[b]: The unit of observation is the decision making in the first period in every round. The total number of observations is the number of subjects × number of rounds.

[c]: The standard errors clustered by session are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

4.2 Strategy Analysis

We investigate how subjects employ strategies conditional on a history and partner's contribution. Firstly, we confirm whether the subjects employ strategies conditional on a history that is longer than one period. We adopt Fudenberg et al.'s (2012) regression models, regressing a player's contribution in period t against the same player's contribution in period t-1, the total contribution of the player's partners in period t-1, the player's contribution in period t-2, and the total contribution of the player's partners in period t-2, including controls for treatments which GRIM is supported as RDE, and the player's average contribution in the first period and all periods.

Table 10 shows the odds ratio estimates of panel data logistic regression of decision-making history on contribution with a correlated random effect, standard errors clustered by individual. Model (7) uses the overall sample, including both the high- and low-cognitive-ability groups. Model (8) uses the high-cognitive-ability group subsample, while Model (9) uses the low-cognitive-ability group subsample.

Overall, Model (7) show a significant positive effect of the same group partner's contribution one and two periods ago and counter group partners' total contribution one period ago. For high cognitive ability group, Model (8) show a significant positive effect of the same group partner's total contribution one period ago and counter group partners' total contribution one period ago in the high-cognitive-ability group. Meanwhile, for low cognitive ability group, Model (9) show a significant positive effect of the same group partner's contribution one and two periods ago and counter group partners' total contribution one period ago in the low-cognitive-ability group. The results indicate that the high-ability group is fast to forgive, as they only use their same group partner's and counter group partners' one-period-ahead history, and the low-cognitive-ability group is slow to forgive, as they use their same group partner's two-periods-ahead history.

Table 10. Odds ratio estimates of panel data logistic regression of decision-making history on contribution, with standard errors clustered by individual

	(7)	(8)	(9)
VARIABLES	Contribution	Contribution	Contribution
Contribution at t-1	0.092***	0.123***	0.067***
	(0.009)	(0.014)	(0.011)
Same group partner's contribution at t-1	0.075***	0.096***	0.059***
	(0.009)	(0.013)	(0.012)
Counter group partners' contribution at t-1	0.037***	0.040***	0.037***
	(0.006)	(0.010)	(0.008)
Contribution at t-2	0.023***	0.011	0.027**
	(0.009)	(0.014)	(0.012)
Same group partner's contribution at t-2	0.021**	0.020	0.023*
	(0.009)	(0.014)	(0.012)
Counter group partners' contribution at t-2	0.001	0.015	-0.008
	(0.006)	(0.010)	(0.008)
Average Contribution in First Period	0.008	-0.005	0.016
	(0.015)	(0.024)	(0.021)
Average Contribution in overall	0.438***	0.475***	0.420***
	(0.028)	(0.050)	(0.037)
RDE dummy	0.070	0.227	-0.054

	(0.095)	(0.147)	(0.126)
Constant	-3.446***	-3.953***	-3.085***
	(0.113)	(0.206)	(0.150)
Insig2u	-13.318	-5.748	-14.712
	(15.856)	(11.000)	(25.494)
Observations	4,932	2,394	2,538
Number of subjects	216	113	103
Group	Overall	High cognitive ability group	Low cognitive ability group
Wald chi2	1071.49	455.07	466.51
Prob > chi2	<0.001	<0.001	<0.001

[a]: RDE dummy = 0 for treatment 1 and 2. RDE dummy = 1 for treatment 3 and 4.

[b]: The unit of observation is the decision making in the direct response method stage.

[c]: The standard errors clustered by individual in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Secondly, we confirm whether the subjects employ strategies conditional on their same group partner and counter group partners. We estimate the odds ratios and average marginal effect of same group partner's and counter group partners' one period ahead history on contribution in direct response method stage. Table 11 shows the odds ratio estimates and average marginal effect of logistic regression of one period ahead history of same group and counter group partners on contribution in direct response method stage, with standard error clustered by individual.

When same group partner's contribution increases from 0 to 10 at t-1, players increase their contribution at t by 9% in treatment 2, 25% in treatment 3 and 27% in treatment 4, but no significance in treatment 1. When counter group partners' total contribution increases from 0 to 10 at t-1, players increase their contribution at t by 15% in treatment 4, but no significance in other treatments. When counter group partners' total contribution increases from 0 to 20 at t-1, players increase their contribution at t by 20% in treatment 2, 11% in treatment 3 and 22% in treatment 4, but no significance in treatment 1. Based on the results, we consider the strategies which are lenient and forgiving, and conditional on one period ahead history for classification.

Table 11. Odds ratio estimates and average marginal effect of logistic regression of one period ahead history of same group and counter group partners on contribution in direct response method stage, with standard error clustered by individual

	(10)		(11)		(12)		(13)	
VARIABLES	Contribution		Contribution		Contribution		Contribution	
At t-1	Odds Ratio	Average Marginal Effect	Odds Ratio	Average Marginal Effect	Odds Ratio	Average Marginal Effect	Odds Ratio	Average Marginal Effect
same group partner's								
contribution=10	0.296	0.055	0.546***	0.091**	1.317***	0.249***	1.238***	0.272***
	(0.278)	(0.053)	(0.207)	(0.037)	(0.270)	(0.066)	(0.164)	(0.038)
counter group partners'								
contribution=10	-0.137	-0.025	0.231	0.035	0.229	0.035	0.736***	0.148***
	(0.177)	(0.032)	(0.181)	(0.028)	(0.203)	(0.032)	(0.116)	(0.022)
contribution=20	-0.646	-0.102	1.062***	0.199***	0.629**	0.107*	1.039***	0.216***
	(0.546)	(0.071)	(0.338)	(0.075)	(0.318)	(0.059)	(0.221)	(0.047)
Constant	-1.159***		-1.717***		-1.826***		-1.578***	
	(0.195)		(0.177)		(0.207)		(0.171)	
Observations	468	468	956	956	924	924	2,800	2,800
Treatment	1	1	2	2	3	3	4	4
Clusters	64		76		36		40	
Wald chi2	2.011		15.631		28.963		90.538	
Prob > chi2	0.570		0.001		0.000		0.000	
Pseudo R2	0.007		0.021		0.068		0.104	

[a]: The total number of observations is the number of subjects × number of periods except the first period in direct response methods stage.

[b]: The standard errors clustered by individuals are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

4.2.1 Description of strategies

We constructed a dataset of 26 simplified strategies with one-period-ahead histories, which partially included 20 commonly studied strategies from the Prisoner's Dilemma game (Fudenberg et al., 2012). The constructed strategy dataset included UC, GRIM, other trigger types, TFT types, defective TFT types (DTFT, which is also called suspicious TFT), C to All D, DC Alternative, D to All C, and UD. Table 12 shows a description of each strategy and strategy type.

