INTELLIGENCE PROMOTES COOPERATION IN LONG-TERM INTERACTION: EXPERIMENTAL EVIDENCE IN INFINITELY REPEATED PUBLIC GOODS GAMES

Tetsuya Kawamura
Tiffany Tsz Kwan Tse

October 2021

Intelligence promotes cooperation in long-term interaction: Experimental evidence in infinitely repeated public goods games

Tetsuya Kawamura[1] and Tiffany Tsz Kwan Tse[2*]

[1*]Department of Economics, Tezukayama University, Tezukayama, Nara, 6318501, Japan.
[2]Institute of Social and Economic Research, Osaka University, Ibaraki, Osaka, 5670047, Japan.

*Corresponding author(s). E-mail(s): tiffany.ttk@gmail.com;
Contributing authors: kawamuratetsuya2027@gmail.com;

Abstract

A growing body of literature in experimental economics examines how cognitive ability affects cooperation in social dilemma settings. We contribute to the existing literature by studying this relationship in a more complex and strategic environment when the number of partners increases in an infinitely repeated public goods game. We designed four treatments with different continuation probability under two conditions: whether cooperation can be sustained as risk dominance or not. We asked participants to decide whether to cooperate in every period in the first five rounds. They were further asked to decide if they should elicit their strategy at the beginning of each super game using the strategy method in the last five rounds. We found that participants with greater cognitive abilities cooperated more (less) when cooperation could(not) be sustained as risk dominance. A similar trend was observed in the frequency of fully cooperative strategies. We also found that participants with greater cognitive abilities employed lenient and forgiving strategies more frequently when the continuation probability was far higher than the risk dominant threshold level.

1 Introduction

How does the intelligence of participants affect decision-making in strategic interactions? It may depend on the number of equilibria of the game and whether the interaction is intertemporal. Experimental evidence (see Brañas-Garza et al. (2012), Carpenter et al. (2013), and Gill and Prowse (2016) for p-beauty game experiments; Kawamura and Ogawa (2019) for recipient behavior in ultimatum game experiments; and Barreda-Tarrazona et al. (2017) for prisoner's dilemma (PD) game experiments) suggests that more intelligent individuals will exhibit behavior close to the theoretical prediction in the one-shot game, with a single sub-game perfect Nash equilibrium (SPE).

When a game is repeated and the strategic interaction is intertemporal, even if the game has a unique SPE, the relationship between intelligence and behavior is complicated. Al-Ubaydli et al. (2016) and Barreda-Tarrazona et al. (2017) found no significant relationship between participants' intelligence and cooperation rates in finitely repeated PD game experiments.

When the game has multiple SPEs, the relationship between participants' intelligence and behavior becomes more complicated. Jones (2008) found a positive relationship between participants' intelligence and cooperation rate. Proto et al. (2019) established that intelligence has a large and positive long-run effect on cooperative behavior in an infinitely repeated PD game.

Can the same trend of more intelligent individuals becoming more cooperative in long-term interactions in a more complex strategic environment be achieved when the number of partners increases in an infinitely repeated public goods (PG) game? This study is an attempt to answer this question.

The rich experimental literature on infinitely repeated PD games provides important attributes for studying infinitely repeated PG games. These studies investigate cooperative behavior in infinitely repeated PD games from the following aspects: equilibrium selection (Blonski et al., 2011), the shadow of the future (Dal Bó & Fréchette, 2011), strategy methods (Dal Bó & Fréchette, 2019; Romero & Rosokha, 2018), discounting and random termination (Fréchette & Sevgi, 2017), and the effects of intelligence and personal characteristics (Dreber et al., 2014; Proto et al., 2019).[1]

Dal Bó and Fréchette (2011) found that increasing the continuation probability δ facilitates cooperation. Blonski et al. (2011) established that when the grim trigger strategy (GRIM)[2] is supported as a risk dominance equilibrium (RDE), cooperation is more easily achieved than when it is not an RDE. Proto et al. (2019) found that participants with high cognitive ability cooperate or employ cooperative strategies more frequently when GRIM is an RDE.

Few experimental studies have investigated infinitely repeated PG games, as most compare cooperative behavior in infinitely and finitely repeated games. Palfrey and Rosenthal (1994) determined that the cooperation rate is higher in an infinitely repeated PG game than in a one-shot PG game. Tan and Wei

---

[1]In addition, some studies have examined the impact of monitoring (Aoyagi et al., 2019) and group matching methods (Duffy & Ochs, 2009) in infinitely repeated PD games.
[2]Players using GRIM will cooperate if all partners cooperate; otherwise, they defect.

([2014](#)) found no significant difference in the cooperation rate between finitely and infinitely repeated PG games. Lugovsky et al. ([2017](#)) established that the cooperation rate is significantly higher in infinitely repeated settings than in finitely repeated settings in a four-person PG game. Sell and Wilson ([1999](#)) compared the cooperation rate under multiple δ in infinitely repeated PG games and found that the cooperation rate increases when δ increases, but only in the treatment in which participants are required to employ the grim trigger strategy. They designed treatments in which GRIM is supported as an SPE, but not as an RDE. To our knowledge, no study has explored cooperative behavior when GRIM is supported as an RDE in infinitely repeated PG games.

The threshold discount factor for RDE is known to be a good predictor of the cooperation trend in infinitely repeated PD game experiments. This study examined whether higher intelligence allows for more efficient equilibria to be reached by processing richer information. The theoretical prediction from two-person games was extended to n-person games (Carlsson & van Damme, [1993](#); Kim, [1996](#))[3] to design δ, so that we have one treatment for which δ is lower than the risk-dominant threshold and two treatments for which δ is higher than the risk-dominant threshold.

In an infinitely repeated PG game, the strategy space is broader than in an infinitely repeated PD game. Unlike the PD game, punishing a player who deviates from the equilibrium strategy in the PG game not only affects the payoff of the punished player, but also affects the payoff of the other players who did not deviate from the equilibrium strategy. To achieve mutual cooperation, participants have more chances to employ lenient and forgiving strategies. To our knowledge, no existing study has explored strategies in an infinitely repeated PG game. By employing the one-period-ahead strategy method presented in Dal Bó and Fréchette ([2019](#))'s study , we explored the strategy in an infinitely repeated PG game. We investigated not only the difference in cooperation rate, but also the difference in strategies between participants with high cognitive ability (HCA) and participants with low cognitive ability (LCA).

The remainder of this paper is organized as follows. In Section 2, we introduce the experimental design and procedure. In Section 3, we introduce the methodology employed. In Section 4, we propose our hypotheses based on the two equilibrium concepts in infinitely repeated game theory: the SPE and RDE. In Section 5, we present our experimental results. In Sections 6 and 7, we discuss our findings and conclude the paper, respectively.

2 Experimental Design

2.1 Parameter settings

The group comprised of four players who played the PG game infinitely and repeatedly. In the PG game, players make a binary choice regarding whether to cooperate or not. We set the initial endowment to 10, and the marginal

---

[3]Carlsson & van Damme ([1993](#)) and Kim ([1996](#)) explore Harsanyi and Selten ([1988](#))'s notion of RDE in two-person to n-person games.

per capita return at 0.5. Here, x_i denotes player i's level of cooperation. The payoff of player i is given by:

$$\pi_i = 10 - x_i + 0.5 \sum_{j=1}^{4} x_j$$

We set the continuation probability of all treatments above the threshold level in which GRIM is supported as an SPE. Therefore, we focused on situations where both cooperative and non-cooperative equilibria exist in all treatments. In an infinitely repeated PD game, whether GRIM is supported as an RDE or not can be a good predictor of the cooperation trend, as in the infinitely repeated PD game experiments. We investigated cooperative behavior when GRIM is and is not supported as an RDE.

We conducted four treatments with $\delta_{T1} = 0.4$ (Treatment 1, or T1), $\delta_{T2} = 0.6$ (T2), $\delta_{T3} = 0.8$ (T3), and $\delta_{T4} = 0.9$ (T4), where GRIM is supported as the SPE in all the treatments and is supported as an RDE in T3 and T4. The threshold value of the continuation probability for GRIM to be supported as RDE δ_{RDE} is 0.8, which is equal to δ_{T3}[4]. We set δ_{T1} and δ_{T2} to be lower than δ_{RDE}, and δ_{T4} was higher than δ_{RDE}.

2.2 Experimental Procedure

The experiments were conducted in the laboratory of the Center for Experimental Economics at Kansai University. We used the online bulletin board of Kansai University to recruit participants who did not have any experience with PG and PD game experiments. Experiments were conducted in eleven sessions between July 2018 and July 2021. Each participant participated in only one session.

Each session lasted about 120 (180) min in T1, T2 and T3 (T4) and was conducted by the same experimenter. After the participants were randomly assigned to their seats, they were asked to sign the consent form. After confirming that all participants had signed the consent form, the experimenter read them the instructions. Each participant received printed handouts of the instructions and listened to the audio instructions. During this time the participants could ask any questions about the experiment. After the instructions, a three-question review test about the payoff calculation was conducted to check the participants' understanding of the game. After all the participants had answered every question correctly, the experiment began.

The experiment was implemented using a z-tree (Fischbacher, 2007). Each session consisted of 10 rounds (also called supergames), and in each round, participants repeatedly played a PG game with their fixed partners. The number of periods in a round is determined by the δ of the corresponding treatment (0.4 in T1, 0.6 in T2, 0.8 in T3, and 0.9 in T4, respectively). At the end of each period, the experimenter drew one card from five cards, which consisted

---

[4]The procedure for calculating the threshold value of continuation probability for GRIM to be supported as an RDE is shown in the Appendix A.

of three jokers (two jokers) [one joker] and two (three) [four] spade cards in T1 (T2) [T3]. The experimenter drew one card from 10 cards, which consisted of one joker and nine spade cards in T4. When the experimenter drew a joker, the round was finished, all members were randomly re-matched, and the next round started with four new members. The process of drawing cards was shown on the screen at the front of the laboratory. Therefore, it was ensured that the continuation of every period by the given probability is common knowledge.

The decision-making methods in the first five rounds and the last five rounds differed. Participants decide whether to cooperate in every period in the first five rounds. We refer to this as the direct response method. In the last five rounds, participants constructed their strategy for repeated PG games at the beginning of each round by using a one-period-ahead strategy method.[5] In the strategy method, participants were asked to decide whether to cooperate in all possible one-period-ahead histories and the first period. There are eight one-period-ahead histories (two levels of each player's cooperation rate, multiplied by four levels of the other players' total cooperation rate in the previous period). The nine questions of all possible one-period-ahead histories and the first period were shown randomly. Participants could take notes about their strategic choices after constructing their strategies. The strategies were then played automatically. The participants could not change their strategies during a round.

After 10 rounds of repeated PG games, participants answered 16 questions[6] from the Raven Progressive Matrices Test (Raven, 1936) in 10 minutes. The maximum test score was 16. The total profit earned in all the rounds and periods was exchanged at a rate of 3 JPY per point to control for the income effect. The total payment was the sum of the participation fee (1,000 JPY) and the earnings in the game.

3 Methodology

3.1 Strategy Classification

We used a one-period-ahead strategy method to investigate the types of strategies employed by the participants.[7] Using this method, we can simplify and clarify the experimental results to determine the types of strategies that are significantly related to the cooperation rate.

---

[5]The strategy method for infinitely repeated games was introduced by Selten (1967). Vespa (2020) extended the strategy method into a one-period-ahead strategy method and Romero and Rosokha (2018) introduced the constructing strategy method. There is still no evidence that players employ strategies beyond two-period-ahead histories (or above) in infinitely repeated PG games. Hence, to reduce players' difficulty in eliciting strategies, we used the one-period-ahead strategy method to investigate the one-period-ahead history strategies in an infinitely repeated PG game following Dal Bó and Fréchette (2019) and Vespa (2020).

[6]The 16 selected questions are commonly used in Japan and Europe (see Hanaki et al., 2016). These 16 questions are selected from all 48 questions, arranged from easy to difficult.

[7]We also used the strategy frequency estimation method (Dal Bó & Fréchette, 2011) to estimate strategies under the direct response method. The results are reported in the Appendix C. We thank Dal Bó and Fréchette (2011) and Bigoni et al. (2015) for providing their code for strategy estimation.

We considered 35 simplified strategies with a one-period-ahead history, which includes 20 commonly studied strategies in infinitely repeated PD games (Fudenberg et al., 2012). The strategy dataset includes unconditional cooperation (UC), GRIM, other trigger types, Tit-for-Tat (TFT) types, exploitative TFT (DTFT, also called suspicious TFT) types, false cooperator (C to All D), false defector (D to All C), alternator (DC Alternative), and unconditional defection (UD) strategies. Following Fudenberg et al. (2012), we classified these strategies into fully cooperative, fully non-cooperative, partially cooperative, lenient, forgiving, and unforgiving strategies. Our definition of leniency differs slightly from that of Fudenberg et al. (2012), who defined leniency based on a partner's history. We call this "vertical leniency." As there are three partners in our infinitely repeated PG game, we consider a strategy to be lenient when it can endure one or two partners' defection in the previous period. We call this "horizontal leniency." A description of the strategy types is presented in Table 1.

