# It's your turn: experiments with three-player public good games

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# It's Your Turn: Experiments with Three-Player Public Good Games *

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**Abstract**

We report results from experiments designed to investigate the prevalence of turn-taking in three-person finitely repeated threshold public good games without communication. Individuals can each make a discrete contribution. If the number of contributors is at least equal to the threshold, a public benefit accrues to all group members. Players take turns to provide the public good each round when the endowments are homogeneous. When the turn-taking path is at odds with efficiency or under private information of endowments, players seldom engage in taking turns. An endogenous-move protocol limits the frequency of mis-coordinated outcomes every round.

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# 1 Introduction

Cooperation can take many forms when a group of people interact repeatedly over time. Turn-taking is one such form of inter-temporal cooperation that is observed in several daily activities. Instances where individuals engage in turn-taking are abound: colleagues alternate in paying for meals; roommates take turns to clean the apartment that they share; firms facing each other in multiple markets collude by alternately staying out of their less profitable markets; fishermen take turns to go to the preferred spot. The ability to take turns develops as early as at the age of five years in humans (see Melis et al. (2016)).

With two players, several studies have documented turn-taking as a way of cooperation.[1] In this paper we present the results of a series of experiments designed to analyse the incidence of turn-taking when the play involves more than two players. We implement settings such that in some sessions, taking turns is one of the efficient ways to cooperate intertemporally, while in others, turn-taking is at odds with efficiency: there are alternate paths of play that has higher joint payoffs for the entire group. What are the circumstances under which turn-taking is likely to emerge as the most chosen path of play? Will players use this scheme more often when information is limited than when the game has a complete information structure?

In order to address the above questions, we study a finitely repeated game with three players. The basic stage game involves the well-known voluntary contribution public goods game where the production and contribution decisions are binary: a public good is produced if at least $k$ out of $N$ players make a contribution.[2] We choose to use this threshold public good game primarily for two reasons. First, the socially optimal outcome in our game never requires all players to contribute. In fact, from the point of view of the society it is best if exactly $k$ players contribute. This requires considerable amount of coordination among individuals and it provides us with a setting where turn-taking could emerge naturally. This is in contrast to the standard public goods game which is not well-suited to study the incidence of turn-taking behaviour as the socially optimal outcome involves all players contributing their endowments towards the provision of the public good. Second, our stage game has a high real-life relevance as it appropriately describes the lumpy nature of many public goods including parks, roads, community libraries etc.

We conduct this game for several rounds under different assumptions on the distribution and observability of the endowment. A turn-taking path would involve players following a rotation scheme

[1] A succinct summary of these studies is provided at the end of this section.

[2] Public good provision with threshold contributions has been studied by Van de Kragt et al. (1983), Bagnoli and Lipman (1989), Bagnoli and McKee (1991), Palfrey and Rosenthal (1991), Palfrey and Rosenthal (1994), Palfrey et al. (2015). A comparative analysis of experiments on threshold public good provision is provided in Croson and Marks (2000).

to provide the public good each round. For example, if the threshold is one, then player "A" could contribute on the first round, "B" on the second, "C" on the third, "A" on the fourth and so on. If the threshold is two, turn-taking requires even more coordination without any form of communication: for example, "A" and "B" could contribute on the first round, "B" and "C" on the second, "A" and "C" on the third, "A" and "B" on the fourth and so on. Our paper aims at exploring the effect of having heterogeneous endowments in a group as opposed to homogeneous endowments on the incidence of turn-taking. The aspect of turn-taking is closely related to the notion of fairness: when perfect turn-taking is present and individuals are homogeneous, fairness prevails as everybody will have his (her) turn to do the deed. However, when individuals differ in their cost of doing the job, turn-taking and fairness may be at odds with efficiency. Efficiency requires that individuals who have the lowest cost of doing the job should always be the ones to do the job, and clearly this arrangement may not be the fairest arrangement for all. In such a setting, how would the incentive to take turns be affected? This paper looks at the issue by comparing a setting where individuals have homogeneous endowments (costs) and that where individuals are heterogeneous in their endowments (costs). Second, we investigate the effect of private observability of endowments on the players' usage of history-dependent strategies (including rotation schemes). We also evaluate how changing the threshold value influences the extent of public good provision and turn-taking.

Our stage game every round employs an endogenous-move setting where players can make their decisions in real time. Apart from the fact that this arrangement mirrors real-life activities like fund-raising campaigns (Andreoni (1998)), it is also expected to reduce problems arising from coordination failures. This is because with endogenous move, when a player observes another player's decision to contribute in real time it gives a credible signal conditional on which the player can decide to contribute or not. In contrast, under a simultaneous-move game, players have to decide independently at the same time. Reduction of mis-coordination by means of the above discussed setting is important for our study as no communication is allowed in our experiments.[3] Dorsey (1992) documents a higher rate of successful provision of the threshold public good if real time adjustments of the voluntary contributions can be made. Unlike real time revision, our endogenous-move arrangement is a one-time decision and is irreversible. Also, we investigate both publicly and privately observed values, unlike Dorsey (1992). While we are unaware of studies that feature an endogenous-move setting, some studies have implemented sequential move structure in the laboratory instead of a simultaneous-move protocol. A sequential contributions mechanism has been found to increase efficiency compared to a simultaneous contributions mechanism in the case of a threshold public goods game (Erev and

[3]Our design eliminates coordination failure as a reason for players not engaging in turn-taking.

Rapoport (1990), Coats et al. (2009)).[4]

We find that the extent of efficient provision of public good in the sessions with heterogeneous endowments is the same as the sessions with homogeneous endowments, as long as the endowments are publicly observed. Under private information, several instances of inefficient provision occurs, especially in sessions with higher threshold where at least two out of three players are required to contribute in order to provide the public good. Coordination failures are limited, owing to the aspect that players contribute endogenously in our experiments. Individuals engage in turn-taking behaviour when the endowments are homogeneous. In this scenario, each member within a group is similar and turn-taking emerges naturally as a way of inter-temporal cooperation. Under heterogeneous endowment values people seldom go along the turn-taking path. They learn to take the most efficient path with contributors being the lowest $k$ values each round within a group. This is remarkable as it is achieved with no communication among players.