Table 12. Description of each strategy and strategy type

Strategy	Description
UC	Players always cooperate.
Grim	Players cooperate if all partners cooperate; otherwise, they defect
Trigger_sgX	Players cooperate in the first period and continue cooperating if at least *X* same group partners cooperated in the previous period; otherwise, they defect forever.
Trigger_cgY	Players cooperate in the first period and continue cooperating if at least Y counter group partners cooperated in the previous period; otherwise, they defect forever.
Trigger_sgX&cgY	Players cooperate in the first period and continue cooperating if at least *X* same group partners and Y counter group partners cooperated in the previous period; otherwise, they defect forever.
Trigger_sgX|cgY	Players cooperate in the first period and continue cooperating if at least *X* same group partners or Y counter group partners cooperated in the previous period; otherwise, they defect forever.
TFT	Players cooperate if all partners cooperated in the previous period.
TFT_sgX	Players cooperate in the first period and cooperate if at least *X* same group partners cooperated in the previous period.
TFT_cgY	Players cooperate in the first period and cooperate if at least Y counter group

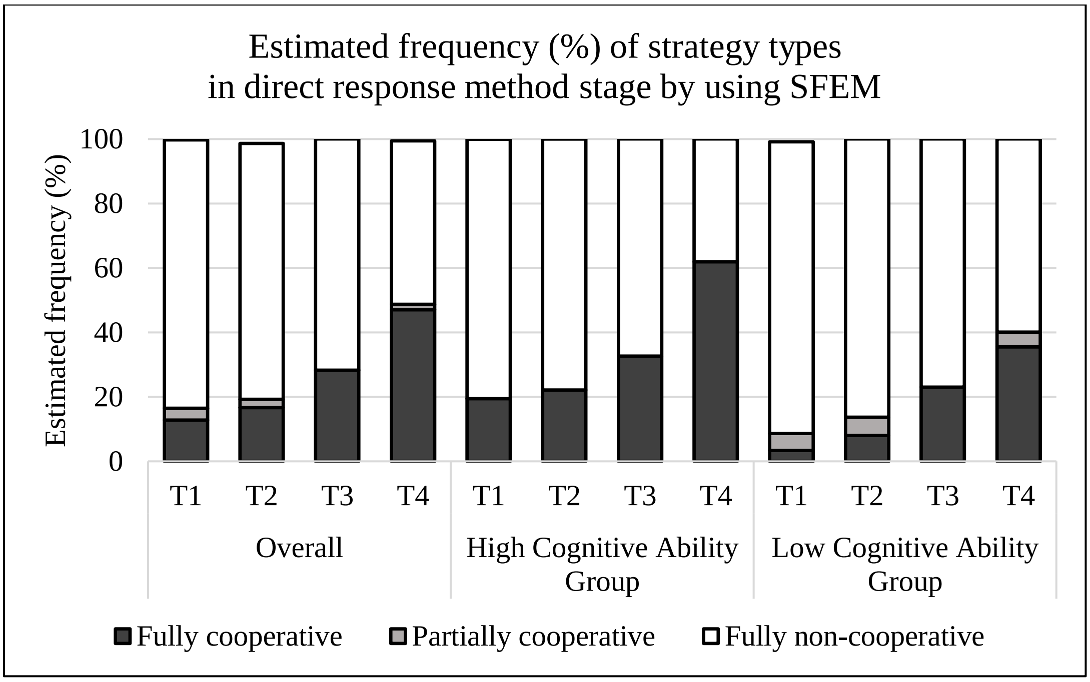
	partners cooperated in the previous period.
TFT_sgX&cgY	Players cooperate in the first period and cooperate if at least *X* same group partners and Y counter group partners cooperated in the previous period.
TFT_sgX|cgY	Players cooperate in the first period and cooperate if at least *X* same group partners or Y counter group partners cooperated in the previous period.
DTFT	Players defect in the first period. They cooperate in later periods if all partners cooperated in the previous period.
DTFT_sgX	Players defect in the first period and cooperate in later periods if at least *X* same group partners cooperate in the previous period.
DTFT_cgY	Players defect in the first period and cooperate in later periods if at least Y counter group partners cooperate in the previous period.
DTFT_sgX&cgY	Players defect in the first period and cooperate in later periods if at least *X* same group partners and Y counter group partners cooperate in the previous period.
DTFT_sgX|cgY	Players defect in the first period and cooperate in later periods if at least *X* same group partners or Y counter group partners cooperated in the previous period.
D to All C	Players defect first and then cooperate forever.
C to All D	Players cooperate first and then defect forever.
DC-alternative	Players start with defection and then alternate between cooperation and defection.
UD	Players always defect.

<u>Strategy Type</u>

Fully Cooperative	These strategies obtain full cooperation when subjects employing the same type of strategies are put together.
Partially Cooperative	These strategies obtain a mixture of cooperation and defection when subjects employing the same type of strategies are put together.
Fully Non-	These strategies obtain full defection when subjects employing the same type of

cooperative	strategies are put together.
Lenient	These fully cooperative strategies are slower to resort to punishment. They include all fully cooperative strategies except UC, GRIM, and TFT. UC keeps cooperating into infinity, and GRIM and TFT keep cooperating only when all partners fully contribute.
Forgiving	These fully cooperative strategies are fast to forgive. They include all cooperative TFT types.
Unforgiving	These fully cooperative strategies never forgive. They include all cooperative trigger types.

4.2.2 Direct Response Method Stage



[a]: T1 for treatment 1. T2 for treatment 2. T3 for treatment 3. T4 for treatment 4.

[b]: Overall uses all samples. High cognitive ability group uses the subsample of high cognitive ability group. Low cognitive ability group uses the subsample of low cognitive ability group.

Fig 1. Estimated frequency (%) of strategy types in direct response method stage by using SFEM

We estimated strategy frequency in each treatment by using the strategy frequency estimation method.[4] Figure 1 shows the estimated frequency of strategies in direct response method stage. For overall, the frequency of fully cooperative strategies is 13% in treatment 1, 17% in treatment 2, 28 % in treatment 3 and 47% in treatment 4. Hypothesis 1-2 is supported.

For high cognitive ability group, the frequency of fully cooperative strategies is 19% in treatment 1, 22% in treatment 2, 33% in treatment 3, and 62% in treatment 4. For low cognitive ability group, the frequency of fully cooperative strategies is 3 % in treatment 1, 8% in treatment 2, 23% in treatment 3 and 36% in treatment 4.[5] Subjects always more frequently employ fully cooperative strategies when GRIM is supported as RDE, no matter what levels their cognitive ability are. When the δ increases from 0.8 to 0.9, the frequency of fully cooperative strategies increases sharply in the high cognitive ability group. Hypothesis 2-2 is supported.

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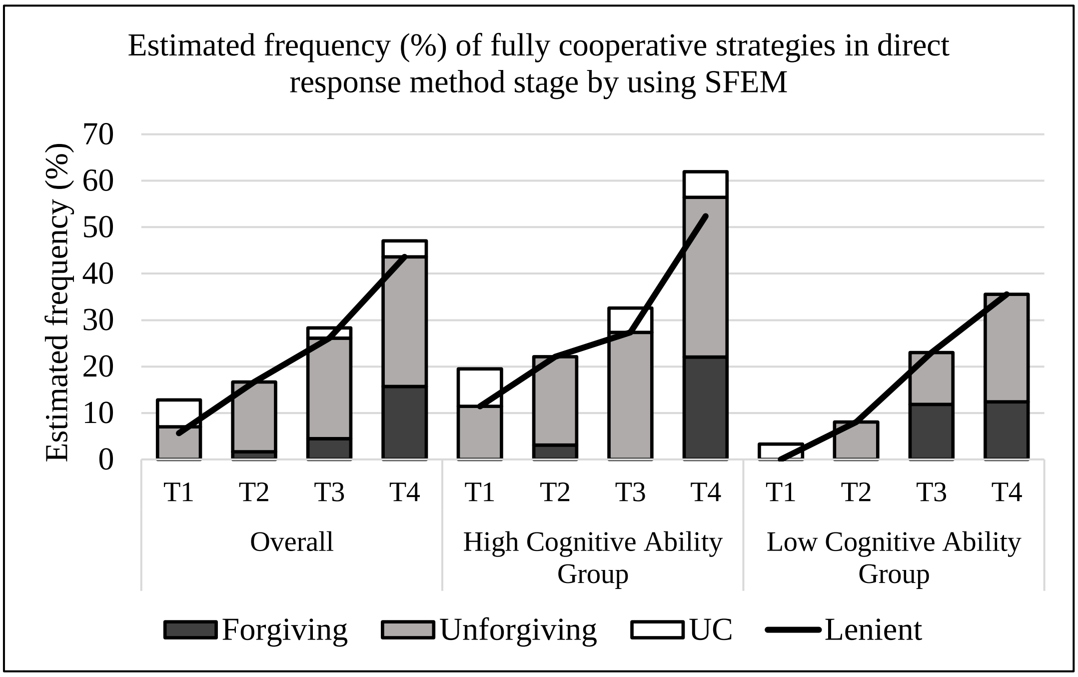
[4] We thank you Dal Bó and Fréchette (2011) and Bigoni et al., (2015) for providing their code for strategy estimation. We based on Bigoni et al.'s (2015) code for our strategy estimation.