3.2 Simulation

In the strategy method, participants construct their strategies before interacting with their partners, and they cannot change their strategies during a round. Therefore, we expect that they construct strategies to respond to other participants in their session, but not their partners whom they do not know when constructing their strategies. Therefore, we simulated all possible group matching in each session and calculated the average cooperation rate of the constructed strategies. In each session and each round, we matched the participants to form all possible groups; for example, if the number of participants was 16 in a session, the number of all possible group matching was $\binom{16}{4} = \frac{16!}{4!(16-4)!} = 1820$. We used the same number of periods in each round in each session, as in the experiments. Participants played a game fictitiously. We then calculated the average cooperation rates of HCA and LCA participants.

4 Hypothesis

Proto et al. (2019) investigated the relationship between cognitive ability, as measured by the Raven Progressive Matrices Test, and cooperation rate in an infinitely repeated PD game when δ is strictly higher than δ_{RDE}. They found that HCA participants were more cooperative than LCA participants. Based on the results of Proto et al. (2019), we expect that HCA participants more frequently reach more efficient equilibria (i.e., RDE) than LCA participants by maximizing their expected payoff by processing rich information. In our design, UD risk dominates GRIM in T1 and T2, and GRIM risk dominates UD in T3 and T4. We expect that the cooperation rate among HCA participants is higher (lower) than that of LCA participants when δ is higher (lower) than δ_{RDE}. Thus, we propose the following hypotheses:

Hypothesis 1-1: The cooperation rate among HCA participants is lower than

Table 1 Description of strategy types

Strategy	Description
UC	Players always cooperate.
GRIM	Players cooperate if all partners cooperate; otherwise, they defect.
Trigger$X$	Players cooperate in the first period and continue cooperating if at least X partners cooperated in the previous period; otherwise, they defect forever.
TFT	Players cooperate if all partners cooperated in the previous period.
TFTcXdY	Players cooperate in the first period, and they cooperate in the current period if the players cooperate and at least X partners cooperated in the previous period. They also cooperate in the current period if the players defect and at least Y partners cooperated in the previous period.
DTFT	Players defect in the first period. They cooperate if all partners cooperated in the previous period.
DTFTcXdY	Players defect in the first period, and they cooperate in the current period if the players cooperate and at least X partners cooperated in the previous period. They also cooperate in the current period if the players defect and at least Y 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.
Strategy Types	Description
Fully cooperative	The strategies obtain full cooperation when players who employ the same type of strategies are matched with each other.
Partially cooperative	The strategies obtain a mixture of cooperation and defection when players who employ the same type of strategies are matched with each other.
Fully non-cooperative	The strategies obtain full defection when players who employ the same type of strategies are matched with each other.
Lenient	These are fully cooperative strategies that are slower to resort to punishment. They include all fully cooperative strategies, except UC, GRIM, and TFT; In the UC strategy, a player cooperates infinitely, while in the GRIM and TFT, a player cooperates infinitely only when all partners contribute fully.
Forgiving	These are fully cooperative strategies that are fast to forgive. They include all cooperative TFT types.
Unforgiving	These are fully cooperative strategies that never forgive. They include all cooperative trigger types.

that of LCA participants in T1.

Hypothesis 1-2: The cooperation rate among HCA participants is lower than that of LCA participants in T2.

Hypothesis 1-3: The cooperation rate among HCA participants is higher than that of LCA participants in T3.

Hypothesis 1-4: The cooperation rate among HCA participants is higher than that of LCA participants in T4.

Dal Bó and Fréchette (2011; 2019) revealed that when δ is set to exceed δ_{RDE}, the frequency of fully cooperative strategies increases. Proto et al. (2019) suggested that HCA participants employ cooperative strategies more frequently, whereas LCA participants employ UD more frequently when δ is set to exceed δ_{RDE}. We expect that fully cooperative strategies are employed more frequently by HCA participants than LCA participants when GRIM is supported as an RDE. When δ is set to be smaller than δ_{RDE}, UD is RDE; hence, HCA participants employ cooperative strategies less frequently than LCA participants. Thus, we propose the following hypotheses:

Hypothesis 2-1: The frequency of fully cooperative strategies among HCA participants is lower than that of LCA participants in T1.

Hypothesis 2-2: The frequency of fully cooperative strategies among HCA participants is lower than that of LCA participants in T2.

Hypothesis 2-3: The frequency of fully cooperative strategies among HCA participants is higher than that of LCA participants in T3.

Hypothesis 2-4: The frequency of fully cooperative strategies among HCA participants is higher than that of LCA participants in T4.

Romero and Rosokha (2018) found that a large proportion of cooperative strategies are lenient and forgiving when δ exceeds δ_{RDE}. Dal Bó and Fréchette (2011) showed that the frequency of TFT (i.e., a forgiving strategy) increases when δ exceeds δ_{RDE}. We expect the same trend of leniency and forgiving in infinitely repeated PG games. We expect HCA participants to employ lenient and forgiving strategies more frequently than LCA participants when δ exceeds δ_{RDE}. We may expect to observe the reverse trend when δ is smaller than δ_{RDE}. Thus, we propose the following hypotheses:

Hypothesis 3-1: The frequency of forgiving strategies among HCA participants is lower than that of LCA participants in T1.

Hypothesis 3-2: The frequency of forgiving strategies among HCA participants is lower than that of LCA participants in T2.

Hypothesis 3-3: The frequency of forgiving strategies among HCA participants is higher than that of LCA participants in T3.

Hypothesis 3-4: The frequency of forgiving strategies among HCA participants is higher than that of LCA participants in T4.

Hypothesis 4-1: The frequency of lenient strategies among HCA participants is lower than that of LCA participants in T1.

Hypothesis 4-2: The frequency of lenient strategies among HCA participants is lower than that of LCA participants in T2.

Hypothesis 4-3: The frequency of lenient strategies among HCA participants is higher than that of LCA participants in T3.

Hypothesis 4-4: The frequency of lenient strategies among HCA participants is higher than that of LCA participants in T4.

5 Experimental Results

A total of 172 participants participated in our experiment, consisting of eleven sessions. The average payment was 1,568 JPY in T1, 1,904 JPY in T2, 3,029 JPY in T3, and 4,128 JPY in T4. Each session lasted for two hours in T1, T2 and T3, and three hours in T4. On average, there were 1.5 periods per round in T1, 2.5 periods per round in T2, 6 periods per round in T3, and 9 periods per round in T4. Table 2 presents a summary of the experiments.

Table 2 Summary of the experiments

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Number of sessions	3	3	3	2
Number of participants	48	40	44	40
The average number of rounds[1]	10	10	10	9.5
The average number of periods per round	1.5	2.5	6	9
Average payment (JPY)	1568	1904	3029	4128
Exchange rate (JPY/point)	3	3	3	3
Raven score	11.25	10.975	11.545	11.1
Male	56.25%	42.5%	56.818%	57.5%
Age	21.021	19.95	20.773	20
Economics or business students	8.333%	27.5%	20.455%	32.5%

[1]Due to time constraint, we conducted nine rounds in one session in Treatment 3.

To check the balance of cognitive ability among the four treatments, we conducted a one-way ANOVA to compare average Raven scores: 11.25 in T1, 10.975 in T2, 11.545 in T3, and 11.1 in T4, with no significant difference ($p = 0.775$). We considered participants who had Raven scores above the mean

as HCA participants and those who had Raven scores below or equal to the mean as LCA participants. There were 28, 14, 26, and 22 participants whose Raven scores were above 11 in T1, T2, T3 and T4, respectively. Meanwhile, 20, 26, 18, and 18 participants had Raven scores below or equal to 11 in T1, T2, T3 and T4, respectively. Figure 1 shows the distribution of the Raven score for each treatment.

Fig. 1 The distribution of the Raven score in each treatment
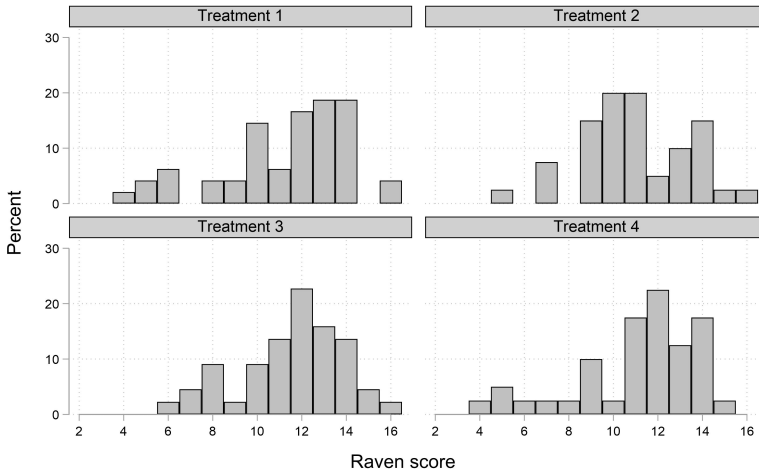
We have also checked the balance of gender, age, and economics or business students among the four treatments by conducting a one-way ANOVA. We found a 1% significant difference among treatments on age and a 5 % significant difference among treatment on economics or business students, but no significant difference on male ($p = 0.474$).

In the analysis of average cooperation rate and the frequency of strategy types, we control demographic characteristics including gender, age, and economics or business students.

5.1 Average Cooperation Rate

Figure 2 shows the average cooperation rate (%) across rounds between HCA participants and LCA participants. We report two types of results: average cooperation rate in period 1 only and all periods. Participants make decision under direct response method from round 1 to 5 and strategy method from round 6 to 10. In treatment 1, HCA participants always cooperated less than LCA participants for both period 1 and all periods. In treatment 2, the average cooperation rate between HCA participants and LCA participants was similar across rounds. In treatment 3, HCA participants cooperated more than LCA participants in period 1 after round 2. HCA participants cooperated more than LCA participants in all periods from round 2 to round 5 and then behaved

similarly from round 6. In treatment 4, HCA participants always cooperated more than LCA participants in period 1 after round 2. However, HCA participants sometimes cooperated more and sometimes less than LCA participants in all periods across rounds.

Fig. 2 Average cooperation rate across rounds between HCA participants and LCA participants
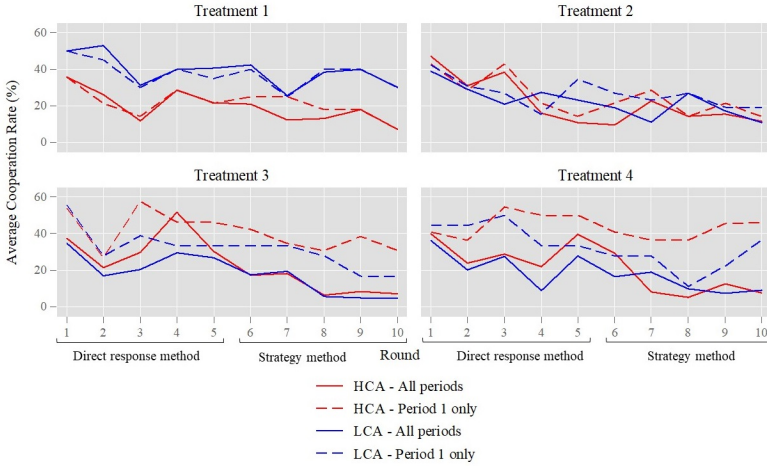
We examined our hypothesis that HCA participants are more (less) likely to cooperate than LCA participants in T3 and T4 (T1 and T2) in period 1 and all periods, in which participants behave according to RDE. We examined our hypothesis by reporting two types of results: experimental results under the direct response method (rounds 1 to 5) and simulation results using strategy method observation.[8]

Figure 3 shows the predicted average cooperation rate (%) between HCA and LCA participants under the direct response method (rounds 1 to 5), and strategy method (simulation) in (a) Treatment 1, (b) Treatment 2, (c) Treatment 3 and (d) Treatment 4. We provide the results of period 1 only and all periods. For each pairwise comparison between HCA and LCA participants in each treatment, we report the results of logistic regression of cooperation rate, with HCA participants as the dummy independent variable, controlling for demographic variables, including age, gender, and economics major.[9] We report robust standard errors clustered by group. We define a p-value less than or equal to 0.05, which is typically ≤ 0.05, as statistically significant. We report the predicted average cooperation rate (predicted probabilities) presented by

---

[8]We report the results of experimental data from strategy method (round 6 to 10) in Table A12 in Appendix D.