To the best of our knowledge, this paper is the first to study turn-taking behaviour with more than two players. We show that turn-taking emerges instinctively under a symmetric environment, even with three players and without any form of communication. However, people are less likely to engage in turn-taking if it is at odds with efficiency and if they are given a setting where they able to coordinate their actions each round. Our endogenous-move protocol used every round in the experiments provides the participants with such a setting. Even with privately observed values, we hardly find any evidence of individuals using rotation schemes.

When the endowments are homogeneous, the phenomenon of turn-taking can be linked to the absence of players in a group who could be classified as "free-riders" as per a preference elicitation mechanism in a related voluntary contribution game. The likelihood of taking turns is 84.6% with groups having no "free-riders" as their members. This number drops to 46.2% when there is at least one "free-rider" in the group. This helps us understand which groups are more likely to engage in turn-taking as the way of cooperation.

We also find that the behaviour of participants with respect to their timing of contribution within a round is starkly different if endowments are privately observed than if they can be publicly seen. People tend to delay their decision to contribute when they can observe the other group members' endowment values. However, the distribution of contribution times is bi-modal in private information

[4] Gächter et al. (2010) find that overall provision is lower under sequential than simultaneous contributions in a quasi-linear two-person setting where the returns from the public good vary across players. There are several related papers on simultaneous and sequential contributions. Nosenzo and Sefton (2011) study a two-player voluntary contribution game where participants can either choose to commit to an early contribution or they can choose to wait. They report that subjects usually avoid committing to an early contribution. Comparing simultaneous versus sequential contribution mechanism, Potters et al. (2007) show that leading-by-example improves group performance in the presence of asymmetric information in a two-player voluntary contribution game.

sessions. While some of the players do delay their decision, an overwhelming number of participants act quickly and contribute very early in the round.

Turn-taking has been formally modelled as the *Alternating Prisoner's Dilemma* (see Nowak and Sigmund (1994), Neill (2003)). The emergence of turn-taking has been theoretically studied in the context of finitely repeated symmetric coordination games (Bhaskar (2000)), infinitely repeated battle-of-the-sexes game (Lau and Mui (2008)) and certain classes of infinitely repeated dominant strategy games (Lau and Mui (2012)). There is a small but growing experimental literature on the incidence of turn-taking. In an entry game with incomplete information, Kaplan and Ruffle (2011) identify conditions under which participants take turns as opposed to using cutoff strategies.[5] Using a repeated common-pool resource assignment game, Cason et al. (2013) show that subjects engage in turn-taking frequently and participants experienced with the usage of such rotation schemes are more likely to teach inexperienced subjects how to undertake turn-taking.

Other researchers have also documented turn-taking behaviour in various two player games in the laboratory, in the context of a symmetric game with two asymmetric joint-payoff maximising outcomes (Prisbey (1992)); game of chicken (Bornstein et al. (1997)); route choice game in traffic management (Helbing et al. (2005)); volunteer's dilemma (Leo (2014)); allocation games (Kuzmics et al. (2014)); allocation game and dominant strategy equilibrium game with and without cheap talk (Sibly et al. (2015)).[6]

There are four novel elements of our paper relative to the existing studies on turn-taking. Firstly, we extend the analysis to a setting with more than two players such that action coordination becomes considerably more difficult. Second, our paper is the first to compare a setting where turn-taking and fairness are not in conflict with efficiency as well as where they are in conflict. We do this by considering separate settings with homogeneous and heterogeneous endowments. Third, we compare a setting where individuals have public information and where they have private information about endowments. Fourth, we adopt a real time decision environment where the order of move becomes endogenous. They can decide whether or not to contribute anytime as long as the time limit is not reached.

The paper is structured as follows. Section 2 describes the design and procedures of the experiment. In section 3, we discuss the research questions that we ask in our study. Section 4 presents the experimental results and section 5 concludes.

[5]Under cutoff strategy, a player chooses to enter when the private value exceeds some threshold; otherwise, she does not enter.

[6]Turn-taking is not only observed in human interactions but also in animal interactions. Neill (2001) find that mongooses take turns to perform the "guard" duty in order to safeguard themselves from predators. Harcourt et al. (2010) present experimental evidence that pairs of stickleback fish learn to use turn-taking to solve coordination and conflict problems.

# 2 Experimental Design and Methods

The experimental game is discussed in Subsection 2.1 while the procedures are reported in Subsection 2.2.

## 2.1 The Experimental Game

All the experiments are based on the *threshold public goods game.* There are $N$ players, each of whom has an endowment of a single indivisible unit of the private good. If at least $k$ players contribute, a public good is produced, each contributor receives a payoff of $b$, and each non-contributor receives a payoff of $b + c_i$, where $c_i$ is the value of player $i$'s endowment. If less than $k$ players contribute, each contributor receives a payoff of 0 and the non-contributors each receive a payoff of $c_i$.

In all of our experiments, we set $N = 3$ and $b = 100$. We employed a $2 \times 3$ between-subject design, in which we varied the value of the threshold ($k = 1$ or $k = 2$) as well as the distribution of endowments. For a given value of the threshold, the following three treatments were conducted:

- Homogeneous endowments: each player had an endowment of 50 each.
- Heterogeneous and publicly observable endowments: the value of the endowments were randomly drawn from one of the nine numbers $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ such that each group member had a value that was distinct from the values assigned to the other two members. Participants were informed of the endowment values of other group members.
- Heterogeneous and privately observable endowments: the value of the endowments were randomly drawn from one of the nine numbers $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ such that each group member had a value that was distinct from the values assigned to the other two members. Participants only observed their endowment value but had information about the distributional assumptions. Thus, if someone gets a value of 10 (90), she knows for sure that she has the lowest (highest) value and other group members have higher (lower) values than her.