[5] For low cognitive ability group, the first period average contribution level in direct response method stage is 28% in treatment 1, 29% in treatment 2, 33% in treatment 3 and 35% in treatment 4, which are no significant difference among treatments. In the results by SFEM, the frequency of fully cooperative strategies is lower in treatment 1 and 2 than in treatment 3 and 4. It is because the frequency of fully cooperative strategies is not perfectly match with the first period contribution level. For example, when subjects only contribute in one round or two rounds in direct response method stage, these histories are more likely to be classified as fully non-cooperative strategies. In treatment 1, 83% of subjects contribute less than or equal to two rounds. In treatment 2, 86% of subjects contribute less than or equal to two rounds. In treatment 3, 76% of subjects contribute less than or equal to two rounds. In treatment 4, 59% of subjects contribute less than or equal to two rounds.



[a]: T1 for treatment 1. T2 for treatment 2. T3 for treatment 3. T4 for treatment 4.

[b]: Overall uses all samples. High cognitive ability group only uses the subsample of high cognitive ability group. Low cognitive ability group only uses the subsample of low cognitive ability group.

Fig 2. Estimated frequency (%) of fully cooperative strategies in direct response method stage by using SFEM

Figure 2 shows the estimated frequency of fully cooperative strategies in direct response method stage by using SFEM. Fully cooperative strategies include forgiving strategies, unforgiving strategies, UC and lenient strategies. Forgiving strategies include all TFT types. Unforgiving strategies include all trigger type strategies. Lenient strategies include all fully cooperative strategies, except UC, GRIM and TFT.

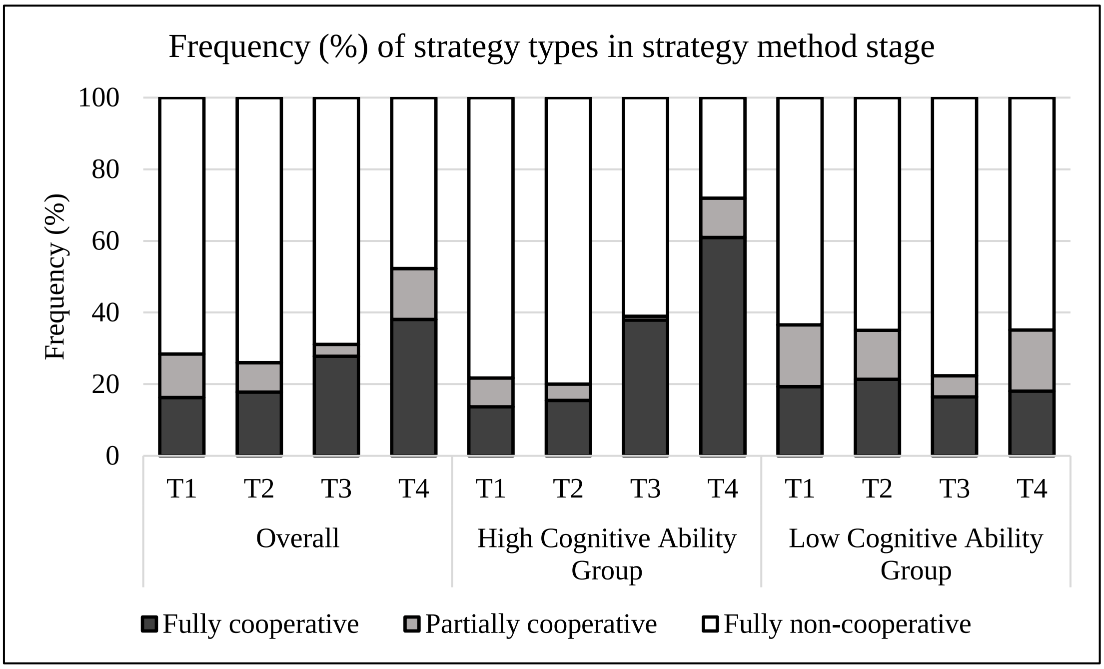
For overall, lenient strategies are 6% in treatment 1, 17% in treatment 2, 26% in treatment 3 and 44% in treatment 4. For high cognitive ability group, lenient strategies are 11% in treatment 1, 22% in treatment 2, 27% in treatment 3 and 52% in treatment 4. For low cognitive ability group, lenient strategies are 0% in treatment 1, 8% in treatment 2, 23% in treatment 3 and 36% in treatment 4. The estimated frequency of lenient strategies is higher when GRIM is supported as RDE, no matter how cognitive ability is. When δ increases from 0.8 to 0.9, the frequency of lenient strategies increases sharply, especially in high cognitive ability group. It indicates that subjects become more lenient when δ gets close to one.

For overall, forgiving strategies are 0% in treatment 1, 2% in treatment 2, 4% in treatment 3 and 16% in treatment 4. For high cognitive ability group, unforgiving strategies are 0% in treatment 1, 3% in treatment 2, 0% in treatment 3 and 22% in treatment 4. For low cognitive ability group, lenient strategies are 0% in treatment 1, 0% in treatment 2, 12% in treatment 3 and 12% in treatment 4. The estimated frequency of forgiving strategies is always higher in treatment 4 than in treatment 1, 2 and 3. It indicates that subjects become more forgiving when δ get close to one.

We also consider the combination of lenient strategies and UC and the combination of forgiving strategies and UC to discuss leniency and forgivingness. When δ increases, for high cognitive ability group, the total frequency of UC and lenient strategies increase which is 19% in treatment 1, 22% in treatment 2, 33% in treatment 3, 58% in treatment 4. For low cognitive ability group, the total frequency of UC and lenient strategies increase in direct response method stage which is 3% in treatment 1, 8% in treatment 2, 23% in treatment 3, 36% in treatment 4.

When δ increases, for high cognitive ability group, the total frequency of UC and forgiving strategies increase which is 8% in treatment 1, 3% in treatment 2, 5% in treatment 3, 28% in treatment 4. For low cognitive ability group, the total frequency of UC and forgiving strategies increase which is 3% in treatment 1, 0% in treatment 2, 12% in treatment 3, 12% in treatment 4.

4.2.3 Strategy Method Stage



[a]: T1 for Treatment 1. T2 for Treatment 2. T3 for Treatment 3. T4 for Treatment 4.

[b]: Overall uses all samples. High cognitive ability group uses the subsample of high cognitive ability group. Low cognitive ability group uses the subsample of low cognitive ability group.