[9]We also conducted the unconditional logistic regression of cooperation rate, with HCA participants as the dummy independent variable, without controlling for demographic variables and robust standard errors clustered by group. The results are shown in Table A18 and Table A20 in Appendix E.

rectangular bars and standard errors of the predicted average cooperation rate presented by error bars.[10]

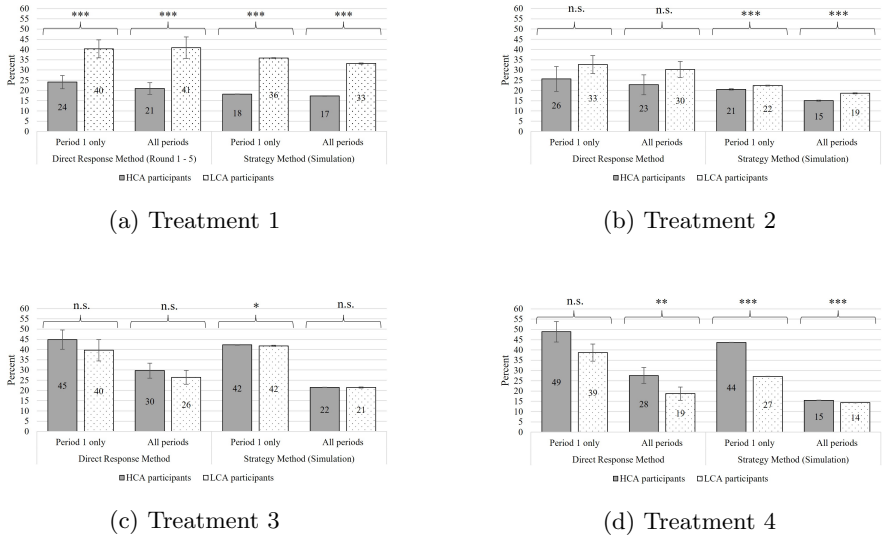**Fig. 3** Predicted Average Cooperation Rate (%) between HCA and LCA participants under the direct response method and strategy method (simulation) in (a) Treatment 1, (b) Treatment 2, (c) Treatment 3, and (d) Treatment 4

(a) Treatment 1

(b) Treatment 2

(c) Treatment 3

(d) Treatment 4

*Notes:*Predicted average cooperation rates and *p*-values are calculated based on logistic regression of cooperation rate, with HCA participants as dummy independent variable, controlling for demographic characteristics (including age, gender, and economics major), with robust standard errors clustered by group. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively. n.s. means the difference is not statistically significant at 0.1. See Table A11 and Table A13 in Appendix D.

(a) Treatment 1

Under the direct response method, the predicted average cooperation rate of HCA participants was always lower than that of LCA participants for both period 1 (HCA: 24% and LCA: 40%) and all periods (HCA: 21% and LCA: 41%). These differences were not statistically significant. Under the strategy method (simulation), the predicted average cooperation rate of HCA participants was always lower than that of LCA participants for both period 1 (HCA: 18% and LCA: 36%) and all periods (HCA: 17% and LCA: 33%). These differences between the HCA and LCA participants were statistically significant. Thus, Hypothesis 1-1 was supported.

(b) Treatment 2

Under the direct response method, the predicted average cooperation rate of HCA participants was lower than that of LCA participants for both period 1 (HCA: 26% and LCA: 33%) and all periods (HCA: 23% and LCA: 30%), and

―――――――――――――――――――

[10]All regression results are shown in Table A11 and A13 in Appendix D.

these differences were not statistically significant. Under the strategy method (simulation), the predicted average cooperation rate of HCA participants was lower than that of LCA participants for both period 1 (HCA: 21% and LCA: 22%) and all periods (HCA: 15% and LCA: 19%), and these differences were statistically significant.[11] Thus, Hypothesis 1-2 was not supported in direct response method, but supported in strategy method (simulation).

(c) Treatment 3

Under the direct response method, the predicted average cooperation rate of HCA participants was higher than that of LCA participants in both period 1 (HCA: 45% and LCA: 40%) and all periods (HCA: 30% and LCA: 26%). These differences were not statistically significant. Under the strategy method (simulation), the predicted average cooperation rate of HCA participants was similar to that of LCA participants in both period 1 (HCA: 42.3% and LCA 41.8%) and all periods (HCA:22% and LCA: 21%). These differences were not statistically significant.[12] Thus, Hypothesis 1-3 was not supported.

(d) Treatment 4

Under the direct response method (rounds 1 to 5), the predicted average cooperation rate of HCA participants was higher than that of LCA participants in both period 1 (HCA: 49% and LCA: 39%) and all periods (HCA: 28% and LCA: 19%), and these differences were not statistically significant in period 1, but statistically significant in all periods.[13] Under the strategy method (simulation), the predicted average cooperation rate of HCA participants was higher than that of LCA participants in both period 1 (HCA: 44% and LCA: 27%) and all periods (HCA: 15% and LCA: 14%), and these differences were statistically significant. Thus, Hypothesis 1-4 was supported, except in period 1 in direct response method.

5.2 Strategy analysis

We examined our hypothesis that HCA participants more (less) frequently employ fully cooperative, forgiving, and lenient strategies than LCA participants in T3 and T4 (T1 and T2), in which participants behave according to RDE. We report the predicted frequency of strategies using the strategy method (rounds 6 to 10).

Figure 4 shows the predicted frequency (%) of the (a) fully cooperative strategy, (b) forgiving strategy, and (c) lenient strategy between HCA and LCA

---

[11]In the results of unconditional logistic regression (i.e., without controlling demographic variables), in strategy method (simulation) in Treatment 2, the average cooperation rate of HCA participants and LCA participants were not statistically significant in period 1 (HCA: 21% and LCA: 22%) and all periods (HCA: 17% and LCA: 17%).

[12]In the results of unconditional logistic regression (i.e., without controlling demographic variables), in strategy method (simulation) in Treatment 3, the average cooperation rate of HCA participants is higher than that of LCA participants in both period 1 (HCA: 44% and LCA:39%) and all periods (HCA: 22% and LCA: 20%) with statistically significant.

[13]In the results of unconditional logistic regression (i.e., without controlling demographic variables), in strategy method (simulation) in Treatment 4, the average cooperation rate of HCA participants and LCA participants were not statistically significant in period 1 (HCA: 46% and LCA: 41%) and all periods (HCA: 27% and LCA: 19%).

participants. For each pairwise comparison between HCA and LCA participants in each treatment, we report the results of logistic regression of strategy types, with HCA participants as the dummy independent variable, controlling for demographic variables, including age, gender, and economics major.[14] We report robust standard error. We report the predicted frequency (predicted probabilities) presented by rectangular bars and standard errors of predicted frequency presented by error bars.[15]

Fig. 4 The predicted frequency (%) of (a) fully cooperative strategy, (b) forgiving strategy, and (c) lenient strategy between HCA and LCA participants under strategy method in each treatment

(a) Fully cooperative strategy

(b) Forgiving strategy

(c) Lenient strategy
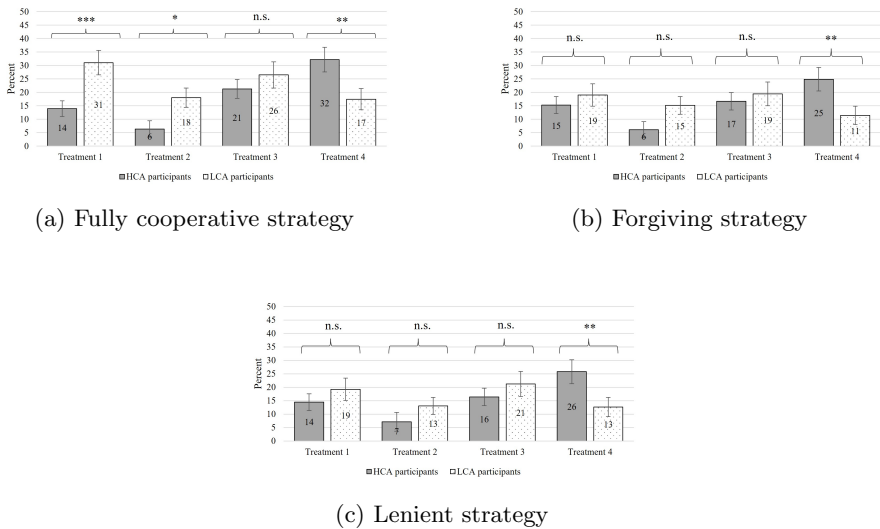
Notes: Predicted frequency and *p*-values are calculated based on logistic regression of strategy types, with HCA participants as dummy independent variable, controlling for demographic characteristics (including age, gender, and economics major), with robust standard errors. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively. See Table A14 to A16 in Appendix D.

(a) Fully cooperative strategy

In Treatment 1, the predicted frequency of the fully cooperative strategy among HCA participants was 14% lower than that of LCA participants (31%), and these differences were statistically significant. Thus, Hypothesis 2-1 was supported. In Treatment 2, the predicted frequency of the fully cooperative strategy among HCA participants was 6% lower than that of LCA participants (18%), and these differences were not statistically significant. Thus, Hypothesis 2-2 was not supported. In Treatment 3, the predicted frequency of the

---

[14]We also conducted the unconditional logistic regression of strategy types, with HCA participants as the dummy independent variable, without controlling for demographic variables and robust standard errors. The results are shown in Table A21 to A23 in Appendix E.

[15]All regression results are shown in Table A14 to A16 in Appendix D.

fully cooperative strategy among HCA was 21% and that of LCA participants was 26%, with no statistically significant differences. Thus, Hypothesis 2-3 was not supported. In Treatment 4, the predicted frequency of the fully cooperative strategy among HCA participants was 32% higher than that of LCA participants (17%) and these differences were statistically significant.[16] Thus, Hypothesis 2-4 was supported.

(b) Forgiving strategy

In Treatment 1, the predicted frequency of the forgiving strategy among HCA participants was 15% lower than that of LCA participants (19%), without statistically significant differences. Thus, Hypothesis 3-1 was not supported. In Treatment 2, the predicted frequency of the forgiving strategy among HCA participants was 6% lower than that of LCA participants (15%), without statistically significant differences. Thus, Hypothesis 3-2 was not supported. In Treatment 3, the predicted frequency of the forgiving strategy among HCA was 17% lower than that of LCA participants (19%), without statistically significant differences. Thus, Hypothesis 3-3 was not supported. In Treatment 4, the predicted frequency of the forgiving strategy among HCA participants was 25% higher than that among LCA participants (11%), and these differences were statistically significant. Thus, Hypothesis 3-4 was supported.

(c) Lenient strategy

In Treatment 1, the predicted frequency of the lenient strategy among HCA participants was 14% lower than that of LCA participants (19%), with no statistically significant difference. Thus, Hypothesis 4-1 was not supported. In Treatment 2, the predicted frequency of the lenient strategy among HCA participants was 7% lower than that of LCA participants (13%), with no statistically significant difference. Thus, Hypothesis 4-2 was not supported. In Treatment 3, the predicted frequency of the lenient strategy among HCA participants was 16%, which is lower than the 21% for LCA participants, with no statistically significant difference. Thus, Hypothesis 4-3 was not supported. In Treatment 4, the frequency of the lenient strategy among HCA participants was 26% higher than that of LCA participants (13%), and these differences were statistically significant. Thus, Hypothesis 4-4 was supported.

6 Discussion

In the theoretical prediction, GRIM risk dominates UD when $\delta \geq \delta_{RDE}$. In our experiment, we set $\delta_{T3} = 0.8$, which is δ_{RDE}. We expect HCA participants to reach more efficient equilibria (i.e., RDE) more frequently than LCA participants by maximizing their expected payoff, which is achieved by processing rich information. However, at $\delta_{T3} = \delta_{RDE}$, the expected payoff employing GRIM is the same as that employing UD. Thus, we focus on the comparison between T1 and T4, or T2 and T4 for investigating the effect of continuation

---

[16]In the results of unconditional logistic regression (i.e., without controlling demographic variables), in Treatment 4, the frequency of fully cooperative strategies among HCA participants and LCA participants was not statistically significant (HCA: 31% and LCA: 18%).

probability (i.e., whether GRIM is supported as the RDE or not) on behaviors among treatments for each type of participant.

Focusing on the direct response method, the cooperation rate of HCA participants in period 1 and all periods increased as the expected payoff of GRIM exceeded that of UD from Treatment 1 to 4 ($p < 0.01$ for period 1 and $p < 0.05$ for all periods; see Table A17 in Appendix D) and from Treatment 2 to 4 ($p < 0.01$ for period 1 and p=0.859 for all periods; see Table A17 in Appendix D). This implies that HCA participants cooperated more in T4 than in T1 or T2 in period 1, in order to maximize their expected payoff.

However , the cooperation rate of LCA participants in the direct response method remained unchanged in period 1 and decreased in all periods from Treatment 1 to 4 ($p = 0.271$ for period 1 and $p < 0.01$ for all periods; see Table A17 in Appendix D) and 2 to 4 ($p = 0.490$ for period 1 and p=0.025 for all periods, see Table A17 in Appendix D). This implies that LCA participants tended to cooperate in period 1 due to similar frequencies in T1, T2, and T4, but defected more in all periods in T4 than they did in T1 or T2. As the frequency of fully non-cooperative strategies was more than 50% among HCA participants and LCA participants in all treatments (see Table A10 in Appendix C), the level of cooperation did not evolve if there was a large fraction of fully non-cooperative strategies. The average number of periods per round was higher in T4 than in T1 and T2. Therefore, the high frequency of fully non-cooperative strategies decreased the cooperation rate in all periods in T4, as compared to that in T1 and T2.

In the direct response method, we found that hypotheses 1-1 and 1-4 were supported, and hypotheses 1-2 and 1-3 were not supported. The background for these results was built up in two aspects: 1) LCA participants cooperated more than HCA participants with statistical significance ($p < 0.01$ for period 1 and all periods) in T1. 2) LCA participants decreased cooperation and HCA participants increased cooperation as δ increased and exceeded δ_{RDE} (see Table A17 in Appendix D). Because the trend of cooperation rate was reversed between HCA and LCA participants as δ increased, the statistically significant difference in the cooperation rate in T1 was rendered insignificant from T1 to T2 and T3. Moreover, the cooperation rate of HCA participants exceeded that of LCA participants from T1 to T4.