We use the above distribution for two reasons. First, it ensures that the endowment values are *truly heterogeneous* as the values are far apart from each other: difference between values among two members is at least 10. Second, the *distinct* feature of the values, generated through draws without replacement, is expected to aid in coordination by completely eliminating the cases where two or more players might have the same value.[7] Table 1 summarises our design.

[7] There are other possible distributions that one could use to address the research questions that we ask. An alternative is to use $U \sim [0, 100]$ as the distribution of endowments.

Table 1: Overview of Treatments

| Treatment | Threshold | Information | Endowment |
|---|---|---|---|
| *k1-homo* | 1 | public | 50 |
| *k1-pub* | 1 | public | $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ |
| *k1-pvt* | 1 | private | $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ |
| *k2-homo* | 2 | public | 50 |
| *k2-pub* | 2 | public | $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ |
| *k2-pvt* | 2 | private | $\{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ |

## 2.2 Procedures

The data for this study were gathered from 12 experimental sessions conducted at the Nanyang Technological University (NTU), Singapore using 231 subjects. They were recruited from the population of undergraduate students at NTU from various majors. No subject participated in more than one session of this experiment. The sessions lasted approximately two hours and participants earned on average $S\$18.2$ in addition to a show-up fee of $S\$2$. The experiment was programmed and conducted with the software z-Tree (Fischbacher (2007)). Upon arrival, subjects were seated at visually isolated computer workstations. Instructions were read aloud and subjects also received a copy of the instructions.[8]

Prior to the conduct of the main experimental game, we asked the participants to go through stage 1 where a one-shot public goods game was implemented by using a variant of the strategy-method (Fischbacher et al. (2001)). Each group consisted of 3 randomly assigned subjects, and each subject received an endowment of 20 tokens. A participant could either keep these tokens for herself or invest them into a so-called 'project' and had the following linear payoff function:

$$\pi_i = 20 - g_i + 0.5 \sum_{j=1}^{3} g_j,$$

where $g_i$ denotes the contribution of subject $i$ to the public good. The marginal payoff of a contribution to the public good is 0.5 tokens. Hence, under standard assumptions the prediction is complete free riding by all subjects.

The details of the preference elicitation and the incentive mechanism followed Fischbacher et al. (2001). Subjects were asked to make two types of contribution decisions. The first type of contribution decision was called '*unconditional contribution*' and the second type of decision was called '*contribution*

[8] A sample copy of the instructions for one of the treatments (*k2-pvt*) is provided in the Appendix.

*table*' (or '*conditional contribution*').[9]

The 'unconditional contribution' was just a single decision about how many of the 20 tokens to invest into the 'project'. For the contribution table, subjects were told that they have to indicate for each of the 21 possible average contribution levels of the other group members (rounded to integers) how much they are willing to contribute towards public good provision.

In order to ensure incentive compatibility, both the unconditional as well as the conditional contribution were potentially payoff relevant. For one randomly selected group member the conditional contribution was relevant, whereas the unconditional contributions were relevant for the other two group members. The outcome of stage 1 decisions was announced only at the end of the experiment (after stage 2).[10]

Once everyone in the room made their stage 1 decisions, the session then went to stage 2 which consisted of 30 rounds of the game described in the previous subsection. Participants were matched in groups of three and their group assignment remain fixed throughout.[11] Each group member was identified by a member ID within her group that stayed the same throughout. Endowments were implemented as opportunity costs. In each round, each subject was allocated a single indivisible "token", which had a value that was referred to as a "token value". The value of the token as well as the ability to observe other group members' token values depended on the treatment. Subjects were told that they can either spend their token on a group project or keep it privately.

Each round, for $k = 1$ sessions, if at least one of the three subjects spent their token, then the public good was provided and each subject received 100 points if she had chosen to spend her token and 100 points plus her token value if she kept her token. A subject obtained 100 points if she chose to spend her token regardless of others' decisions. If a subject kept her token and everyone in her group also kept their tokens, then the public good was not provided and the subject received her token value as payoff. For $k = 2$ sessions, if at least two of the three subjects spent their token, then each subject received 100 points if she had chosen to spend her token, while the payoff was 100 points plus her token value if she had chosen to keep her token. If a subject chose to spend but none of her other group members spent their tokens then that subject earned 0 points in the round. If a subject chose not to spend and fewer than two other group members spent their tokens then that subject earned her token value in the round.

For the decisions every round, an endogenous-move setting was employed: participants were given

[9] Subjects had to make both types of decisions without knowing the others' decisions. To ensure thoughtful decisions, we did not impose a time limit.

[10] This was done to ensure that there is no effect of stage 1 play on the conduct of stage 2 (our main experimental game).

[11] The group members were different from the ones in stage 1.

sixty seconds to make their decision. Subjects had to click on a "Spend Token" button at any time within the time limit. Participants were told that this decision was irreversible and she would not be able to change her action for that round once she clicks the button. If a subject didn't click the button within the sixty seconds, then she kept her token automatically (default choice). Participants also received an instant update of the decision made by her group members at any time within the time limit. Thus, a "real time" protocol was implemented. In addition, subjects were also given information about the cumulative count of the number of times each group member had decided to spend her token in all of the previous rounds.