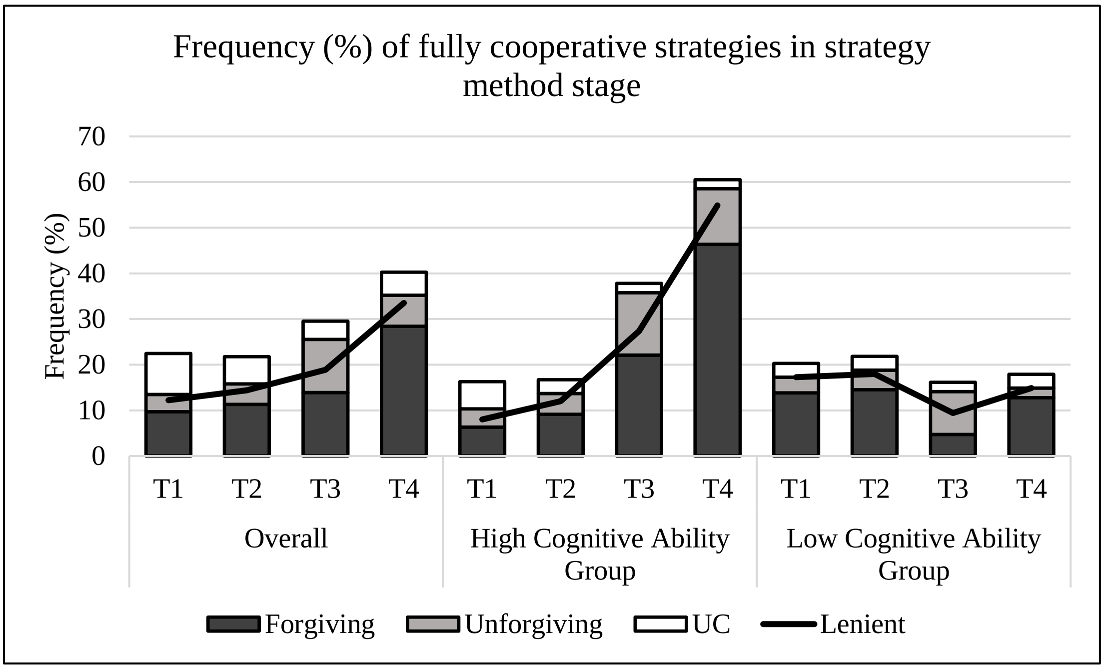
Fig 3. Frequency (%) of strategy types in strategy method stage

Figure 3 shows the frequency of strategy types in strategy methods stage in overall, high and low cognitive ability group. We derive the significance level on comparison results of each strategy types among treatments by using logistic regression of treatment dummy on each strategy types, standard errors clustered by sessions. The details are shown in the appendix.

For overall, fully cooperative strategies are 16% in treatment 1, 18% in treatment 2, 28% in treatment 3 and 38% in treatment 4. The subjects more frequently employ fully cooperative strategies in treatment 3 and 4 than in treatment 1 and 2 (T1 vs. T3: p-value=0.012; T2 vs. T3: p-value=0.034; T1 vs. T4: p-value <0.001; T2 vs. T4: p-value<0.001) and higher in treatment 4 than in treatment 3 (T3 vs. T4: p-value=0.053). Hypothesis 1-2 is supported.

For high cognitive ability group, fully cooperative strategies are 14% in treatment 1, 15% in treatment 2, 38% in treatment 3 and 61% in treatment 4. The subjects with high cognitive ability more frequently employ fully cooperative strategies in treatment 3 and 4 than in treatment 1 and 2 (T1 vs. T3: p-value<0.001; T2 vs. T3: p-value<0.001; T1 vs. T4: p-value <0.001; T2 vs. T4: p-value<0.001) and higher in treatment 3 than in treatment 4 (T3 vs. T4: p-value<0.001). Hypothesis 2-2 is supported.

For low cognitive ability group, fully cooperative strategies are 19% in treatment 1, 21% in treatment 2, 16% in treatment 3 and 18% in treatment 4. The subjects with low cognitive ability employ fully cooperative strategies with similar frequency among treatments (T1 vs. T3: p-value=0.632; T2 vs. T3: p-value=0.414; T1 vs. T4: p-value=0.728; T2 vs. T4: p-value=0.323; T3 vs. T4: p-value=0.774). The results show that only the subjects with high cognitive ability become more cooperative when GRIM is supported as RDE.



[a]: T1 for Treatment 1. T2 for Treatment 2. T3 for Treatment 3. T4 for Treatment 4.

[b]: Overall uses all samples. High cognitive ability group only uses the subsample of high cognitive ability group. Low cognitive ability group only uses the subsample of low cognitive ability group.

Fig 4. Frequency (%) of fully cooperative strategies in the strategy method stage

Figure 4 shows the frequency of fully cooperative strategies in the strategy method stage. For overall, lenient strategies are 12% in treatment 1, 14% in treatment 2 and 19% in treatment 3 and 34% in treatment 4. The subjects employ lenient strategies more frequently in treatment 3 and 4 than in treatment 1 (T1 vs. T3: p-value=0.055; T1 vs. T4: p-value<0.001), more frequently in treatment 4 than in treatment 2 (T2 vs. T3: p-value=0.248; T2 vs. T4: p-value<0.001) and more frequently in treatment 4 than in treatment 3 (T3 vs. T4: p-value<0.001).

For high cognitive ability group, lenient strategies are 8% in treatment 1, 12% in treatment 2, 27% in treatment 3 and 55% in treatment 4. The subjects with high cognitive ability more frequently employ lenient strategies in treatment 3 and 4 than in treatment 1 and 2 (T1 vs. T3: p-value<0.001; T2 vs. T3: p-value=0.014; T1 vs. T4: p-value <0.001; T2 vs. T4: p-value<0.001), and more frequently in treatment 4 than in treatment 3 (T3 vs. T4: p-value<0.001).

For low cognitive ability group, lenient strategies are 17% in treatment 1, 18% in treatment 2, 9% in treatment 3 and 15% in treatment 4. The subjects with low cognitive ability less frequently employ lenient strategies in treatment 3 than in treatment 1 and 2 (T1 vs. T3: p-value<0.001; T2 vs. T3: p-value<0.001) and no significance level between treatment 1, 2 and treatment 4 (T1 vs. T4: p-value= 0.491; T2 vs. T4: p-value=0.362), and more frequently in treatment 4 than in treatment 3 (T3 vs. T4: p-value=0.008). The results show that the subjects with high cognitive ability become more lenient when GRIM is supported as RDE.

For overall, forgiving strategies are 10% in treatment 1, 11% in treatment 2 and 14% in treatment 3 and 28% in treatment 4. The subjects employ forgiving strategies more frequently in treatment 4 than in treatment 1 and 2. (T1 vs. T3: p-value=0.136; T2 vs. T3: p-value=0.366; T1 vs. T4: p-value <0.001; T2 vs. T4: p-value<0.001) and more frequently in treatment 4 than in treatment 3 (T3 vs. T4: p-value<0.001).

For high cognitive ability group, forgiving strategies are 6% in treatment 1, 9% in treatment 2, 22% in treatment 3 and 46% in treatment 4. The subjects with high cognitive ability more frequently employ forgiving strategies in treatment 3 and 4 than in treatment 1 and 2 (T1 vs. T3: p-value=0.005; T2 vs. T3: p-value=0.010; T1 vs. T4: p-value <0.001; T2 vs. T4: p-value<0.001), and more frequently in treatment 4 than in treatment 3 (T3 vs. T4: p-value=0.0181).

For low cognitive ability group, lenient strategies are 14% in treatment 1, 15% in treatment 2, 5% in treatment 3 and 13% in treatment 4. The subjects with low cognitive ability less frequently employ forgiving strategies in treatment 3 than in treatment 1 and 2 (T1 vs. T3: p-value =0.004; T2 vs. T3: p-value=0.005) and no significant difference between treatment 1,2 and treatment 4 (T1 vs. T4: p-value=0.750; T2 vs. T4: p-value=0.644), and more frequently in treatment 4 than in treatment 4 (T3 vs. T4: p-value=0.001). The results show that the subjects with high cognitive ability become more forgiving when GRIM is supported as RDE.