We found that Hypotheses 2-1 and 2-4 were supported but Hypotheses 2-2 and 2-3 were not. We confirmed these results by examining the differences in the trend of the fully cooperative strategies between HCA and LCA participants. HCA participants employed fully cooperative strategies from Treatment 1 to 4 ($p < 0.01$, see Table A17 in Appendix D) and 2 to 4 ($p < 0.01$, see Table A17 in Appendix D) more frequently. However, the frequency of fully cooperative strategies employed by LCA participants was not statistically different between Treatments 1 and 4 ($p = 0.056$, see Table A17 in Appendix D) and Treatment 2 and 4 ($p = 0.385$, see Table A17 in Appendix D).

Similar to the trends in the cooperation rate between HCA and LCA participants, the reversed trends in the frequency of fully cooperative strategies

between the two groups of participants, along with LCA participants employing fully cooperative strategies more frequently than HCA participants in T1, builds up the background for the results testing Hypotheses 2-1 to 2-4. The difference in the frequency of fully cooperative strategies between the two types of participants was diminished came closer as δ increased from T1 to T3, and HCA participants turned to employ fully cooperative strategies more frequently than LCA participants in T4.

Our experimental results suggested the lag effects of the continuation probability (i.e., whether GRIM is supported as the RDE) on the cooperation rate and the frequency of fully cooperative strategies. HCA participants did not change their strategy from fully non-cooperative strategies, including UD, to fully cooperative strategies including GRIM and TFT as soon as δ exceeded δ_{RDE} or the expected payoff of GRIM exceeded that of UD. Instead, HCA participants gradually switched from fully non-cooperative strategies to fully cooperative strategies. These changes in the strategy profiles of HCA participants caused the cooperation rate to gradually increase as δ increased. However, LCA participants tended to maintain the initial relatively high cooperation rate, as δ increased, by maintaining the initial strategy profiles in T1. Thus, our hypotheses were supported in T1 and T4, where δ was far away from δ_{RDE}, but not supported in T2 and T3, where δ was relatively closer to δ_{RDE}.

7 Conclusion

In this study, we designed an infinitely repeated PG game experiment under different δ. We designed two treatments for which the continuation probability was lower than the δ_{RDE} and two treatments in which the continuation probability was higher than the δ_{RDE}. We investigated the differences in cooperation rates and strategies between HCA and LCA participants.

We found that 1) the average cooperation rate of HCA participants was statistically significantly lower than that of LCA participants in T1. 2) The average cooperation rate of HCA participants was statistically significantly lower than that of LCA participants in T2 in the simulation results with strategy method, but not in direct response method. 3) The average cooperation rate of HCA participants was not statistically significantly different from that of LCA participants in T3, which continuation probability was the same as the δ_{RDE}, 4) the average cooperation rate of HCA participants was statistically significantly higher than that of LCA participants in T4, 5) the frequency of fully cooperative strategies for HCA participants was statistically lower than that for LCA participants in T1, but not different in T2, 6) the frequency of fully cooperative strategies for HCA participants was statistically higher than that for LCA participants in T4, but not different in T3, and 7) the frequency of lenient and forgiving strategies for HCA participants was statistically higher than that for LCA participants, but only in T4; they were not different in other treatments.

In the future, we aim to follow Proto et al. (2019)'s experimental design to separate HCA and LCA participants to play the infinitely repeated PG game. HCA participants will only match with HCA partners, and LCA participants will only match with LCA partners. We would like to confirm whether mutual cooperation can be maintained when the group players are all HCA participants and when the GRIM is supported as an RDE. It will also be interesting to conduct experiments with the different types of strategy methods. In the strategy methods, participants choose their strategy from a strategy set consisting of UD, GRIM, lenient Trigger, TFT, and lenient TFT strategies. By doing so, we can directly test the theoretical prediction on RDE condition. This enables us to investigate the relationship between the cognitive abilities of participants and the types of strategies employed: cooperative/defective, lenient/not lenient, and forgiving/unforgiving strategies, with great depth.

References

Al-Ubaydli, O., Jones, G., Weel, J. (2016). Average player traits as predictors of cooperation in a repeated prisoner's dilemma. *Journal of Behavioral and Experimental Economics*, *64*, 50–60.

Aoyagi, M., Bhaskar, V., Fréchette, G.R. (2019). The impact of monitoring in infinitely repeated games: Perfect, public, and private. *American Economic Journal: Microeconomics*, *11*(1), 1–43.

Barreda-Tarrazona, I., Jaramillo-Gutiérrez, A., Pavan, M., Sabater-Grande, G. (2017). Individual characteristics vs. experience: An experimental study on cooperation in prisoner's dilemma. *Frontiers in psychology*, *8*, 596.

Bigoni, M., Casari, M., Skrzypacz, A., Spagnolo, G. (2015). Time horizon and cooperation in continuous time. *Econometrica*, *83*(2), 587–616.

Blonski, M., Ockenfels, P., Spagnolo, G. (2011). Equilibrium selection in the repeated prisoner's dilemma: Axiomatic approach and experimental evidence. *American Economic Journal: Microeconomics*, *3*(3), 164–92.

Brañas-Garza, P., García-Muñoz, T., González, R.H. (2012). Cognitive effort in the beauty contest game. *Journal of Economic Behavior & Organization*, *83*(2), 254–260.

Carlsson, H., & Van Damme, E. (1993). Equilibrium selection in stag hunt games. *Frontiers of game theory*, 237.

Carpenter, J., Graham, M., Wolf, J. (2013). Cognitive ability and strategic sophistication. *Games and Economic Behavior*, *80*, 115–130.

Dal Bó, P., & Fréchette, G.R. (2011). The evolution of cooperation in infinitely repeated games: Experimental evidence. *American Economic Review*, *101*(1), 411–29.

Dal Bó, P., & Fréchette, G.R. (2019). Strategy choice in the infinitely repeated prisoner's dilemma. *American Economic Review*, *109*(11), 3929–52.

Dreber, A., Fudenberg, D., Rand, D.G. (2014). Who cooperates in repeated games: The role of altruism, inequity aversion, and demographics. *Journal of Economic Behavior & Organization*, *98*, 41–55.

Duffy, J., & Ochs, J. (2009). Cooperative behavior and the frequency of social interaction. *Games and Economic Behavior*, *66*(2), 785–812.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, *10*(2), 171–178.

Fréchette, G.R., & Yuksel, S. (2017). Infinitely repeated games in the laboratory: Four perspectives on discounting and random termination. *Experimental Economics*, *20*(2), 279–308.

Fudenberg, D., Rand, D.G., Dreber, A. (2012). Slow to anger and fast to forgive: Cooperation in an uncertain world. *American Economic Review*, *102*(2), 720–49.

Gill, D., & Prowse, V. (2016). Cognitive ability, character skills, and learning to play equilibrium: A level-k analysis. *Journal of Political Economy*, *124*(6), 1619–1676.

Hanaki, N., Jacquemet, N., Luchini, S., Zylbersztejn, A. (2016). Fluid intelligence and cognitive reflection in a strategic environment: evidence from dominance-solvable games. *Frontiers in psychology*, *7*, 1188.

Harsanyi, J.C., Selten, R., et al. (1988). A general theory of equilibrium selection in games. *MIT Press Books*, *1*.

Jones, G. (2008). Are smarter groups more cooperative? evidence from prisoner's dilemma experiments, 1959–2003. *Journal of Economic Behavior & Organization*, *68*(3-4), 489–497.

Kawamura, T., & Ogawa, K. (2019). Cognitive ability and human behavior in experimental ultimatum games. *Research in Economics*, *73*(1), 97–106.

Kim, Y. (1996). Equilibrium selection inn-person coordination games. *Games and Economic Behavior*, *15*(2), 203–227.

Lugovskyy, V., Puzzello, D., Sorensen, A., Walker, J., Williams, A. (2017). An experimental study of finitely and infinitely repeated linear public goods games. *Games and Economic Behavior*, *102*, 286–302.

Palfrey, T.R., & Rosenthal, H. (1994). Repeated play, cooperation and coordination: An experimental study. *The Review of Economic Studies*, *61*(3), 545–565.

Proto, E., Rustichini, A., Sofianos, A. (2019). Intelligence, personality, and gains from cooperation in repeated interactions. *Journal of Political Economy*, *127*(3), 1351–1390.

Raven, J.C. (1936). Mental tests used in genetic studies: The performance of related individuals on tests mainly educative and mainly reproductive. *Unpublished master's thesis, University of London*.

Romero, J., & Rosokha, Y. (2018). Constructing strategies in the indefinitely repeated prisoner's dilemma game. *European Economic Review*, *104*, 185–219.

Sell, J., & Wilson, R.K. (1999). The maintenance of cooperation: expectations of future interaction and the trigger of group punishment. *Social Forces*, *77*(4), 1551–1571.

Selten, R. (1967). Die strategiemethode zur erforschung des engeschraänkt rationalen verhaltens im rahmen eines oligopolexperiments. H. Sauermann (Ed.), *Beiträge zuer experimentellen wirtschaftsforschung* (pp. 136–168). Tübingen: J. C. B. Mohr.

Tan, L., & Wei, L. (2014). Voluntary contribution mechanism played over an infinite horizon. *Pacific Economic Review*, *19*(3), 313–331.

Vespa, E. (2020). An experimental investigation of cooperation in the dynamic common pool game. *International Economic Review*, *61*(1), 417–440.

Declarations

- Conflict of interest/Competing interests
  The authors declare that they have no conflict of interest.
- Ethics approval
  The experiment reported in this paper is approved by Research Ethic Committee at The Research Institute for Socionetwork Strategies (RISS), Kansai University.
- Consent to participate
  All participants signed the consent form to agree to participate this experiments.
- Consent for publication
  All participants signed the consent form to agree to publish the experimental data under the condition of anonymity.
- Availability of data and materials
  Supplementary material is available at journal's website.
- Code availability
  Code used in analysis is available at journal's website
- Authors' contributions
  The authors contributed equally to this work.

Online Supplementary Appendix to:

Kawamura and Tse:[1] "Intelligence promotes cooperation in long-term interaction: Experimental evidence in infinitely repeated public goods games"

Tables of Contents

---

[1] Kawamura: Tezukayama University (kawamuratetsuya2027@gmail.com),Tse: Osaka University (tiffany.ttk@gmail.com)

A. Calculation of the risk dominant threshold

Carlsson and van Damme (1993) and Kim (1996) explore Harsanyi and Selten (1988)'s notion of risk dominance in two-person to n-person games. Using Kim's method of calculating the expected payoff, we show the expected payoff using UD and GRIM under the same probability to find the possible RDE strategies that can minimize strategic risk.

We consider a game with these two pure SPE strategies (UD and GRIM)[2]. The possible situations for a given individual are thus all the combinations of that individual playing GRIM or UD against three partners, with k partners playing GRIM and (3-k) partners playing UD, for any $0 \leq k \leq 3$. We denote the payoff when a player plays GRIM against k partners playing GRIM by α_k and the payoff when a player plays UD against k partners playing GRIM by β_k.

There are four possible events: all three partners choose UD, one partner chooses GRIM and two partners choose UD, two partners choose GRIM and one partner chooses UD, and all three partners choose GRIM. Each partner chooses GRIM with probability y_{Grim} and UD with probability y_{UD}, where $y_{UD} = 1 - y_{Grim}$. To simplify, following Dal Bó and Fréchette (2011), we assume that each partner chooses GRIM and UD with the same probability, where $y_{GRIM} = \frac{1}{2}$ and $y_{UD} = \frac{1}{2}$. The probability of a given player facing with k players employing GRIM and 3-k players employing UD is given in the following formula:

$$\text{Probability} = \binom{3}{k} \times (y_{Grim})^k \times (y_{UD})^{3-k} = \binom{3}{k} \times \left(\frac{1}{2}\right)^k \times \left(\frac{1}{2}\right)^{3-k} = \binom{3}{k} \times \left(\frac{1}{8}\right)$$

$\binom{3}{k}$ indicates the combined probability of selecting k partners choosing GRIM from all three partners. $(y_{Grim})^k$ indicates the combined probability of the multiple individual probabilities of k partners employing GRIM. $(y_{UD})^{3-k}$ indicates the combined probability of the multiple individual probabilities of (3-k) partners employing UD. Table A1 shows the expected payoff using UD and GRIM against the three partners.

---

[2] To prove that GRIM is supported as the SPE, 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/her payoff is given by $\pi_i(GRIM) = \frac{1}{1-\delta}(0.5 \sum_{i=1}^{4} 10) = \frac{20}{1-\delta}$. While if he/she deviates, he/she receives a one-shot gain followed by lower future payoffs: $\pi_i(D|GRIM) = (10 + 0.5 \sum_{i \neq j} 10) + \frac{\delta}{1-\delta} 10 = 25 + \frac{10\delta}{1-\delta}$. Thus, a player has no incentive to deviate from the equilibrium path when $\pi_i(GRIM) \geq \pi_i(D|GRIM)$. Therefore, the threshold value of probability continuation which GRIM is supported as SPE δ_{SPE} is $\frac{1}{3}$.