At the end of the time limit, the outcome and the choices of other group members were revealed and the earnings were calculated. Play then proceeded to the next round. At the end of the repeated game, the payoff from all 30 rounds were added together.[12]

## 3 Research Questions

The experiment is designed specifically to answer five research questions related to efficiency of public good provision under differing endowments structure (homogeneous and heterogeneous) as well as under differing information structure (public and private information setting), use of history-dependent strategies, incidence of turn-taking, and timing of contribution decisions. The provision of threshold public goods combines free riding incentives with a coordination problem. There are four sources of inefficiency each round: *wasteful under-contribution*, where exactly one individual contributes in the $k{=}2$ sessions[13]; *excess contributions*, where more than one people contribute when $k{=}1$ and everyone contributes when $k{=}2$; *under-provision*, where the public good is not provided even though the total social benefit of providing the public good is higher than the total cost; and *cost inefficiency*, where the public good is provided with exactly $k$ contributors, but their endowments are not the $k$ lowest values.[14] Players' endogenous decisions to contribute should in principle be able to limit mis-coordination, thereby mitigating the first two sources of inefficiency. The first question compares the performance of homogeneous sessions with that of the heterogeneous sessions with publicly observed endowments with respect to different indicators of efficiency.

**Research Question 1**: *Are there differences in the rate of public good provision, group earnings as a fraction of the first-best earnings, and frequency of coordinated outcomes when we compare homogeneous and heterogeneous endowments?*

[12]Following completion of the repeated game, subjects also participated in the standard risk-elicitation task (Holt and Laury (2002)) and answered a questionnaire that included information on degree of Major, gender, etc.

[13]This form of inefficiency does not arise in $k{=}1$ sessions.

[14]*Wasteful under-contribution* and *under-provision* are, however, related. All *wasteful under-contributions* lead to *under-provision*, but not all *under-provisions* are in the form of *wasteful under-contribution*.

Observing endowment values privately further exacerbates the problem. Compared to the publicly observed scenario, the coordination incentives are still the same but there is no way to perfectly resolve the inefficiency arising because of the fact that the contributors are not always the ones having lowest $k$ values. Without explicit communication, *cost inefficiency* is impossible to mitigate. This gives rise to our second research question where we compare how private information affects the various indicators of efficiency.

**Research Question 2**: *What is the impact of having privately informed endowment values as opposed to having observable endowments on provision rate, group earnings as a fraction of the first-best earnings, and frequency of coordinated outcomes?*

The next question that we are interested in is concerned with the pattern of contributions across rounds. When the endowment values are homogeneous across players, the Nash equilibrium of the simultaneous-move version of the corresponding stage game involves exactly $k$ players contributing and $3 - k$ players free riding. While the theory would support any path as the equilibrium path of play as long as there are exactly $k$ contributors each round, turn-taking could emerge as a natural way to resolve the issue of inter-temporal cooperation. Players could simply rotate in contributing their endowments and providing the public good each round. Although explicit communication is prohibited, the endogenous-move environment is expected to facilitate players to engage in turn-taking if they wish to do so, as opposed to a simultaneous-move setting.

Similarly, when the endowments are privately observed, turn-taking seems to be an attractive choice as a simple heuristic play of the finitely repeated game. In the scenario when the endowments are heterogeneous and publicly observed, while rotation scheme remains one of the choices for the path of play, it is clearly at odds with efficiency. The most efficient path occurs when (a) there are exactly $k$ contributors each round and (b) the players having the lowest $k$ endowment values contribute. While turn-taking is a history-dependent strategy, going the socially efficient path is independent of history and is conditional only on the current endowment values of the player and her group members. We seek to identify the scheme(s) employed by the subjects in the different treatments as part of the third research question.

**Research Question 3**: *Are the strategies employed by participants history-dependent? Specifically, do people take turns to provide the public good? When endowment values are heterogeneous and publicly observed, do individuals take the efficient path with contributors being the ones with the lowest $k$ endowments each round?*

Along with the decision to contribute or not, the endogenous move protocol for the decision every round provides the players with an additional dimension to think about: the timing of contribution.

The decision time is a way of signaling the intention of a player in these games without any explicit form of communication. Given that contributions are irreversible, these signals are credible and costly as opposed to real time revision of actions or cheap talk. Controlling for the value of the threshold, it would be interesting to see the effect of heterogeneous versus homogeneous endowments and publicly observed versus privately observed endowments on the overall distribution of decision times.

**Research Question 4**: *Within a round, do people decide early or do they delay their contributions? Does the distribution of the timing of contributions differ across treatments?*

Our experimental design enables us to link the behaviour exhibited by the participants in the threshold public good game to the decisions made in stage 1 of the one-shot voluntary contribution game. One could investigate the composition of the groups that are involved in turn-taking and understand what distinguishes them from the ones who do not use rotation schemes as the way of inter-temporal cooperation. A significant correlation of decisions between the two closely related games is likely to give us more insights about which groups are more likely to engage in turn-taking in naturally occurring settings. Can we can relate this to the presence/absence of players who are tagged as "free-riders" according to the classification in stage 1? This constitutes our final research query.

**Research Question 5**: *Can we find a significant correlation between the behaviour in the repeated threshold public goods game and the 'stage 1 voluntary contribution' preference elicitation task? Can group composition in terms of the classification of it's members explain the incidence of turn-taking?*

# 4 Experimental Results

We begin this section by comparing cooperation and other aggregate performance measures across treatments. In Subsection 4.2, we discuss the path of cooperation followed by subjects and analyse the incidence of turn-taking and history-dependent strategies over sessions. We then consider timing of contribution decisions within a round across treatments in Subsection 4.3, and report findings regarding relation between behaviour in the repeated threshold public goods game and the classification made according to stage 1 decisions in Subsection 4.4.

## 4.1 Aggregate Performance Measures

Tables 2-3 report on aggregate results (aggregated over all rounds and all sessions). These are for illustrative purposes only and any statistical tests are done on group level data.[15]

[15]This is done to ensure that all observations are independent of each other. There are 13 independent groups in treatments with $k = 1$ and in *k2-homo*, 14 in *k2-pub* and 11 in *k2-pvt*.