We also consider the combination of lenient strategies and UC and the combination of forgiving strategies and UC to discuss leniency and forgivingness. When δ increases, for high cognitive ability group, the total frequency of UC and lenient strategies increase which is 11% in treatment 1, 14% in treatment 2, 29% in treatment 3, 57% in treatment 4 (T1 vs. T3: p-value=0.023; T2 vs. T3: p-value=0.045; T1 vs. T4: p-value<0.001; T2 vs. T4: p-value<0.001). For low cognitive ability group, the total frequency of UC and lenient strategies keep similar except treatment 3 which is 19% in treatment1, 21% in treatment 2, 12% in treatment 3, 18% in treatment 4 (T1 vs. T3: p-value=0.001; T2 vs. T3: p-value<0.001; T1 vs. T4: p-value=0.728; T2 vs. T4: p-value=0.461).

When δ increases, for high cognitive ability group, the total frequency of UC and forgiving strategies increase which is 10% in treatment 1, 11% in treatment 2, 24 in treatment 3, 49% in treatment 4 (T1 vs. T3: p-value=0.041; T2 vs. T3: p-value=0.016; T1 vs. T4: p-value=0.001; T2 vs. T4: p-value<0.001). For low cognitive ability group, the total frequency of UC and forgiving strategies keep similar except treatment 3 which is 16% in treatment 1, 17% in treatment 2, 7% in treatment 3, 16% in treatment 4 (T1 vs. T3: p-value=0.028; T2 vs. T3: p-value=0.006; T1 vs. T4: p-value=0.979; T2 vs. T4: p-value=0.641).

5. Discussion

We discuss why hypothesis 1-1 is partly supported. For overall, compared with treatment 1 and 2, the first-period average contribution level is higher in treatment 4 but not in treatment 3. Although subjects with high cognitive ability increase their first-period contribution level when GRIM is supported as RDE, subjects with low cognitive ability behave similarly among treatments. Therefore, overall, there is no significant difference in first-period contribution level between treatment 2 and 3. There is still not enough evidence to explain the behavior of low cognitive ability group. When there are more studies about the cognitive ability on repeated behavior in the future, we may explain the low cognitive ability group's behavior.

We consider the combination of lenient strategies and UC and the combination of forgiving strategies and UC to discuss leniency and forgivingness. When δ increases, for high cognitive ability group, the total frequency of UC and lenient strategies increase. For low cognitive ability group, the total frequency of UC and lenient strategies increase in direct response method stage but keep similar in strategy methods stage except treatment 3. When δ increases, for high cognitive ability group, the total frequency of UC and forgiving strategies increase. For low cognitive ability group, the total frequency of UC and forgiving strategies increase in direct response method stage but keep similar in strategy methods stage except treatment 3.

Low cognitive ability subjects behave differently on leniency and forgivingness across δ between the direct response method stage and strategy method stage. In the direct response method stage, low cognitive ability subjects can update their action by observing their partners. Therefore, they become lenient and forgiving by learning from their partners. However, in strategy method stage, subjects cannot update their action within the game. It becomes the possible reasons to explain why low cognitive ability subjects behave differently on leniency and forgivingness between direct response method stage and strategy method stage.

6. Conclusion

We experimentally investigate the infinitely repeated TPG game under the increasing δ. In treatment 1 and 2, the cooperative strategy is not supported as RDE, while in treatment 3 and 4, the cooperative strategy is. The results of these experiments demonstrate cognitive ability's effect on the equilibrium selection in the infinitely repeated TPG game. Compared with the low-cognitive-ability group, the subjects with high cognitive ability tend to be more cooperative in treatment 3 and 4. These results show that the subjects with high cognitive ability more frequently behave according to a more efficient equilibrium RDE. In the direct-response-method stage, all subjects tend to employ more cooperative, lenient and forgiving strategies when GRIM is supported as RDE. In the strategy method stage, only subjects with high cognitive ability tend to employ more cooperative, lenient and forgiving strategies when GRIM is supported as RDE.

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Appendix

Table A1. Estimation of strategies used (data from direct-response-method stage)

Treatment 1				Treatment 2				Treatment 3				Treatment 4			
Strategy	Freq. (%)	s.d.	P	Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p-value	Strategy	Freq. (%)	s.d.	p
UC	5.806	0.053	0.137	Trigger_sg1|cg2	9.187	0.051	0.035	UC	2.195	0.033	0.256	UC	3.451	0.045	0.224
GRIM	1.368	0.020	0.251	Trigger_cg2	5.851	0.058	0.155	Trigger_sg1	6.428	0.033	0.027	Trigger_sg1	1.403	0.041	0.365
Trigger_cg1	5.623	0.042	0.093	TFT_sg1|cg1	1.663	0.017	0.171	Trigger_sg1|cg1	5.664	0.091	0.267	Trigger_sg1|cg1	26.532	0.092	0.002
C to All D	1.367	0.020	0.252	DC alternative	2.572	0.034	0.224	Trigger_sg1|cg2	9.515	0.084	0.129	TFT_sg1|cg1	2.878	0.038	0.222
D to All C	2.344	0.030	0.214	DTFT_sg1|cg2	6.046	0.000	0.000	TFT_sg1|cg1	4.484	0.024	0.032	TFT_sg1|cg2	10.429	0.044	0.009
DTFT_sg1	14.288	0.128	0.133	DTFT_sg1|cg1	2.333	0.042	0.289	DTFT_sg1|cg2	8.385	0.000	0.000	TFT_cg1	2.371	0.006	0.000
UD	68.980	0.196	0.000	UD	71.001	0.237	0.001	DTFT_cg2	4.852	0.123	0.346	D to All C	1.699	0.024	0.243
γ	59.952	0.056	0.000	γ	56.032	0.039	0.000	UD	58.475	0.128	0.000	DTFT	9.479	0.145	0.257
β	84.131			β	85.628			γ	50.335	0.048	0.000	DTFT_sg1	3.304	0.038	0.191
								β	87.939			DTFT_sg1&cg1	8.666	0.052	0.046
												DTFT_sg1|cg2	1.608	0.000	0.000
												UD	27.626	0.108	0.005
												γ	68.565	0.047	0.000
												β	81.130		

[a]: The table reports the estimated frequency of each strategy in the population. We show the strategies which their estimated frequency is larger than 1%.

[b]: The parameter γ is used in estimation with $\beta = \frac{1}{1+\exp(-1/\gamma)}$.

Table A2. Estimation of strategies used in the high cognitive ability group (data from the direct-response-method stage)

Treatment 1				Treatment 2				Treatment 3				Treatment 4			
Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p-value	Strategy	Freq. (%)	s.d.	p
UC	8.038	0.060	0.092	Trigger_sg1&cg1	7.691	0.059	0.098	UC	5.263	0.070	0.225	UC	5.556	0.069	0.211
Trigger_cg1	5.710	0.055	0.151	Trigger_sg1|cg1	4.061	0.039	0.146	Trigger_sg1	19.612	0.037	0.000	Trigger_sg1|cg1	23.305	0.140	0.047
Trigger_cg2	5.751	0.039	0.070	Trigger_sg1|cg2	3.858	0.039	0.163	Trigger_sg1|cg1	7.746	0.077	0.156	Trigger_sg1|cg2	11.031	0.096	0.125
DTFT_sg1|cg1	4.426	0.102	0.331	Trigger_cg2	3.424	0.048	0.239	DTFT_sg1	10.752	0.089	0.114	TFT	4.029	0.062	0.259
UD	75.989	0.190	0.000	TFT_sg1|cg1	3.096	0.026	0.113	UD	56.626	0.162	0.000	TFT_sg1|cg1	5.815	0.061	0.170
γ	52.148	0.056	0.000	DTFT_sg1|cg2	2.818	0.000	0.000	γ	49.129	0.105	0.000	TFT_sg1|cg2	12.223	0.089	0.086
β	87.187			UD	75.053	0.256	0.002	β	88.447			DTFT	10.795	0.141	0.223
				γ	45.189	0.052	0.000					DTFT_sg1&cg1	11.167	0.101	0.135
				β	90.140							DTFT_sg1|cg2	3.124	0.000	0.000
												UD	12.954	0.102	0.101
												γ	59.539	0.079	0.000
												β	84.285		

[a]: The table reports the estimated frequency of each strategy in the population. We show the strategies which their estimated frequency is larger than 1%.