Table A1. Expected payoff using the possible SPE strategies (UD and GRIM)

	Partners			
Player i	3UD	1GRIM+2UD	2GRIM+1UD	3GRIM
GRIM	$5 + \dfrac{10\delta}{1-\delta}$	$10 + \dfrac{10\delta}{1-\delta}$	$15 + \dfrac{10\delta}{1-\delta}$	$\dfrac{20}{1-\delta}$
UD	$\dfrac{10}{1-\delta}$	$15 + \dfrac{10\delta}{1-\delta}$	$20 + \dfrac{10\delta}{1-\delta}$	$25 + \dfrac{10\delta}{1-\delta}$
Probability	$\dfrac{1}{8}$	$\dfrac{3}{8}$	$\dfrac{3}{8}$	$\dfrac{1}{8}$

GRIM risk dominates UD if

$$\pi_{GRIM} = \sum_{k=0}^{3}\binom{3}{k}\left(\frac{1}{8}\right)\alpha_k \geq \sum_{k=0}^{3}\binom{3}{k}\left(\frac{1}{8}\right)\beta_k = \pi_{UD}$$

$$\frac{1}{8}\left(5 + \frac{10\delta}{1-\delta}\right) + \frac{3}{8}\left(10 + \frac{10\delta}{1-\delta}\right) + \frac{3}{8}\left(15 + \frac{10\delta}{1-\delta}\right) + \frac{1}{8}\left(\frac{20}{1-\delta}\right) \geq$$

$$\geq \frac{1}{8}\left(\frac{10}{1-\delta}\right) + \frac{3}{8}\left(15 + \frac{10\delta}{1-\delta}\right) + \frac{3}{8}\left(20 + \frac{10\delta}{1-\delta}\right) + \frac{1}{8}\left(25 + \frac{10\delta}{1-\delta}\right)$$

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

B. Description of a strategic plan

Table A2. Description of a strategic plan

Choice	Own Contribution at t-1	Partners' Contribution at t-1	What is your contribution at t?
1	0	0	0 or 10?
2	0	10	0 or 10?
3	0	20	0 or 10?
4	0	30	0 or 10?
5	10	0	0 or 10?
6	10	10	0 or 10?
7	10	20	0 or 10?

| 8 | 10 | 30 | 0 or 10? |
| 9 | First Period | | 0 or 10? |

C. Strategy analysis results

1. Strategy Method (Round 6-10)

Table A3. Summary of strategies used by HCA participants in the strategy method stage

Treatment 1		Treatment 2		Treatment 3		Treatment 4	
Strategy	Freq.	Strategy	Freq.	Strategy	Freq.	Strategy	Freq.
TFT	1	TFTc1d1	1	UC	1	UC	4
TFTc1d2	11	TFTc1d2	2	GRIM	4	GRIM	1
TFTc2d2	1	TFTc2d2	1	Trigger 2	2	Trigger 1	1
TFTc2d3	3	TFTc2d3	1	TFT	2	Trigger 2	1
TFTc3d2	1	C to All D	1	TFTc1d1	2	TFT	1
C to All D	4	DTFT	1	TFTc1d2	4	TFTc1d1	4
DTFT	4	DTFTc2d3	7	TFTc2d0	1	TFTc1d2	6
DTFTc1d2	8	UD	31	TFTc2d3	5	TFTc2d1	1
DTFTc1d3	1	Unclassified	25	TFTc3d0	1	TFTc2d2	4
DTFTc2d2	10	Obs.	70	TFTc3d2	1	TFTc2d3	4
DTFTc2d3	14			C to All D	2	C to All D	4
UD	62			DTFT	2	D to All C	1
Unclassified	20			DTFTc1d3	1	DTFT	5
Obs.	140			DTFTc2d2	2	DTFTc1d2	3
				DTFTc2d3	2	DTFTc2d2	2
				DTFTc3d2	2	DTFTc2d3	2
				UD	60	UD	32
				Unclassified	36	Unclassified	25
				Obs.	130	Obs.	101

4

a: The unit of observation is the decision making in every round in the strategy-method stage.

b: The total number of observations is the number of HCA/LCA participants× the number of rounds under strategy method (Round 6 to 10).

Table A4. Summary of strategies used by LCA participants in the strategy method stage

Treatment 1		Treatment 2		Treatment 3		Treatment 4	
Strategy	Freq.	Strategy	Freq.	Strategy	Freq.	Strategy	Freq.
UC	9	UC	5	UC	1	UC	2
GRIM	2	Trigger2	4	GRIM	2	GRIM	2
Trigger 1	1	TFTc1d1	5	Trigger 2	2	Trigger 2	1
Trigger 2	1	TFTc1d2	4	TFT	1	TFTc1d1	1
TFT	2	TFTc2d3	4	TFTc1d2	4	TFTc1d2	4
TFTc1d1	1	C to All D	1	TFTc1d3	1	TFTc2d2	1
TFTc1d2	6	DTFT	2	TFTc2d2	3	TFTc2d3	2
TFTc1d3	2	DTFTc1d1	1	TFTc2d3	3	TFTc3d0	1
TFTc2d3	1	DTFTc1d2	3	C to All D	1	C to All D	1
DTFT	1	DTFTc2d2	1	DTFTc0d2	1	DTFT	2
DTFTc1d2	2	DTFTc2d3	11	DTFTc1d2	1	DTFTc1d2	5
DTFTc2d3	5	UD	50	DTFTc2d3	6	DTFTc1d3	3
DTFTc3d1	1	Unclassified	39	UD	45	DTFTc2d2	1
DTFTc3d2	2	Obs.	130	Unclassified	19	DTFTc2d3	4
UD	37			Obs.	90	UD	40
Unclassified	27					Unclassified	13
Obs.	100					Obs.	83

a: The unit of observation is the decision making in every round in the strategy-method stage.

5

Table A5. Summary of frequency (%) of strategy types in strategy method stage

Strategy Types	HCA participants				LCA participants			
	T1	T2	T3	T4	T1	T2	T3	T4
Fully cooperative	14.286	7.143	23.077	30.693	30	16.923	23.333	18.072
UC	0	0	0.769	3.960	9.000	3.846	1.111	2.410
Lenient	13.571	7.143	17.692	24.752	17	13.077	18.889	13.253
Forgiving	14.286	7.143	17.692	23.762	17	13.846	17.778	12.048
Unforgiving	0	0	4.615	2.970	4	3.077	4.444	3.614
Partially cooperative	5	20	13.077	12.871	15	9.231	6.667	9.639
Fully non-cooperative	80.714	72.857	63.846	56.436	55	73.846	70	72.289
UD	44.286	44.286	46.154	31.683	37	38.462	50	48.193
Obs.	140	70	130	101	100	130	90	83

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

[b]: The unit of observation is the decision making in every round in the strategy-method stage.

[c]: The total number of observations is the number of HCA/LCA participants× the number of rounds under strategy method (Round 6 to 10).

2. Direct Response Method (Round 1- 5)

We employ the strategy frequency estimation method, following Dal Bó and Fréchette (2011) and Fudenberg et al. (2012), to estimate the subjects' strategies in the first five rounds under direct-response method.[3]

The method works on the history of play as follows. First, we generate the simulated action sequence by following the constructed strategy set which 35 simplified strategies considered in Table 1 in section 3.1. We compare a subject's actual action sequence against the simulated action sequence generated by a given strategy from constructed strategy set s^k. Then, strategy s^k correctly matches the subject's action sequence C times and does not match the sequence E times. Therefore, the probability that player i employs strategy k is given by

$$P_i(s^k) = \prod_{round} \prod_{period} \beta^C (1-\beta)^E$$

β is the probability of correctly matching actions from the constructed strategy set and actions from the subjects. In each period, the subject plays according to the chosen strategy with probability $\beta\epsilon(\frac{1}{2}, 1)$ and makes a mistake with probability (1-β). When β is close to $\frac{1}{2}$, choices are almost random, and when it is close to 1, choices are almost perfectly predicted. In addition, the likelihood function is given by

$$\mathcal{L}(\beta, \phi) = \sum_{i \in Subjects} \ln \left(\sum_{k \in Strategies} \phi^k P_i(s^k) \right)$$

ϕ^k is the frequency of strategy k.

For each treatment, we draw 100 random samples to calculate bootstrapped standard errors. Firstly, we generate random samples using the following two ways. For the analysis of the entire sample, we take all subjects in a given treatment and draw them at random with replacement until the random sample has as many subjects as in the treatment. For the analysis of the HCA/LCA participants subsample, we take all subjects from each subsample in a given treatment and draw them at random with replacement until the random sample has as many subjects as in the corresponding cognitive ability group in the treatment. Secondly, we estimate the strategy frequency for each random sample. Finally, we calculate the bootstrapped standard error.

Table A6. Estimation of strategies used in treatment 1(data from the direct-response-method stage)

HCA participants		LCA participants

Strategy	Freq. (%)	Bootstrapped SE	p-value	Strategy	Freq. (%)	Bootstrapped SE	p-value
TFT	3.506	0.017	0.019	UC	18.702	0.110	0.045
TFTc2d3	3.507	0.017	0.019	TFTc3d2	7.377	0.056	0.093
TFTc1d3	3.506	0.017	0.019	TFTc1d2	7.365	0.055	0.092
DTFT1	9.851	0.079	0.106	DTFT2	62.004	0.242	0.005
DTFTc2d3	7.555	0.066	0.127	DTFTc3d0	1.517	0.019	0.217
DTFTc1d3	7.498	0.066	0.128	DTFTc1d0	1.517	0.019	0.217
DTFT	7.442	0.066	0.130	DTFTc2d0	1.517	0.019	0.217
DTFTc0d3	7.498	0.066	0.128	γ	72.426	0.088	0.000
UD	49.632	0.256	0.026	β	79.911		
γ	53.485	0.061	0.000				
β	86.642						

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

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

Table A7. Estimation of strategies used in treatment 2(data from the direct-response-method stage)

HCA participants				LCA participants			
Strategy	Freq. (%)	Bootstrapped SE	p-value	Strategy	Freq. (%)	Bootstrapped SE	p-value
TFTc1d1	7.145	0.090	0.213	UC	5.4939	0.035	0.059
DC alternative	6.804	0.000	0.000	Trigger2	6.7704	0.083	0.209
DTFT	39.426	0.199	0.024	TFTc1d1	3.2768	0.037	0.188
DTFTc1d1	7.202	0.078	0.179	DTFTc2d2	21.673	0.127	0.043
DTFTc1d3	9.890	0.061	0.053	DTFTc3d1	1.9531	0.013	0.068

DTFTc0d3	9.889	0.061	0.053	DTFTc2d1	1.9531	0.013	0.068
DTFTc2d3	9.824	0.061	0.054	DTFTc0d1	1.9527	0.013	0.068
UD	9.817	0.061	0.054	UD	56.927	0.250	0.011
γ	54.191	0.073	0.000	γ	62.225	0.056	0.000
β	86.358			β	83.300		

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

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

Table A8. Estimation of strategies used in treatment 3 (data from the direct-response-method stage)

HCA participants				LCA participants			
Strategy	Freq. (%)	Bootstrapped SE	p-value	Strategy	Freq. (%)	Bootstrapped SE	p-value
Trigger1	20.565	0.113	0.034	Trigger2	6.793	0.058	0.123
Trigger2	2.662	0.046	0.283	TFT2	19.199	0.126	0.063
TFTc1d1	18.788	0.065	0.002	TFT1	5.474	0.071	0.222
TFT	3.190	0.042	0.222	DTFT1	5.152	0.072	0.236
DC alternative	1.377	0.000	0.000	C to All D	4.511	0.049	0.180
DTFT	8.446	0.100	0.199	UD	58.870	0.157	0.000
DTFTc3d2	2.663	0.024	0.129	γ	56.506	0.095	0.000
DTFTc1d0	2.663	0.024	0.129	β	85.442		
DTFTc0d2	2.663	0.024	0.129				
UD	36.983	0.197	0.030				
γ	68.832	0.092	0.000				
β	81.043						

Table A9. Estimation of strategies used in treatment 4 (data from the direct-response-method stage)

	HCA participants				LCA participants		
Strategy	Freq. (%)	Bootstrapped SE	p-value	Strategy	Freq. (%)	Bootstrapped SE	p-value
UC	12.983	0.092	0.078	Trigger1	20.423	0.107	0.028
Grim	6.879	0.057	0.114	Trigger2	9.386	0.081	0.123
Trigger1	3.681	0.104	0.361	TFT2	13.209	0.084	0.058
TFT1	13.838	0.075	0.032	DTFT1	4.833	0.043	0.133
TFT2	5.116	0.068	0.224	UD	51.193	0.154	0.000
TFTc1d2	3.454	0.025	0.084	γ	46.942	0.073	0.000
TFTc3d2	3.448	0.025	0.083	β	89.381		
UD	50.601	0.199	0.005				
γ	54.082	0.074	0.000				
β	86.401						

Table A10. Summary of estimated frequency (%) of strategy types in direct response method by using SFEM

Strategy Types	HCA participants				LCA participants			
	T1	T2	T3	T4	T1	T2	T3	T4
Fully cooperative	10.519	7.145	45.205	49.399	33.444	15.541	31.466	43.018

UC	0	0	0	12.983	18.702	5.494	0	0
Lenient	7.013	7.145	42.015	29.537	14.742	10.047	31.466	43.018
Forgiving	10.519	7.145	21.978	25.856	14.742	3.277	24.673	13.209
Unforgiving	0	0	23.227	10.560	0	6.770	6.793	29.809
Partially cooperative	0	6.804	1.377	0	0	0	4.511	0
Fully non-cooperative	89.476	86.048	53.418	50.601	66.555	84.459	64.022	56.026
UD	49.632	9.817	36.983	50.601	0	56.927	58.870	51.193
Obs.	28	14	26	22	20	26	18	18

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

[b]: The unit of observation is the number of HCA participants and LCA participants in each treatment.