Table 2: Frequency of public good provision and normalised efficiency measure.

| | *k1-homo* | *k1-pub* | *k1-pvt* | *k2-homo* | *k2-pub* | *k2-pvt* |
|---|---|---|---|---|---|---|
| Provision rate | 0.93 | 0.95 | 0.92 | 0.91 | 0.91 | 0.78 |
| Normalised efficiency | 0.91 | 0.93 | 0.87 | 0.89 | 0.90 | 0.70 |
| No. of observations | 390 | 390 | 390 | 390 | 420 | 330 |

Table 3: Frequency distribution of number of contributors in percentages.

| No. of contributors | *k1-homo* | *k1-pub* | *k1-pvt* | *k2-homo* | *k2-pub* | *k2-pvt* |
|---|---|---|---|---|---|---|
| 0 | 7.4 | 5.4 | 8.5 | 4.1 | 5.0 | 8.8 |
| 1 | 86.9 | 90.5 | 78.5 | 5.1 | 3.8 | 13.0 |
| 2 | 4.6 | 3.8 | 12.3 | 88.5 | 89.1 | 68.2 |
| 3 | 1.1 | 0.3 | 0.7 | 2.3 | 2.1 | 10.0 |
| 0 or $k$* | 94.3 | 95.9 | 87 | 92.6 | 94.1 | 77 |
| Observations | 390 | 390 | 390 | 390 | 420 | 330 |

*This row provides the frequency of coordinated outcomes.

Table 2 documents the frequencies of public good provision and normalised efficiency for each of the six treatments. Normalised efficiency is defined as group earnings net of endowments as a percentage of first-best group earnings net of endowments.[16] Keeping the value of threshold constant, there are no differences in the provision rate and normalised efficiency across sessions with homogeneous and publicly observable heterogeneous endowments. This is also confirmed statistically by conducting Mann-Whitney U tests on group level data for provision rate and efficiency, separately for $k = 1$ and for $k = 2$ sessions ($p$-values $> 0.4$).

The distribution of the number of contributors is reported in Table 3. The frequency of coordinated outcomes (0 or $k$ contributors) is very high (above 90%) and similar in the sessions with homogeneous and publicly observable heterogeneous endowments. Having a high efficiency level is partly driven by the fact that participants are able to coordinate successfully and avoid wasteful under-contributions or excess contributions. The arrangement of endogenous move for decisions is crucial for successful coordination. If decisions are made simultaneously, higher incidence of coordination failures is likely, without any communication.[17] Conducting Mann-Whitney U tests on group level data for the frequency of coordinated outcomes, we find that coordination is not significantly affected by the distribution (homogeneous versus heterogeneous) as long as endowments are publicly

[16]For calculating normalised efficiency, we use net earnings as opposed to gross earnings to reduce the randomness present due to the realisation of the drawn endowment values. Thus our measure of group earnings is relative to a benchmark of zero contributions. First-best group earnings correspond to the situation when (a) there are exactly $k$ contributors each round and (b) the players having the lowest $k$ endowment values contribute.

[17]Coats et al. (2009) report high levels of under- and over-contribution under simultaneous play.

observed ($p$-values $> 0.8$). The above discussion leads us to conclude the following.

**Result 1.** *For a given value of the threshold, the extent of efficient provision of public good and successful coordination are the same with homogeneous endowment and with observable heterogeneous endowments.*

Tables 2 and 3 also show that provision rate, normalised efficiency and instances of successful coordination are lower with private information in contrast to observable heterogeneous endowments, especially for $k = 2$. For the low threshold case, both the efficiency and provision rate are significantly higher under publicly observed endowments (with $p$-values from Mann-Whitney U tests $< 0.01$). For high threshold scenario, only the efficiency is significantly higher with observable endowments (with $p$-value $< 0.05$) but provision rate is similar ($p$-value$= 0.168$). The $p$-values from Mann-Whitney U tests for successful coordination are $< 0.01$ for both $k = 1$ and $k = 2$ sessions. Taken together, our next result emphasises the negative impact of private information on the aggregate performance measures.

**Result 2.** *For a given value of the threshold, the extent of efficient provision of public good as well as the frequency of coordinated outcomes are significantly higher with observable heterogeneous endowments than under private information. The difference is greater when the threshold is high.*

The detrimental effect of observing endowments privately is not surprising. One of the reasons this happens is because there is no way to implement the first-best situation where the contributions come from the players with lowest $k$ endowments. This impossibility certainly pulls down the normalised efficiency. However, what is worth noting is that the provision rate is lower and there are higher instances of under- and over-contributions in the sessions with private information than without (see Table 3). A plausible explanation for the higher instances of mis-coordination under private information could be that a lower variation in endowment values across players in a round is likely to prevent a successful coordination. However, we do not find any evidence towards this hypothesis. For $k = 1$ sessions, the frequency of coordinated outcomes is 85.5 when the difference between the maximum and minimum endowment within a group in a round is low ($\leq 30$) compared to 89.8 when the difference is high ($\geq 50$). The corresponding frequencies for $k = 2$ sessions are 72.0 and 80.0, respectively.

To summarise, in terms of the four sources of inefficiency introduced in Section 3, the level of *wasteful under-contribution*, *excess contribution* and *under-provision* are the same between homogeneous and observable heterogeneous endowments while those measures are higher under privately observed endowments than without. For a given value of the threshold, *cost inefficiency* is higher with private information than under publicly observable endowments.