[b]: The parameter γ is used in estimation with $\beta = \frac{1}{1+\exp(-1/\gamma)}$.

Table A3. Estimation of strategies used in low cognitive ability group (data from the direct-response-method stage)

Treatment 1				Treatment 2				Treatment 3				Treatment 4			
Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p	Strategy	Freq. (%)	s.d.	p
UC	3.405	0.063	0.294	Trigger_sg1|cg2	8.082	0.052	0.061	Trigger_sg1|cg2	11.137	0.070	0.057	Trigger_sg1|cg1	23.143	0.084	0.003
D to All C	5.147	0.056	0.180	DC alternative	5.574	0.063	0.187	TFT_sg1|cg1	11.844	0.051	0.010	TFT_sg1	3.330	0.052	0.262
DTFT	16.902	0.094	0.036	DTFT	63.121	0.168	0.000	DTFT_cg2	21.713	0.171	0.102	TFT_cg1	4.373	0.014	0.001
DTFT_sg1	32.782	0.248	0.093	DTFT_sg1	14.178	0.107	0.092	UD	55.306	0.145	0.000	TFT_sg1|cg2	4.705	0.029	0.055
DTFT_sg1&cg1	14.257	0.116	0.110	DTFT_sg1|cg1	5.327	0.083	0.262	γ	51.131	0.063	0.000	D to All C	4.561	0.042	0.140
DTFT_cg2	9.648	0.226	0.335	DTFT_sg1&cg1	3.718	0.159	0.408	β	87.607			DTFT_sg1	6.499	0.049	0.095
UD	17.217	0.094	0.034	γ	70.161	0.090	0.000					DTFT_sg1&cg1	6.809	0.046	0.068
γ	73.486	0.067	0.000	β	80.617							DTFT_cg2	2.321	0.130	0.429
β	79.589											UD	44.259	0.128	0.000
												γ	76.064	0.108	0.000
												β	78.830		

[a]: The table reports the estimated frequency of each strategy in the population. We show the strategies which their estimated frequency is larger than 1%.

[b]: The parameter γ is used in estimation with $\beta = \frac{1}{1+\exp(-1/\gamma)}$.

Table A4. Summary of estimated frequency (%) of strategy types in direct response method by using SFEM

Strategy Types	Overall				High Cognitive Ability Group				Low Cognitive Ability Group			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Fully cooperative	12.797	16.701	28.286	47.064	19.499	22.130	32.621	61.959	3.405	8.082	22.981	35.551
UC	5.806	0	2.195	3.451	8.038	0	5.263	5.556	3.405	0	0	0
Lenient	5.623	16.701	26.091	43.613	11.461	22.130	27.358	52.374	0	8.082	22.981	35.551
Forgiving	0	1.663	4.484	15.678	0	3.096	0	22.067	0	0	11.844	12.408
Unforgiving	6.991	15.038	21.607	27.935	11.461	19.034	27.358	34.336	0	8.082	11.137	23.143
Partially cooperative	3.711	2.572	0	1.699	0	0	0	0	5.147	5.574	0	4.561
Fully non-cooperative	83.268	79.380	71.712	50.683	80.415	77.871	67.378	38.040	90.806	86.344	77.019	59.888

[a]: T1 indicates treatment 1. T2 indicates treatment 2. T3 indicates treatment 3. T4 indicates treatment 4.

Table A5. The frequency of strategies used (data from the strategy-method stage)

Treatment 1		Treatment 2		Treatment 3		Treatment 4	
Strategy	Freq.	Strategy	Freq.	Strategy	Freq.	Strategy	Freq.
UC	9	UC	6	UC	4	UC	5
GRIM	4	GRIM	4	GRIM	9	GRIM	3
Trigger_sg1&cg1	2	Trigger_sg1&cg1	6	Trigger_sg1	1	Trigger_sg1	6
Trigger_sg1|cg2	2	Trigger_sg1|cg2	2	Trigger_sg1&cg1	9	Trigger_sg1&cg1	1
Trigger_cg1	2	C to All D	1	Trigger_sg1|cg2	1	Trigger_sg1|cg2	1
C to All D	1	DTFT	5	TFT	3	TFT_sg1	3
DC alternative	1	DTFT_cg1	1	TFT_sg1	1	TFT_sg1&cg1	1
DTFT	4	UD	137	TFT_sg1&cg1	1	TFT_sg1|cg1	4
DTFT_sg1	5	Unclassified	130	TFT_sg1|cg1	2	C to All D	1
DTFT_cg2	1	Obs.	292	DTFT	1	UD	50
UD	152			DTFT_sg1	1	Unclassified	101
Unclassified	137			DTFT_sg1|cg2	1	Obs.	176
Obs.	320			UD	89		
				Unclassified	57		
				Obs.	180		

[a]: The total number of observations is the number of subjects × number of rounds in the strategy methods stage in each treatment.

Table A6. The frequency of strategies used in the high cognitive ability group (data from strategy-method stage)

Treatment 1		Treatment 2		Treatment 3		Treatment 4	
Strategy	Freq.	Strategy	Freq.	Strategy	Freq.	Strategy	Freq.
UC	6	UC	3	UC	2	UC	2
GRIM	4	GRIM	3	GRIM	5	GRIM	3
Trigger_sg1|cg2	1	Trigger_sg1&cg1	3	Trigger_sg1	1	Trigger_sg1	5
Trigger_cg1	1	Trigger_sg1|cg2	2	Trigger_sg1&cg1	6	Trigger_sg1&cg1	1
DC alternative	1	DTFT	5	Trigger_sg1|cg2	1	Trigger_sg1|cg2	1
DTFT_sg1	5	UD	95	TFT	3	TFT_sg1	3
UD	101	Unclassified	64	TFT_sg1	1	TFT_sg1&cg1	1
Unclassified	56	Obs.	175	TFT_sg1&cg1	1	TFT_sg1|cg1	4
Obs.	175			TFT_sg1|cg1	2	UD	14
				DTFT_sg1	1	Unclassified	48
				UD	49	Obs.	82
				Unclassified	23		
				Obs.	95		

[a]: The total number of observations is the number of subjects with high cognitive ability × number of rounds in the strategy methods stage in each treatment.

Table A7. The frequency of strategies used in the low cognitive ability group (data from the strategy-method stage)

Treatment 1		Treatment 2		Treatment 3		Treatment 4	
Strategy	Freq.	Strategy	Freq.	Strategy	Freq.	Strategy	Freq.
UC	3	UC	3	UC	2	UC	3
Trigger_sg1&cg1	2	GRIM	1	GRIM	4	Trigger_sg1	1
Trigger_sg1|cg2	1	Trigger_sg1&cg1	3	Trigger_sg1&cg1	3	C to All D	1
Trigger_cg1	1	C to All D	1	DTFT	1	UD	36
C to All D	1	DTFT_cg1	1	DTFT_sg1|cg2	1	Unclassified	53
DTFT	4	UD	42	UD	40	Obs.	94
DTFT_cg2	1	Unclassified	66	Unclassified	34		
UD	51	Obs.	117	Obs.	85		
Unclassified	81						
Obs.	145						

[a]: The total number of observations is the number of subjects with low cognitive ability × number of rounds in the strategy methods stage in each treatment.