D. Regression results for figures

Table A11. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on first period cooperation and all periods cooperation in direct response method (Round 1 to 5) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Direct Response Method (Round 1 to 5) First Period Cooperation				Direct Response Method (Round 1 to 5) All Period Cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.766***	-0.354	0.228	0.473	-0.969***	-0.392	0.165	0.530**
	(0.246)	(0.431)	(0.312)	(0.293)	(0.238)	(0.330)	(0.214)	(0.228)
Age	-0.120	0.037	0.204***	0.344***	-0.036	0.001	0.104**	0.287***
	(0.083)	(0.145)	(0.070)	(0.104)	(0.074)	(0.118)	(0.051)	(0.061)
Male	0.066	0.485	0.420	-0.097	0.024	0.667**	0.379*	-0.263
	(0.289)	(0.399)	(0.324)	(0.287)	(0.254)	(0.308)	(0.220)	(0.239)
Economics	-0.462	-0.706*	-0.387	-1.145***	-0.784	-0.329	-0.379	-0.615**
	(0.576)	(0.402)	(0.435)	(0.343)	(0.514)	(0.295)	(0.236)	(0.303)
Constant	2.125	-1.512	-4.850***	-6.989***	0.427	-1.063	-3.344***	-6.955***
	(1.744)	(2.942)	(1.548)	(2.020)	(1.570)	(2.377)	(1.143)	(1.360)
Observations	240	200	220	200	400	464	1,256	1,776

Clusters	60	50	55	50	60	50	55	50
Wald chi2	12.332	5.467	21.417	22.516	19.362	7.568	24.605	35.750
Prob > chi2	0.015	0.243	0.000	0.000	0.001	0.109	0.000	0.000
Pseudo R2	0.030	0.022	0.055	0.091	0.043	0.017	0.025	0.056
	Predicted first period cooperation rate				Predicted all period cooperation rate			
HCA	0.241	0.256	0.448	0.489	0.209	0.228	0.297	0.276
participants	(0.032)	(0.061)	(0.047)	(0.050))	(0.029)	(0.049)	(0.037)	(0.039)
LCA	0.404	0.327	0.397	0.387	0.409	0.302	0.264	0.187
participants	(0.044)	(0.043)	(0.052)	(0.042)	(0.052)	(0.039)	(0.034)	(0.033)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in period 1 in every round. The total number of observations is the number of subjects × number of rounds. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A12. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on first period cooperation and all periods cooperation in strategy method (Round 6 to 10) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Strategy Method (Round 6 to 10)				Strategy Method (Round 6 to 10)			
	First period cooperation				All period cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.944***	-0.615	0.288	1.045***	-1.239***	-0.482	0.141	-0.363
	(0.349)	(0.385)	(0.295)	(0.327)	(0.355)	(0.517)	(0.277)	(0.473)
Age	-0.057	0.101	0.100	0.156*	-0.053	0.017	0.320***	0.476***
	(0.092)	(0.159)	(0.076)	(0.090)	(0.087)	(0.139)	(0.078)	(0.129)
Male	0.281	0.715*	0.553	0.752**	0.363	0.880**	0.167	-0.567
	(0.361)	(0.414)	(0.358)	(0.381)	(0.338)	(0.404)	(0.400)	(0.417)
Economics	-2.162*	0.158	-0.480	-0.869**	-2.524**	-0.007	0.522	-0.132
	(1.110)	(0.381)	(0.427)	(0.381)	(1.150)	(0.335)	(0.641)	(0.451)
Constant	0.570	-3.447	-3.306**	-4.642**	0.441	-2.273	-9.072***	-11.239***
	(1.897)	(3.210)	(1.636)	(1.822)	(1.823)	(2.775)	(1.719)	(2.511)
Observations	240	200	220	184	320	532	1,232	1,792
Clusters	60	50	55	46	60	50	55	46
Wald chi2	11.212	3.881	9.779	22.027	15.983	7.161	19.586	14.797
Prob > chi2	0.024	0.422	0.044	0.000	0.003	0.128	0.001	0.005
Pseudo R2	0.060	0.017	0.041	0.091	0.089	0.020	0.048	0.076
	Predicted first period cooperation rate				Predicted all period cooperation rate			

HCA	0.182	0.162	0.336	0.431	0.140	0.123	0.112	0.089
participants	(0.035)	(0.039)	(0.039)	(0.047)	(0.027)	(0.033)	(0.022)	(0.020)
LCA	0.358	0.260	0.278	0.224	0.352	0.183	0.099	0.121
participants	(0.051)	(0.037)	(0.045)	(0.042)	(0.057)	(0.041)	(0.025)	(0.041)

[a]: HCA dummy = 1 for subjects belong to HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in period 1 in every round. The total number of observations is the number of subjects × number of rounds. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A13. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on first period cooperation and all periods cooperation in strategy method (Simulation) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Strategy Method (Simulation)				Strategy Method (Simulation)			
	First period cooperation				All period cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.944***	-0.112***	0.021*	0.768***	-0.888***	-0.263***	0.003	0.083***
	(0.016)	(0.027)	(0.013)	(0.009)	(0.016)	(0.030)	(0.014)	(0.010)
Age	-0.057***	0.077***	0.085***	-0.000	-0.048***	0.109***	0.161***	-0.018***
	(0.004)	(0.008)	(0.003)	(0.004)	(0.004)	(0.007)	(0.003)	(0.005)
Male	0.281***	0.115***	1.004***	0.278***	0.263***	0.448***	0.581***	-0.300***
	(0.016)	(0.028)	(0.013)	(0.010)	(0.015)	(0.028)	(0.013)	(0.011)
Economics	-2.162***	-0.259***	-0.061***	-0.989***	-2.495***	-0.305***	0.284***	-0.807***
	(0.050)	(0.026)	(0.017)	(0.011)	(0.051)	(0.027)	(0.020)	(0.014)
Constant	0.570***	-2.783***	-2.743***	-0.939***	0.284***	-3.806***	-5.119***	-1.076***
	(0.083)	(0.155)	(0.065)	(0.074)	(0.079)	(0.153)	(0.076)	(0.094)
Observations	109,200	56,200	116,700	241,640	145,600	148,100	460,560	2,773,568
Clusters	27300	14050	29175	60410	27300	14050	29175	60410
Wald chi2	5768.71	309.56	8801.68	20508.26	5643.65	785.36	4555.24	3811.93
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.060	0.004	0.053	0.056	0.062	0.0097	0.028	0.017
	Predicted first period cooperation rate				Predicted all period cooperation rate			
HCA	0.182	0.205	0.423	0.436	0.173	0.150	0.215	0.144
participants	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)
LCA	0.358	0.224	0.418	0.271	0.332	0.187	0.215	0.154
participants	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)

Table A14. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on the fully cooperative strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Fully cooperative strategy dummy			
VARIABLES	T1	T2	T3	T4
HCA dummy	-1.055***	-1.202*	-0.308	0.880**
	(0.341)	(0.624)	(0.364)	(0.386)
Age	0.012	-0.123	0.125	0.310***
	(0.093)	(0.198)	(0.085)	(0.109)
Male	0.585	0.672	0.939**	0.475
	(0.370)	(0.467)	(0.393)	(0.438)
Economics	-1.902*	0.790*	-0.502	-0.651
	(1.085)	(0.435)	(0.528)	(0.450)
Constant	-1.286	0.362	-4.157**	-7.956***
	(1.929)	(3.916)	(1.832)	(2.104)
Observations	240	200	220	184
Wald chi2	13.573	9.315	11.103	19.406
Prob > chi2	0.009	0.054	0.025	0.001
Pseudo R2	0.069	0.064	0.058	0.094
	Predicted Frequency			
HCA participants	0.139 (0.029)	0.064 (0.031)	0.213 (0.035)	0.322 (0.046)
LCA participants	0.310 (0.045)	0.180 (0.036)	0.265 (0.049)	0.175 (0.040)

Table A15. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on the forgiving strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Forgiving strategy dummy			

VARIABLES	T1	T2	T3	T4
HCA dummy	-0.266	-1.074	-0.192	0.970**
	(0.369)	(0.661)	(0.399)	(0.426)
Age	0.047	-0.169	0.119	0.150
	(0.089)	(0.232)	(0.092)	(0.121)
Male	0.216	1.015**	0.518	0.424
	(0.383)	(0.508)	(0.422)	(0.491)
Economics	N/A	1.165**	-0.568	-0.616
		(0.467)	(0.593)	(0.513)
Constant	-2.566	0.710	-4.138**	-5.180**
	(1.845)	(4.560)	(1.971)	(2.283)
Observations	220	200	220	184
Wald chi2	1.099	11.844	5.835	10.386
Prob > chi2	0.777	0.019	0.212	0.034
Pseudo R2	0.006	0.094	0.033	0.058
	Predicted Frequency			
HCA participants	0.153 (0.032)	0.061 (0.030)	0.167 (0.033)	0.249 (0.044)
LCA participants	0.190 (0.042)	0.151 (0.033)	0.194 (0.044)	0.114 (0.034)

[a]: Forgiving strategy dummy = 1 for forgiving strategy and 0 for other strategies. HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A16. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on the lenient strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Lenient strategy dummy			
VARIABLES	T1	T2	T3	T4
HCA dummy	-0.345	-0.677	-0.332	0.898**
	(0.375)	(0.644)	(0.404)	(0.416)
Age	0.042	-0.157	0.080	0.157
	(0.092)	(0.209)	(0.099)	(0.117)
Male	0.449	0.276	0.757*	0.379
	(0.405)	(0.516)	(0.441)	(0.469)
Economics	N/A	0.596	-0.577	-0.520
		(0.475)	(0.588)	(0.495)
Constant	-2.597	0.906	-3.381	-5.186**

	(1.890)	(4.109)	(2.093)	(2.224)
Observations	220	200	220	184
Wald chi2	2.328	4.949	6.649	9.564
Prob > chi2	0.507	0.293	0.156	0.048
Pseudo R2	0.013	0.032	0.040	0.052
	Predicted Frequency			
HCA participants	0.144 (0.031)	0.072 (0.035)	0.164 (0.033)	0.258 (0.045)
LCA participants	0.192 (0.042)	0.131 (0.032)	0.212 (0.047)	0.127 (0.036)

[a]: Lenient strategy dummy =1 for lenient strategy and 0 for other strategies. HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A17. Odds ratio estimates of logistic regression of treatment dummy and demographic characteristics on cooperation in period 1 and all periods among HCA participants and LCA participants in direct response method (Round 1 to 5) with robust standard error clustered by group; and the fully cooperative strategy among HCA participants and LCA participants in strategy method (Round 6 to 10) with robust standard error

	(1) HCA Direct Response Method (Round 1 to 5) Cooperation Period 1	(2) LCA Direct Response Method (Round 1 to 5) Cooperation Period 1	(1) HCA Direct Response Method (Round 1 to 5) Cooperation All periods	(2) LCA Direct Response Method (Round 1 to 5) Cooperation All periods	(3) HCA Strategy Method (Round 6 to 10) Fully cooperative strategy	(4) LCA Strategy Method (Round 6 to 10) Fully cooperative strategy
(Default: Treatment 1)						
Treatment 2	0.453	0.114	0.576*	-0.209	-0.645	-0.419
	(0.327)	(0.287)	(0.329)	(0.287)	(0.533)	(0.349)
Treatment 3	1.079***	0.090	0.633**	-0.584**	0.630*	-0.227
	(0.271)	(0.298)	(0.251)	(0.271)	(0.327)	(0.336)
Treatment 4	1.326***	0.326	0.635**	-0.970***	1.361***	-0.779*
	(0.282)	(0.296)	(0.272)	(0.347)	(0.353)	(0.408)
Age	0.074	0.249***	0.168***	0.130**	0.163***	0.034
	(0.050)	(0.084)	(0.045)	(0.066)	(0.059)	(0.092)
Male	-0.041	0.391*	-0.126	0.455*	0.439	0.952***
	(0.208)	(0.227)	(0.175)	(0.240)	(0.286)	(0.281)
Economics	-0.748***	-0.747**	-0.437*	-0.482**	-0.499	-0.146

	(0.259)	(0.297)	(0.256)	(0.228)	(0.351)	(0.316)
Constant	-2.639**	-5.798***	-4.769***	-3.305**	-5.496***	-2.075
	(1.104)	(1.759)	(0.993)	(1.412)	(1.311)	(1.957)
Observations	450	410	2,124	1,772	441	403
Clusters	201	199	201	199		
Wald chi2	37.035	24.096	32.290	30.014	27.068	19.034
Prob > chi2	0.000	0.001	0.000	0.000	0.000	0.004
Pseudo R2	0.052	0.052	0.030	0.040	0.077	0.050