Table 4: Percentage of times the contributors are the members with the lower $k$ endowments, conditional on exactly $k$ contributing. Number of observations where exactly $k$ people contribute in parentheses.

| *k1-pub* | *k1-pvt* | *k2-pub* | *k2-pvt* |
|---|---|---|---|
| 91.5 | 76.1 | 94.9 | 69.3 |
| (353) | (306) | (374) | (225) |

### 4.2 Path of Cooperation: Taking Turns or Not?

Table 4 reports the percentage of times the contributors are the players with the lower $k$ endowment values in the treatments with heterogeneous endowments. The percentages are very high in all four treatments; above 90% when endowments are publicly observable. The ability to implement the most efficient Nash equilibrium each round in most of the cases with observable endowments results in the high efficiency as reported in Table 2. While the corresponding percentage numbers are lower in the private information counterparts, it is still significantly higher than random play. When compared with the benchmark case of 33% (that would have happened just by chance), the numbers are two times higher, both with low and high threshold. On the one hand, this is remarkable: without any explicit communication, players are still able to follow the socially efficient path in most of the cases. On the other hand, this provides evidence of players not engaging in rotation schemes when the endowments are heterogeneous; the numbers would have been around 33% if people used perfect turn-taking.

In order to understand and evaluate the statistical significance of the use of history-dependent strategies and the effect of current endowment values on current contribution decision, we estimate a random-effects Probit model. Tables 5 and 6 display the regression coefficients and marginal effects separately for each treatment with contribution decision in round $t$ ($c_{i,t}$) as the binary dependent variable. The independent variables include the number of times the subject contributed in last two rounds ($c_{i,t-1} + c_{i,t-2}$) and the endowment value at round $t$.[18]

Strategies employed are significantly history-dependent when endowments are homogeneous. There is a sizable negative effect of $c_{i,t-1} + c_{i,t-2}$: the higher the number of times a subject contributed in last two rounds, the lower is the likelihood of contributing in the current round. A visual inspection of the data shows that 9 out of the 13 groups in *k1-homo* and 8 out of the 13 groups in *k2-homo* sessions engage in perfect turn-taking as the way of cooperation over time. A higher threshold does not hinder in the incidence of turn-taking and the use of history dependent strategies.

When endowments are heterogeneous and publicly observable, players condition their current

[18] $c_{i,t-1} + c_{i,t-2}$ takes a value of 0 or 1 or 2.

Table 5: Random effects probit regressions for contribution decisions: $k = 1$ sessions.

| Variable | *k1-homo* | | *k1-pub* | | *k1-pvt* | |
|---|---|---|---|---|---|---|
| | Coefficient (SE) | Marginal (SE) | Coefficient (SE) | Marginal (SE) | Coefficient (SE) | Marginal (SE) |
| $c_{i,t-1} + c_{i,t-2}$ | -1.836*** | -0.607*** | -0.021 | -0.006 | -0.274*** | -0.094*** |
| | (0.469) | (0.127) | (0.074) | (0.021) | (0.105) | (0.036) |
| *Endowment* | | | -0.046*** | -0.013*** | -0.032*** | -0.011*** |
| | | | (0.003) | (0.001) | (0.003) | (0.001) |
| Constant | 0.595** | | 1.447*** | | 1.258*** | |
| | (0.256) | | (0.151) | | (0.172) | |
| Observations | 1092 | | 1092 | | 1092 | |
| Log $L$ | -476.83 | | -415.28 | | -530.29 | |
| pseudo $R^2$ | 0.305 | | 0.392 | | 0.249 | |

Note: *** (**) denotes 1% (5%) significance, bootstrapped standard errors are given in parentheses.

Table 6: Random effects probit regressions for contribution decisions: $k = 2$ sessions.

| Variable | *k2-homo* | | *k2-pub* | | *k2-pvt* | |
|---|---|---|---|---|---|---|
| | Coefficient (SE) | Marginal (SE) | Coefficient (SE) | Marginal (SE) | Coefficient (SE) | Marginal (SE) |
| $c_{i,t-1} + c_{i,t-2}$ | -1.497*** | -0.558*** | 0.096 | 0.033 | -0.044 | -0.016 |
| | (0.381) | (0.158) | (0.074) | (0.026) | (0.105) | (0.040) |
| *Endowment* | | | -0.050*** | -0.017*** | -0.030*** | -0.011*** |
| | | | (0.003) | (0.001) | (0.004) | (0.001) |
| Constant | 2.249*** | | 2.834*** | | 2.007*** | |
| | (0.488) | | (0.197) | | (0.276) | |
| Observations | 1092 | | 1176 | | 924 | |
| Log $L$ | -534.19 | | -442.45 | | -494.56 | |
| pseudo $R^2$ | 0.223 | | 0.428 | | 0.202 | |

Note: *** denotes 1% significance, bootstrapped standard errors are given in parentheses.

contribution decision on the current endowment value. Table 4 already documented this feature; highly significant coefficients on "endowment value" in Tables 5-6 confirm this fact. Also, while there is a significant negative effect of higher endowment values on contribution decisions, the impact of history is now insignificant. Results are consistent for both $k = 1$ and $k = 2$. None of the 13 groups engage in turn-taking when threshold is low and only one of the 14 groups implement rotation scheme as the path of play when $k = 2$.

With privately observed endowments, the effect of current endowment value is significant in all sessions. For $k = 1$ sessions, there is a significant effect of history while no such effect is present when $k = 2$. A closer look at the data shows that only one of the 25 groups engage in perfect turn-taking. We also find that subjects do not employ cutoff strategies of the following form: contribute if and only if the privately observed endowment is lower than a critical value and not contribute otherwise. Palfrey and Rosenthal (1994) and Kaplan and Ruffle (2011) show evidence of play of cutoff strategies in related simultaneous-move games with private information. The endogenous move protocol that we have adopted results in the complete absence of the use of such strategies.

Summarising the above discussion, we have the following result.