Table A8. Summary of frequency (%) of strategy types in strategy method stage.

Strategy Types	Overall				High Cognitive Ability Group				Low Cognitive Ability Group			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Fully cooperative	16.25	17.808	27.778	38.068	13.714	15.429	37.895	60.976	19.310	21.368	16.471	18.085
UC	2.813	2.055	2.222	2.841	3.429	1.714	2.105	2.439	2.069	2.564	2.353	3.191
Lenient	12.188	14.384	18.889	33.523	8	12	27.368	54.878	17.241	17.948	9.412	14.894
Forgiving	9.688	11.301	13.889	28.409	6.286	9.143	22.105	46.341	13.793	14.530	4.706	12.766
Unforgiving	3.75	4.452	11.667	6.818	4	4.571	13.684	12.195	3.448	4.274	9.412	2.128
Partially cooperative	12.188	8.219	3.333	14.205	8	4.571	1.053	10.976	17.241	13.675	5.882	17.021
Fully non-cooperative	71.562	73.973	68.889	47.727	78.286	80	61.053	28.049	63.448	64.957	77.647	64.894
Obs.	320	292	180	176	175	175	95	82	145	117	85	94

[a]: T1 indicates treatment 1. T2 indicates treatment 2. T3 indicates treatment 3. T4 indicates treatment 4.

[b]: The number of observations is the number of subjects in overall or high or low cognitive ability group × number of rounds in the strategy methods stage in each treatment.

Table A9. Odds ratio estimates of logistic regression of treatment dummy on the probability of each strategy types in strategy method stage, with standard error clustered by session.

VARIABLES	(1) Fully cooperative	(2) Lenient	(3) Forgiving	(4) Fully cooperative	(5) Lenient	(6) Forgiving	(7) Fully cooperative	(8) Lenient	(9) Forgiving
Treatment 2 dummy	0.110	0.191	0.172	0.138	0.450	0.406	0.127	0.049	0.061
	(0.190)	(0.257)	(0.378)	(0.435)	(0.527)	(0.512)	(0.228)	(0.240)	(0.395)
Treatment 3 dummy	0.684**	0.518*	0.408	1.345***	1.466***	1.442***	-0.194	-0.696***	-1.176***
	(0.273)	(0.270)	(0.273)	(0.321)	(0.389)	(0.511)	(0.404)	(0.190)	(0.408)
Treatment 4 dummy	1.153***	1.290***	1.308***	2.286***	2.638***	2.555***	-0.081	-0.174	-0.089
	(0.147)	(0.171)	(0.282)	(0.372)	(0.436)	(0.566)	(0.232)	(0.253)	(0.280)
Constant	-1.640***	-1.975***	-2.232***	-1.839***	-2.442***	-2.702***	-1.430***	-1.569***	-1.833***
	(0.136)	(0.171)	(0.273)	(0.321)	(0.358)	(0.424)	(0.175)	(0.176)	(0.254)
Observations	968	968	968	527	527	527	441	441	441
Clusters	12	12	12	12	12	12	12	12	12
Cognitive ability	Overall	Overall	Overall	High	High	High	Low	Low	Low
Wald chi2	100.470	103.249	160.966	59.378	45.662	29.124	1.317	29.733	11.422
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.725	0.000	0.010
Pseudo R2	0.034	0.039	0.040	0.129	0.149	0.141	0.002	0.009	0.020

[a]: Treatment 2 dummy = 1 for treatment 2 and 0 for other treatments. Treatment 3 dummy = 1 for treatment 3 and 0 for other treatments. Treatment 4 dummy = 1 for treatment 4 and 0 for other treatments. The default is treatment 1. [b]: Fully cooperative =1 for fully cooperative strategies and 0 for other strategy types. Lenient=1 for lenient strategies and 0 for other strategy types. Forgiving=1 for forgiving strategies and 0 for other strategy types. [c]: The total number of observations is the number of subjects in overall or high or low cognitive ability group × number of rounds in the strategy methods stage. [d]: The standard errors clustered by session are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A10. Odds ratio estimates of logistic regression of treatment dummy on the probability of each strategy types in strategy method stage, with standard error clustered by session.

	(10)	(11)	(12)	(13)
VARIABLES	Lenient and UC	Lenient and UC	Forgiving and UC	Forgiving and UC
Treatment 2 dummy	0.208	0.075	0.124	0.090
	(0.643)	(0.229)	(0.605)	(0.296)
Treatment 3 dummy	1.175**	-0.585***	1.088**	-0.909**
	(0.517)	(0.176)	(0.531)	(0.415)
Treatment 4 dummy	2.342***	-0.081	2.181***	0.007
	(0.544)	(0.232)	(0.628)	(0.271)
Constant	-2.048***	-1.430***	-2.229***	-1.669***
	(0.473)	(0.175)	(0.494)	(0.255)
Observations	527	441	527	441
Clusters	12.000	12.000	12.000	12.000
Cognitive ability group	High	Low	High	Low
Wald chi2	29.169	41.724	19.779	8.006
Prob > chi2	0.000	0.000	0.000	0.046
Pseudo R2	0.127	0.008	0.115	0.015

[a]: Treatment 2 dummy = 1 for treatment 2 and 0 for other treatments. Treatment 3 dummy = 1 for treatment 3 and 0 for other treatments. Treatment 4 dummy = 1 for treatment 4 and 0 for other treatments. The default is treatment 1. [b]: Lenient and UC =1 for lenient strategies or UC and 0 for other strategy types. Forgiving and UC =1 for forgiving strategies or UC and 0 for other strategy types. [c]: The total number of observations is the number of subjects × number of rounds in the strategy methods stage. The standard errors clustered by session are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Sample of Experimental Instruction for treatment 4 (in Japanese)

経済実験説明書

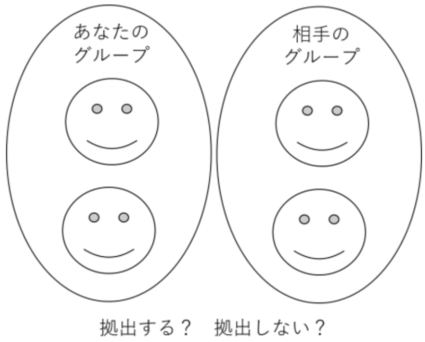
実験にご参加いただきありがとうございます。これから、経済実験を行います。説明書をよく読み、内容を完全に理解して参加ください。何か不明な点があれば、すぐに手を上げスタッフにお知らせください。

注意事項
- 実験中は私語をしないでください。
- スマートフォン・携帯の電源をお切りください。
- 実験の内容を口外しないでください。
- 配布した資料は持ち帰らないでください。

1. 配布資料
席に着いたら、A4 用紙の紙が 5 種類あることを確認して下さい。
1. 実験参加同意書　2. 実験説明書　3. 画面説明書　4. 記録用紙　5. 領収書

2. 実験の報酬について
実験の報酬は 3 つの部分からなります。1 つは**参加報酬**です。参加報酬として皆様全員に 1000 円をお支払いします。2 つ目は、**理解度確認クイズ**の報酬です。最後の 1 つは実験の**成果報酬**です。成果報酬は実験の結果によって決まります。