	Predicted Frequency					
T1	0.223 (0.032)	0.339 (0.041)	0.182 (0.027)	0.367 (0.048)	0.132 (0.028)	0.277 (0.044)
T2	0.309 (0.054)	0.363 (0.044)	0.280 (0.053)	0.321 (0.042)	0.074 (0.032)	0.204 (0.039)
T3	0.451 (0.049)	0.358 (0.049)	0.291 (0.036)	0.248 (0.033)	0.218 (0.035)	0.236 (0.044)
T4	0.511 (0.049)	0.409 (0.048)	0.292 (0.040)	0.184 (0.037)	0.360 (0.050)	0.154 (0.040)
	Prob > chi2	Prob > chi2	Prob > chi2	Prob > chi2	Prob > chi2	Prob > chi2
T1=T2	0.166	0.693	0.080	0.467	0.226	0.230
T1=T3	0.000	0.762	0.012	0.031	0.054	0.499
T1=T4	0.000	0.271	0.020	0.005	0.000	0.056
T2=T3	0.058	0.940	0.861	0.159	0.014	0.594
T2=T4	0.008	0.490	0.859	0.025	0.000	0.385
T3=T4	0.401	0.470	0.993	0.237	0.025	0.194

[a]: Treatment 1 dummy = 1 for treatment 1 and 0 for others. Treatment 2 dummy = 1 for treatment 2 and 0 for others. Treatment 3 dummy = 1 for treatment 3 and 0 for others. Treatment 4 dummy = 1 for treatment 4 and 0 for others. The default treatment is treatment 1. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in all periods in every round. The total number of observations is the number of subjects × number of rounds × number of periods. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

E. Analyses of experimental results unconditional on personal characteristics

Table A18. Odds ratio estimates of logistic regression of HCA dummy on first period cooperation and all periods cooperation in direct response method (Round 1 to 5) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Direct Response Method				Direct Response Method			
	(Round 1 to 5)				(Round 1 to 5)			
	First Period Cooperation				All Period Cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.732***	0.000	0.345	0.214	-0.932***	0.010	0.293	0.452*

	(0.235)	(0.342)	(0.292)	(0.276)	(0.229)	(0.308)	(0.188)	(0.244)
Constant	-0.405**	-0.847***	-0.499**	-0.359*	-0.386*	-0.979***	-1.104***	-1.447***
	(0.177)	(0.193)	(0.222)	(0.207)	(0.208)	(0.177)	(0.169)	(0.227)
Observations	240	200	220	200	400	464	1,256	1,776
Clusters	60.000	50.000	55.000	50.000	60.000	50.000	55.000	50.000
Wald chi2	9.702	0.000	1.393	0.598	16.590	0.001	2.438	3.421
Prob > chi2	0.002	1.000	0.238	0.439	0.000	0.974	0.118	0.064
Pseudo R2	0.023	0.000	0.005	0.002	0.036	0.000	0.003	0.008
	First period cooperation rate				All period cooperation rate			
HCA	0.243	0.300	0.462	0.464	0.211	0.275	0.308	0.270
participants	(0.036)	(0.055)	(0.044)	(0.048)	(0.027)	(0.035)	(0.017)	(0.014)
LCA	0.400	0.300	0.378	0.411	0.405	0.273	0.249	0.190
participants	(0.049)	(0.040)	(0.051)	(0.052)	(0.038)	(0.026)	(0.019)	(0.014)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in period 1 in every round. The total number of observations is the number of subjects × number of rounds. [c]: The robust standard errors cluster by group are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

Table A19. Odds ratio estimates of logistic regression of HCA dummy on first period cooperation and all periods cooperation in strategy method (Round 6 to 10) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Strategy Method (Round 6 to 10)				Strategy Method (Round 6 to 10)			
	First period cooperation				All period cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.859**	-0.182	0.467*	0.767***	-1.144***	0.035	0.016	-0.299
	(0.334)	(0.340)	(0.275)	(0.278)	(0.338)	(0.342)	(0.395)	(0.493)
Constant	-0.619***	-1.204***	-1.069***	-1.147***	-0.648**	-1.701***	-2.138***	-2.002***
	(0.222)	(0.180)	(0.221)	(0.227)	(0.256)	(0.225)	(0.367)	(0.416)
Observations	240	200	220	184	320	532	1,232	1,792
Clusters	60.000	50.000	55.000	46.000	60.000	50.000	55.000	46.000
Wald chi2	6.606	0.287	2.874	7.585	11.431	0.011	0.002	0.366
Prob > chi2	0.010	0.592	0.090	0.006	0.001	0.918	0.969	0.545
Pseudo R2	0.030	0.001	0.009	0.024	0.052	0.000	0.000	0.003
	First period cooperation rate				All period cooperation rate			
HCA	0.186	0.2	0.354	0.406	0.143	0.159	0.107	0.091
participants	(0.033)	(0.048)	(0.042)	(0.049)	(0.026)	(0.026)	(0.012)	(0.009)

LCA	0.35	0.231	0.256	0.241	0.344	0.154	0.105	0.119
participants	(0.048)	(0.037)	(0.046)	(0.047)	(0.042)	(0.020)	(0.136)	(0.011)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in period 1 in every round. The total number of observations is the number of subjects × number of rounds. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A20. Odds ratio estimates of logistic regression of HCA dummy on first period cooperation and all periods cooperation in strategy method (Simulation) with robust standard error clustered by group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Strategy Method (Simulation)				Strategy Method (Simulation)			
	First period cooperation				All period cooperation			
VARIABLES	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	-0.859***	-0.024	0.218***	0.702***	-0.807***	0.034*	0.125***	0.097***
	(0.015)	(0.020)	(0.012)	(0.008)	(0.016)	(0.020)	(0.014)	(0.010)
Constant	-0.619***	-1.275***	-0.463***	-0.976***	-0.735***	-1.588***	-1.377***	-1.790***
	(0.010)	(0.012)	(0.010)	(0.006)	(0.010)	(0.014)	(0.015)	(0.010)
Observations	109,200	56,200	116,700	241,640	145,600	148,100	460,560	2,773,568
Clusters	27300	14050	29175	60410	27300	14050	29175	60410
Wald chi2	3326.01	1.38	322.65	7017.64	2622.39	2.97	81.90	88.26
Prob > chi2	0.000	0.240	0.000	0.000	0.000	0.085	0.000	0.000
Pseudo R2	0.030	0.000	0.002	0.021	0.026	0.000	0.001	0.000
	First period cooperation rate				All period cooperation rate			
HCA	0.186	0.214	0.439	0.432	0.176	0.174	0.222	0.155
participants	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)
LCA	0.350	0.218	0.386	0.274	0.324	0.170	0.201	0.143
participants	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in period 1 in every round. The total number of observations is the number of subjects × number of rounds. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A21. Odds ratio estimates of logistic regression of HCA dummy on the fully cooperative strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Fully cooperative strategy			
VARIABLES	T1	T2	T3	T4
HCA dummy	-0.944***	-0.974*	-0.014	0.697*
	(0.326)	(0.521)	(0.325)	(0.359)
Constant	-0.847***	-1.591***	-1.190***	-1.511***
	(0.219)	(0.234)	(0.250)	(0.286)
Observations	240	200	220	184
Wald chi2	8.384	3.494	0.002	3.777
Prob > chi2	0.004	0.062	0.965	0.052
Pseudo R2	0.035	0.026	0.000	0.019
	Frequency			
HCA participants	0.143 (0.030)	0.071 (0.031)	0.231 (0.037)	0.307 (0.046)
LCA participants	0.300 (0.046)	0.169 (0.033)	0.233 (0.045)	0.181 (0.042)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A22. Odds ratio estimates of logistic regression of HCA dummy on the forgiving strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Forgiving strategy			
VARIABLES	T1	T2	T3	T4
HCA dummy	-0.206	-0.737	-0.006	0.822**
	(0.360)	(0.530)	(0.360)	(0.411)
Constant	-1.586***	-1.828***	-1.531***	-1.988***
	(0.267)	(0.255)	(0.276)	(0.338)
Observations	240	200	220	184
Wald chi2	0.327	1.930	0.000	3.993
Prob > chi2	0.567	0.165	0.987	0.046
Pseudo R2	0.002	0.015	0.000	0.024
	Frequency			
HCA participants	0.143 (0.030)	0.071 (0.031)	0.177 (0.034)	0.238 (0.043)
LCA participants	0.170 (0.038)	0.138 (0.030)	0.178 (0.041)	0.120 (0.036)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female.

Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A23. Odds ratio estimates of logistic regression of HCA dummy on the lenient strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Lenient strategy			
VARIABLES	T1	T2	T3	T4
HCA dummy	-0.266	-0.671	-0.080	0.767*
	(0.364)	(0.533)	(0.355)	(0.399)
Constant	-1.586***	-1.894***	-1.457***	-1.879***
	(0.267)	(0.261)	(0.270)	(0.325)
Observations	240	200	220	184
Wald chi2	0.534	1.582	0.051	3.703
Prob > chi2	0.465	0.209	0.821	0.054
Pseudo R2	0.003	0.013	0.000	0.022
Frequency				
HCA participants	0.136 (0.029)	0.071 (0.031)	0.177 (0.034)	0.248 (0.043)
LCA participants	0.170 (0.038)	0.131 (0.030)	0.189 (0.041)	0.133 (0.037)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

F. The frequency of unconditional defection strategy between HCA participants and LCA participants

Table A24. Odds ratio estimates of logistic regression of HCA dummy and demographic characteristics on the unconditional strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Unconditional defection			
VARIABLES	T1	T2	T3	T4
HCA dummy	0.376	1.006**	-0.0791	-0.834**
	(0.277)	(0.402)	(0.288)	(0.324)
Age	-0.012	0.011	-0.029	0.064
	(0.089)	(0.149)	(0.071)	(0.088)
Male	-0.109	-1.161***	-0.158	-0.380
	(0.293)	(0.380)	(0.300)	(0.316)
Economics	1.642***	0.851**	0.272	0.452
	(0.550)	(0.342)	(0.374)	(0.330)
Constant	-0.392	-0.725	0.595	-1.210
	(1.866)	(2.985)	(1.538)	(1.772)
Observations	240	200	220	184
Wald chi2	12.83	14.34	1.952	9.100
Prob > chi2	0.012	0.006	0.745	0.059
Pseudo R2	0.038	0.063	0.007	0.037
Predicted Frequency				
HCA participants	0.448 (0.040)	0.553 (0.066)	0.469 (0.045)	0.305 (0.046)
LCA participants	0.362 (0.048)	0.335 (0.038)	0.489 (0.054)	0.498 (0.054)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

Table A25. Odds ratio estimates of logistic regression of HCA dummy on the unconditional defection strategy in strategy method stage, with robust standard error

	(1)	(2)	(3)	(4)
	Unconditional defection			
VARIABLES	T1	T2	T3	T4
HCA dummy	0.303	0.240	-0.154	-0.696**
	(0.269)	(0.301)	(0.275)	(0.307)
Constant	-0.532**	-0.470***	-0	-0.0723
	(0.208)	(0.181)	(0.211)	(0.220)

Observations	240	200	220	184
Wald chi2	1.269	0.636	0.314	5.126
Prob > chi2	0.260	0.425	0.575	0.0236
Pseudo R2	0.00394	0.00236	0.00104	0.0212
Frequency				
HCA participants	0.443 (0.042)	0.443 (0.060)	0.462 (0.044)	0.317 (0.046)
LCA participants	0.37 (0.048)	0.385 (0.043)	0.5 (0.053)	0.482 (0.055)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the elicited strategy in every round. The total number of observations is the number of subjects $\times$ number of rounds. [c]: The robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

G. Average payoff between HCA participants and LCA participants

Table A26. OLS regression of HCA dummy and demographic characteristics on payoff in direct response method (Round 1 to 5), strategy method (Round 6 to 10) and strategy method (simulation) with robust standard error clustered by group

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Direct Response Method (Round 1 to 5) Payoff				Strategy Method (Round 6 to 10) Payoff				Strategy Method (Simulation) Payoff			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
HCA dummy	0.783	1.431**	-0.057	-0.811*	0.447	-0.253	0.255	-0.219	0.930***	0.074*	0.289***	0.153***
	(0.514)	(0.558)	(0.481)	(0.460)	(0.506)	(0.663)	(0.332)	(0.363)	(0.027)	(0.041)	(0.022)	(0.014)
Age	0.227	-0.272	0.214*	-0.220*	-0.246*	-0.069	0.231**	-0.065	0.081***	-0.091***	0.153***	-0.008
	(0.170)	(0.208)	(0.111)	(0.127)	(0.132)	(0.177)	(0.106)	(0.164)	(0.007)	(0.011)	(0.006)	(0.005)
Male	-0.232	-1.245**	-0.271	0.119	-0.089	-0.409	0.561	0.362	-0.375***	-0.309***	-	0.077***
											0.154***	
	(0.403)	(0.523)	(0.416)	(0.487)	(0.557)	(0.524)	(0.432)	(0.364)	(0.027)	(0.039)	(0.022)	(0.014)
Economics	0.102	1.452**	-0.107	-0.196	0.997	0.481	0.206	0.376	1.389***	0.586***	0.358***	0.137***
	(0.607)	(0.555)	(0.452)	(0.471)	(1.056)	(0.411)	(0.531)	(0.363)	(0.044)	(0.033)	(0.031)	(0.016)
Constant	7.817**	17.779***	8.628***	17.198***	17.112***	13.087***	5.837**	12.113***	10.194***	13.527***	8.758***	11.482***
	(3.608)	(4.204)	(2.468)	(2.784)	(2.808)	(3.545)	(2.225)	(3.263)	(0.155)	(0.224)	(0.136)	(0.106)
Observations	400	464	1,256	1,776	320	532	1,232	1,792	145,600	148,100	460,560	2,773,568
Clusters	60	50	55	50	60	50.000	55	46	27300	14050	29175	60410
F	0.958	4.113	1.821	1.476	1.741	1.109	2.253	0.657	491.00	131.15	192.49	59.24
Prob > F	0.437	0.006	0.138	0.224	0.153	0.363	0.075	0.625	0.000	0.000	0.000	0.000
R2	0.013	0.042	0.009	0.019	0.018	0.011	0.027	0.008	0.019	0.007	0.006	0.001
	Predicted average payoff				Predicted average payoff				Predicted average payoff			