**Result 3.** *Turn-taking is likely to be observed only when the endowments are homogeneous. Players do not engage in turn-taking when it is at odds with efficiency as well as when endowments are privately observed. Use of history-dependent strategies is extremely limited in sessions with heterogeneous endowments: players condition their contribution decisions on current endowment values. With observable endowments, individuals are able to follow the socially efficient path of play.*

### 4.3 Timing of Contribution Decisions

In order to address our fourth research question, we now look at the times at which players make their contributions. Figure 1 shows the distribution of within-round timing of contribution decisions for all rounds in each of the six treatments. The distribution is similar for homogeneous as well as heterogeneous and publicly observable endowments. Much of the activity happens towards the end of the endogenous-move stage: people tend to delay their decisions as much as possible. The private information sessions however reveal a different pattern: there are several individuals who contribute early in the stage. This implies a tendency of early decisions when information is incomplete/limited and a "wait and watch with deliberate delay" approach when more information is available.

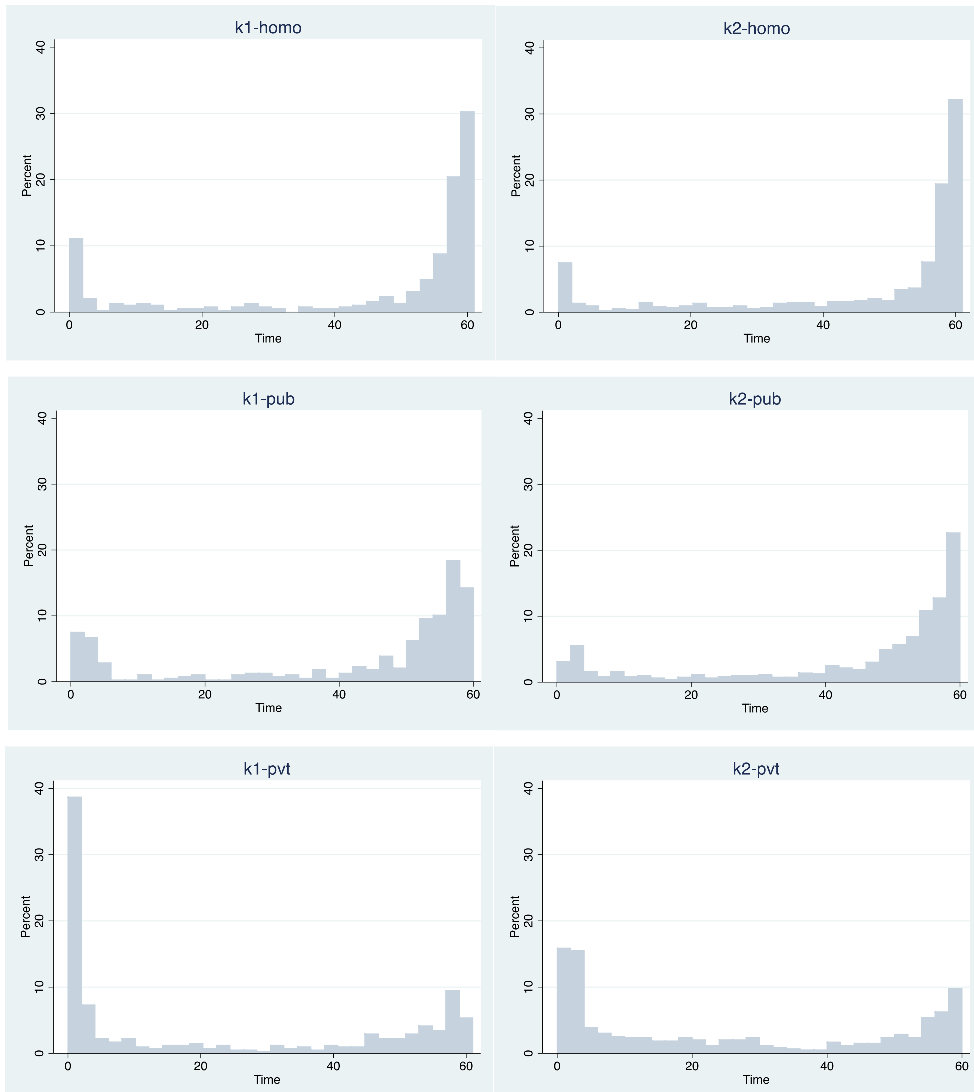



Figure 1: Distribution of Timing of Contribution Decisions

In order to understand more about the variables affecting the timing of contribution decision, we perform an OLS regression estimated using individual decision time each round as the dependent variable.[19] Table 7 reports on the results. We include a dummy variable *Public Information* that equals 1 if the endowment is publicly observable, a dummy variable *High Threshold* that equals 1 if the threshold is two ($k = 2$), and the *endowment value*. We also include interaction terms of the above variables. Several other regressors are also used: a dummy variable *Previous First Mover* that equals

[19] We only consider the heterogeneous sessions (*k1-pub*, *k1-pvt*, *k2-pub*, *k2-pvt*) for the regression. The standard errors are clustered at the group level.

Table 7: OLS regression of Decision Time. Robust standard errors in parentheses.

| Explanatory Variables | (1) Decision Time | (2) Decision Time |
|---|---|---|
| Public Information | 6.053** (1.79) | 15.21*** (2.26) |
| High Threshold | 9.959*** (1.94) | 14.52*** (2.79) |
| Endowment | -0.465*** (0.02) | -0.281*** (0.04) |
| Public Information × High Threshold | | 4.158 (2.59) |
| Public Information × Endowment | | -0.224*** (0.03) |
| High Threshold × Endowment | | -0.139*** (0.04) |
| Previous First Mover | -5.286*** (0.56) | -5.420*** (0.63) |
| Previous Decision Time | 0.131*** (0.02) | 0.134*** (0.03) |
| Female | -0.118 (1.22) | -0.177 (1.22) |
| Round | -0.087* (0.04) | -0.095** (0.04) |
| Constant | 32.62*** (1.51) | 24.49*** (2.34) |
| Number of Observations | 4437 | 4437 |
| $R^2$ | 0.379 | 0.404 |

*significant at 10%, **significant at 5%, ***significant at 1%

1 if the individual was the first mover in her group in the previous round; *Previous Decision Time* that gives the decision time of the individual in the previous round; a dummy variable *Female* that equals 1 if the individual is a female; and *Round*.