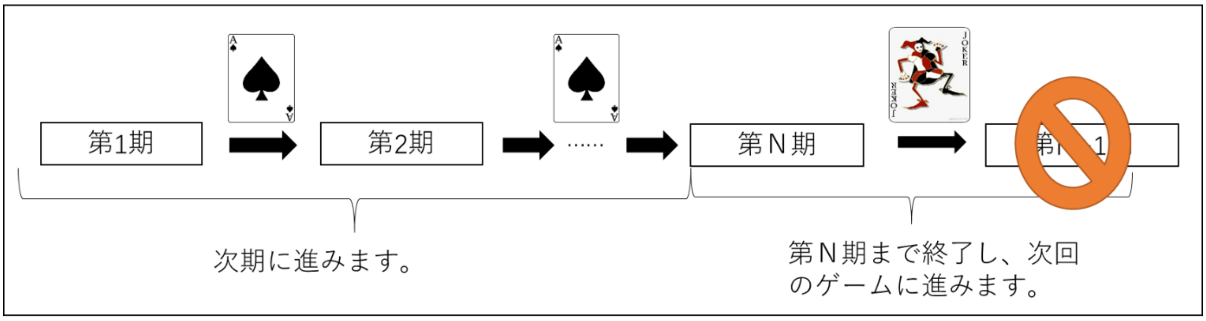
3. グループの決まり方



- 各回のゲーム開始時に、グループがランダムに決まります。全てのグループは **2 人**の参加者からなります。また、各グループは他の１つのグループを相手のグループとして割り当てられます。
- 自分のグループ番号と相手のグループ番号がコンピュータ画面に表示されます。
- 各回のゲームでは、すべての期で自分のグループと相手のグループは同じです。あなたは、自分のグループと相手のグループのメンバーが誰なのかを知ることはできません。
- 実験は **10 回**からなります。この実験は、**前半** 5 回と**後半** 5 回で意思決定の仕方が異なりますが、自分のグループと相手のグループの決まり方と期数の決まり方は同じです。
- 各回のゲームの開始時点で、全てのグループはランダムに組みなおされます。従って、あなたはもう一度同じメンバーとグループを組むかもしれませんし、まったく新しいメンバーとグループを組むかもしれません。
- 自分のグループ番号と相手のグループ番号を確認したら、次の意思決定に進んでください。

4. 各回での期数の決まり方
実験は**１０回**からなります。
- 各回が何期続くのかは、実験者がくじで決めます。
- 実験者は各期終了時に、10 枚のカードから 1 枚を引きます。

- ５枚のカードは、スペード（♠）が９枚、ジョーカーが１枚です。
- 実験者が引いたカードが、スペード（♠）だった場合、次期に進みます。
- 実験者がジョーカーを引いた場合、この期に終了し、次回に進みます。
- 従って、各期は **90%(=9/10)で続き**、**10%(=1/10)**で終了します。
- 各回は**平均 10 期**の意思決定からなります。



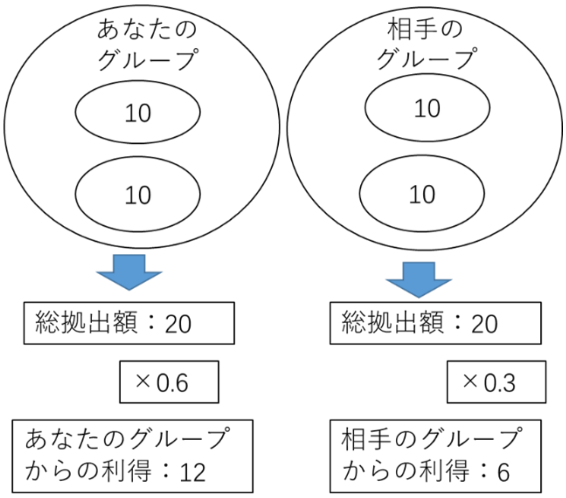
5. 利得の決まり方

あなたは、各期のはじめに初期保有ポイントとして 10 ポイントを与えられます。あなたは、10 ポイントから、自分のグループの公共財に**全額拠出する**または**拠出しない**を決めます。

あなたのポイントは、自分のグループの総拠出額及び相手のグループの総拠出額によって決まります。　同様に、相手のグループのメンバーのポイントは、あなたのグループの総拠出額及び相手のグループの総拠出額によって決まります。あなたは自分のグループの総拠出額及び相手のグループの総拠出額を知ることができます。ある期のあなたの利得は以下の式で計算されます。

ある期におけるあなたの利得
＝10－自分の拠出額＋0.6×（自分のグループの総拠出額）＋0.3×（相手のグループの総拠出額）

i.　例えば、あなたが 10 ポイントを全額拠出し、自分のグループの総拠出額が 20 ポイント、相手のグループの総拠出額が 20 ポイントの場合を考えましょう。この期のあなたの利得は以下のようになります。
この期のあなたのポイント＝(10－10)+0.6×20＋0.3×20＝0+12+6＝18 ポイント



ii.　例えば、あなたが拠出しない、自分のグループの総拠出額が 0 ポイント、相手のグルー

プの総拠出額が 0 ポイントの場合を考えましょう。この期のあなたの利得は以下のようになります。
この期のあなたのポイント＝(10－0)+0.6×0+0.3×0＝10+0+0＝10 ポイント

ケース	自分の拠出額	自分のグループの総拠出額	相手のグループの総拠出額	利得
1	0	0	0	10
2	0	0	10	13
3	0	0	20	16
4	0	10	0	16
5	0	10	10	19
6	0	10	20	22
7	10	10	0	6
8	10	10	10	9
9	10	10	20	12
10	10	20	0	12
11	10	20	10	15
12	10	20	20	18

表 1. ある期におけるあなたの利得リスト

要するに、ある回は N 期の意思決定からなり、あなたの利得は以下の式で計算されます。

ある回におけるあなたの利得＝$\sum_{i=1}^{N}$ ある期におけるあなたの利得

iii. 例えば、ある回は 3 期の意思決定からなるとしましょう。第 1～3 期におけるあなたの利得が 18 ポイントの場合を考えましょう。この回のあなたの利得は以下のようになります。
この回におけるあなたの利得＝18+18+18=54 ポイント

6-1. 意思決定（前半部分）

はじめに、1～5 回の前半部分での意思決定を説明します。

各参加者は、各期に自分のグループの公共財に**全額拠出する**または**拠出しない**から選んで下さい。

6-2. 意思決定（後半部分）

- 次に、6～10 回の後半部分での意思決定について説明します。後半部分では、各回のはじめに、すべての期での意思決定の方針を定めます。後半部分では、あなたの定めた行動方針によって、公共財に**全額拠出する**または**拠出しないが**決定されます。
- 具体的には、13 問の質問に回答することで、あなたの行動方針が定まります。各設問は、
  ① 第 1 期で公共財に全額拠出するか否か（全 1 問）、
  ② 1 期前にあなたの選択（拠出する、拠出しない）、自分のグループの総拠出額(0, 10, 20)及び相手のグループの総拠出額(0, 10, 20)に応じて、今期あなたは公共財に拠出するか否か（全 12 問）です。

- 各設問はランダムな順番で画面に表示されます。全てに回答して下さい。
- 全ての質問（合計 13 問）の回答が終わると、あなたの選んだ方針を確認する画面が表示されます。自分の選んだ方針を記録用紙にメモしてください。
- 後半の回では、行動方針が定まった後は、その方針に基づいて自動的にゲームがプレイされます。ゲーム開始後、回の途中で、あなたの行動方針を変更することはできません。あなたは各期で結果を確認するだけです。
- 各回のはじめに、同じ 13 の質問が表示されます。前回と同じ方針を採用する場合、記録用紙を見ながら前回と同じ回答を入力してください。

7. 報酬額

あなたの最終ポイントは、10 回の合計ポイントで計算されます。1 ポイント=3 円で計算され、参加報酬 1000 円と、理解度確認クイズの報酬（最大で 240 円、誤答のたびにマイナス 10 円）と合計してあなたへの報酬額が決定されます。

あなたの報酬額
＝￥１０００＋　理解度確認クイズの報酬＋10 回の合計ポイント×￥3

以上