HCA	13.254	13.675	12.820	11.978	12.433	11.400	11.169	10.938	12.747	11.761	12.251	11.567
participants	(0.366)	(0.531)	(0.374)	(0.370)	(0.430)	(0.512)	(0.269)	(0.304)	(0.019)	(0.031)	(0.017)	(0.013)
LCA	12.471	12.244	12.876	12.789	11.986	11.653	10.915	11.157	11.817	11.687	11.962	11.414
participants	(0.366)	(0.325)	(0.395)	(0.460)	(0.366)	(0.283)	(0.255)	(0.309)	(0.020)	(0.022)	(0.022)	(0.013)

[a]: HCA dummy = 1 for HCA participants and 0 for LCA participants. Male =1 for male and 0 for female. Economics =1 for students from economics and management major and 0 for otherwise. [b]: The unit of observation is the decision making in all periods in every round. The total number of observations is the number of subjects $\times$ number of rounds $\times$ number of periods. [c]: The robust standard errors cluster by group are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$

H. Experimental instruction

Sample of Experimental Instruction for treatment 4 (in Japanese)

<div align="center">経済実験説明書</div>

　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。

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2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。もう1つは**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
➤　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4人の参加者からなります。グループ番号がコンピュータ画面に表示されます。
➤　各ラウンドで、グループは同じです。あなたは、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ラウンド**からなります。この実験は、**前半5ラウンド**と**後半5**ラウンドで意思決定の仕方が異なりますが、グループの決まり方とピリオドの決まり方は同じです。
➤　各ラウンドの開始時点で、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。
➤　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。
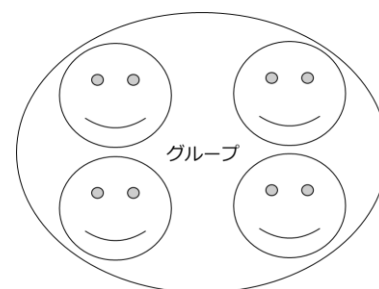
拠出する？　拠出しない？

4. 各ラウンドでのピリオドの決まり方
実験は10ラウンドからなります。
➤　各ラウンドが何ピリオド続くのかは、実験者がくじで決めます。
➤　実験者は各ピリオド終了時に、10枚のカードから1枚を引きます。
➤　10枚のカードは、スペード(♠)が9枚、ジョーカーが1枚です。
➤　ピリオド終了時に、実験者がこの10枚のカードから1枚をランダムに引きます。
➤　実験者が引いたカードが、スペード(♠)だった場合、次のピリオドに進みます。
➤　実験者がジョーカーを引いた場合、ピリオドは終了し、次のラウンドに進みます。
➤　従って、各ピリオドは90%(=9/10)で続き、10%(=1/10)で終了します。

図：ピリオド1 → ピリオド2 → …… → ピリオドN → ピリオドN+1（禁止）

次のピリオドに進みます。

ピリオドNまで終了し、次のラウンドに進みます。
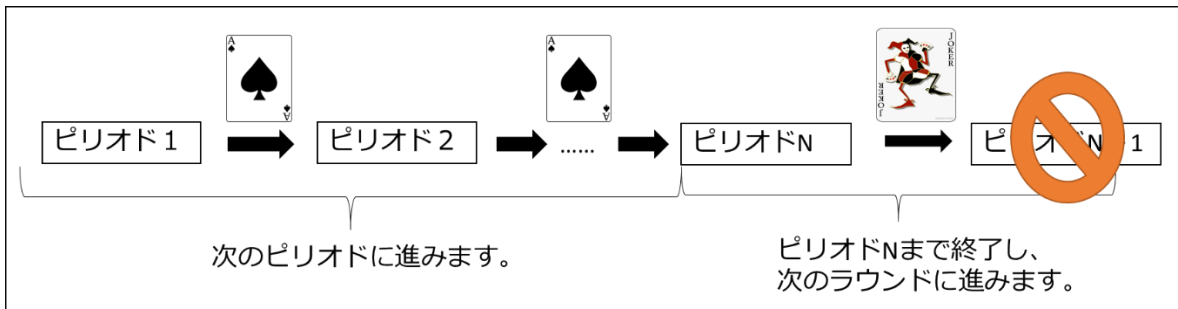
5-1. 意思決定（前半パート）

　はじめに、1～5ラウンドの前半パートでの意思決定を説明します。

　各参加者は、各ピリオド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。10ポイントから、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。

5-2. 意思決定（後半パート）

➢ 次に、6～10ラウンドの後半ラウンドでの意思決定について説明します。後半ラウンドのはじめに、各ラウンドにおける意思決定の方針を定めます。後半ラウンドでは、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、9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ピリオドで公共財に全額拠出するか否か（全1問）、
②1期前にあなたの選択（拠出する、拠出しない）及びグループの拠出額(0，10，20，30、40)に応じて、今期あなたは公共財に拠出するか否か（全8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9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。

➢ 後半ラウンドでは、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、あなたは各ピリオドで結果を確認するだけです。

➢ 各ラウンドのはじめに、同じ9の質問が表示されます。過去のラウンドと同じ方針を採用する場合、記録用紙を見ながら前のラウンドと同じ回答を入力してください。

6. 利得の決まり方

　あなたはグループの総拠出額を知ることができます。

　あなたのポイントは、グループの総拠出額によって決まります。あるピリオドのあなたの利得は以下の式で計算されます。

あるピリオドにおけるあなたのポイント
＝10－自分の拠出額＋0.5×（グループの総拠出額）

　例えば、あなたが10ポイントを全額拠出し、グループの総拠出額が40ポイントの場合を考えましょう。このピリオドのあなたの利得は以下のようになります。

　このピリオドのあなたのポイント＝(10－10)+0.5×40＝0+20＝20

例えば、あなたが拠出しない、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。このピリオドのあなたの利得は以下のようになります。

　このピリオドのあなたのポイント＝(10－0)+0.5×0＝10+0＝10

7. 報酬額

あなたの最終ポイントは、10 ラウンド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＋　10 ラウンドの合計ポイント×￥3

<div align="right">以上</div>

Sample of Experiment Instructions for Treatment 4 (translated in English)

Economic Experiment Instructions

Thank you for participating in our experiment. We will conduct an economic experiment. Please read the instructions carefully and make sure you understand the content fully. If you have any questions, please raise your hand immediately and let the staff know.

1. Handouts
When you get to your seat, make sure you have five handouts:

  1. Experiment Participation Agreement 2. Experiment Instructions 3. Screen Instructions 4. Record Form 5. Receipt

2. How to decide the profit
The profit for the participants consists of two parts. The first is **the participation payment.**   We will pay JPY 1,000 to all of you for your participation. The second is **the experiment payment.**   The result of the experiment determines the amount to be paid.

3. How to set up a group
➢   At the start of the game, the group is randomly determined. All groups consist of **four** participants. Your group number appears on the computer screen.

➢   For each round, the group is the same. You won't know who the other group members are.

➢   The experiment consists of **10 rounds.** This experiment is different in the first five rounds and the last five rounds, but the way groups are formed is the same.

➢   At the beginning of each round, all groups are randomly regrouped. Therefore, you may join the same members again, or you may go with entirely new members.

➢   Once you have verified the group number, proceed to the next decision.
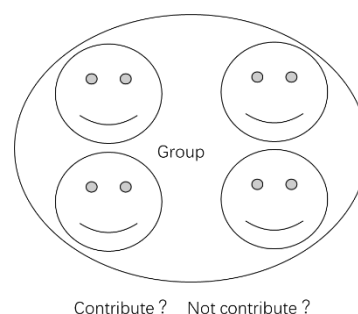
4. How to set the number of periods in each round
The experiment consists of 10 rounds.
➢   The experimenter decides how many periods each round lasts.
➢   At the end of each period, the experimenter draws one from ten cards.
➢   There are nine spades (♠) and one Joker.
➢   At the end of the period, the experimenter randomly draws one of these ten cards.
➢   If the card drawn by the experimenter was a spade (♠), go to the next period.
➢   If the card drawn by the experimenter was a Joker, the period ends and proceeds to the next round.

> Therefore, each period is followed by 90% (=9/10) and ends at 10% (=1/10).

Go to next period.

The game ends at Period N and proceeds to the next round.
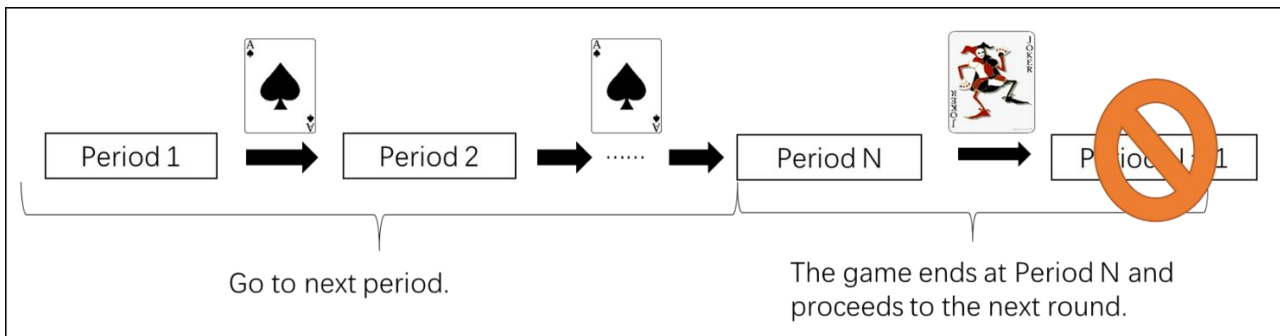
5-1. Decision making (First Five Rounds)

First, let's consider the decision making from Round 1 to Round 5. Each participant is given 10 points as the initial endowment at the beginning of each period. Please choose from 10 points to **fully contribute** or **not contribute** to **the group's public goods.**

5-2. Decision-Making (Last Five Rounds)

> Next, we'll talk about the decision-making from Round 6 to Round 10. At the beginning of each round, you will be asked to create a strategic plan. Your strategic plan will determine whether you will fully contribute or not contribute to public goods.
> Specifically, you will be asked to answer the following nine questions to frame your strategic plan:
> (1) Will you contribute fully to public goods in the first period? (There is a total of 1 question.).
> (2) Depending on your choice (contribution, no contribution) and the group's contribution (0, 10, 20, 30, 40) in the previous period, will you contribute fully to public goods in this current period? (There is a total of 8 questions.).
> Each question is displayed on the screen in random order. Please answer all questions.
> After answering all of the questions (9 questions in total), you will be prompted to review your chosen strategic plan. Make a note of your choice on the record form.
> Once you decide upon your strategic plan, the game is automatically played, based on that strategic plan, and you only need to read the results for each period.
> At the beginning of each round, you'll see the same nine questions. <u>If you want to adopt the same strategy as in the past rounds, check the record form and enter the same choice as the previous round.</u>

6. How to determine the gain

You can know the total contribution of your group. Your points are determined by the total contribution of your group. The following equation calculates your point for a period:

Your point in a period
= 10 – My contribution + 0.5 × (total contribution of the group)

For example, consider a case where you fully contribute, and your group contributes 40 points in total. Your profit in this period:

Your point of this period = (10 – 10) + 0.5 × 40 = 0 + 20 = 20

Consider a case when you do not contribute, and your group contributes 0 points in total. Your profit in this period:

Your point of this period = (10 − 0) + 0.5 × 0 = 10 + 0 = 10

7. Total Profit

Your final point is calculated at an overall point of 10 rounds. It is calculated at 1 point = JPY 3, and your total profit amount is determined with the participation fee of JPY 1000.

Your total profit = JPY 1000 + total points in 10 rounds × JPY 3

References

Carlsson, H., & Van Damme, E. (1993). Equilibrium Selection in Stag Hunt Games. *Frontiers of game theory*, 237.

Dal Bó, P., & Fréchette, G. R. (2011). The evolution of cooperation in infinitely repeated games: Experimental evidence. *American Economic Review*, *101*(1), 411-29.

Fudenberg, D., Rand, D.G., Dreber, A. (2012). Slow to anger and fast to forgive: Cooperation in an uncertain world. *American Economic Review, 102 (2)*, 720–49.

Harsanyi, J. C., & Selten, R. (1988). A general theory of equilibrium selection in games. *MIT Press Books*, *1*.

Kim, Y. (1996). Equilibrium selection inn-person coordination games. *Games and Economic Behavior, 15 (2)*, 203–227.