Consistent with the implication from Figure 1, Table 7 shows that the participants in the sessions with publicly observable endowments tend to take longer time to make a contribution decision, compared to the private information sessions. In the treatments with publicly observable endowments, there is no uncertainty with regards to others' endowments. Subjects with high endowment values would expect the subjects with low values to contribute first. This reasoning might be a contributing factor in the delay in deciding to contribute. In contrast, when endowments are privately observed, participants would prefer to signal their willingness to contribute early and make decisions within initial few seconds rather than risking to have no provision at all.

Endowment values also have a significant effect on decision times: on an average, the higher the value, the earlier the subject decides. Also, a higher threshold results in delay in decision time only when the endowments are privately observed. In fact, in *k2-pvt* treatment, the distribution of timing of contribution decisions is bi-modal. If subjects were previously first movers, they would in general tend to make early decisions. While gender has no effect, round has a mild but significant effect on decision time.

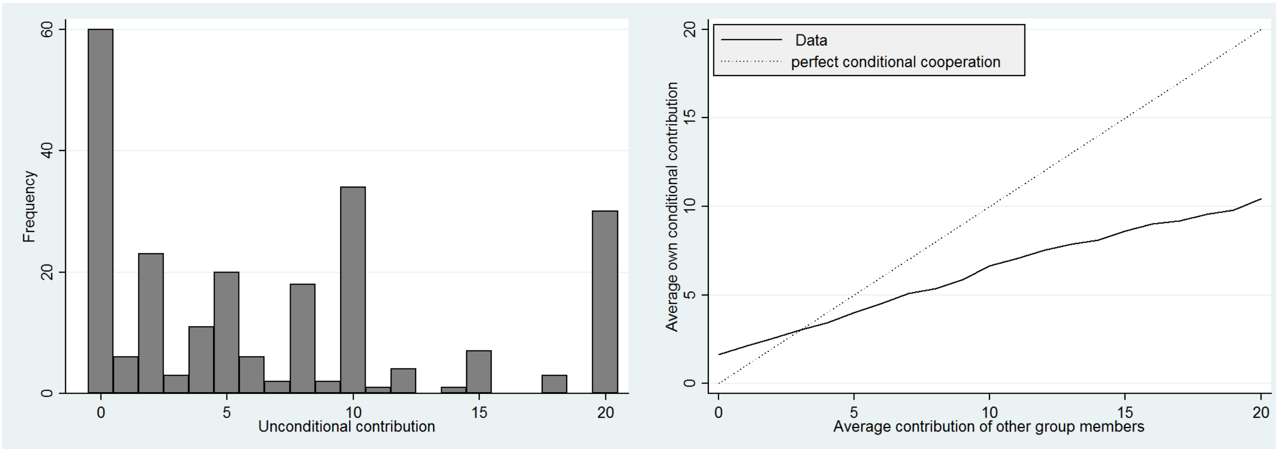
The above discussion leads to the following result.

**Result 4.** *Within a round, people tend to decide early in the presence of incomplete information compared to sessions with publicly observable endowment values; in the latter sessions, there is a significantly higher tendency to delay contribution decisions.*

### 4.4 Relation to Stage 1 Classification

One of our contributions is to conduct the stage 1- preference elicitation in voluntary contributions game using a large sample size than considered before. Fischbacher et al. (2001) conducted the experiments in Switzerland and utilised 44 subjects while Kocher et al. (2008) used 36 participants each in the United States, Austria, and Japan. In contrast, we have data for 231 participants.

The average unconditional contribution in stage 1 is 6.88 points with 26% of the subjects deciding to invest zero points into the group project. There are several instances of positive unconditional contribution, with around 15% investing 10 points (half of the endowment) and 13% contributing everything. The left panel of Figure 2 shows the distribution of the unconditional contributions in stage 1. The elicited willingness to contribute given the average contribution level of others is captured in the "contribution table" entries for each subject. The mean contribution is clearly increasing in the average contribution of other group members, as depicted in the right panel of Figure 2. Thus, on average, subjects display conditional cooperation. The 45-degree line in the figure indicates the scenario of perfect conditional cooperation.




(a) Unconditional contribution

(b) Average conditional contributions

Figure 2: Summary of decisions made in Stage 1.

The inspection of the data at the individual level shows that majority of the players (139 out of 231) are *conditional cooperators*: they either submit a contribution schedule that is monotonically increasing with the average contribution of others or the schedule is not monotonically increasing but shows a highly significant (at the 1% level) positive Spearman rank correlation coefficient between own and others' contributions. Around 18% of the subjects can be classified as *free riders* who contribute nothing for any average group contribution. *Hump-shaped contributors* submit a contribution schedule that is first increasing and then decreasing in the average contribution of others; 7% of the players can be classified as such.

Nine subjects (constituting about 4% of total) contribute everything for any average group contribution. Previous studies have never documented such type of players. The absence of these types who contribute all points into the group project regardless of the average group contribution of others might be due to smaller sample sizes in earlier studies or could be attributed to the culture of Singapore in contrast to the other places considered.

We have already established in Subsection 4.2 that turn-taking does not take place when players' endowments are heterogeneous. For each group in the sessions with homogeneous endowments, Table 8 shows whether the group engages in perfect turn-taking or not. It also summarises the composition of each group in terms of the member types, according to the classification in stage 1. An interesting pattern emerges from the table: the groups having no free-riders have a higher likelihood to take turns. Out of 13 such groups, 11 (i.e., 84.6%) are involved in turn-taking. In contrast, only 6 out of 13 groups (46.2%) engage in turn-taking when we restrict our attention to only those groups which have at least one free-rider among it's members. Summarising the above discussion, we have our final result.

Table 8: Turn-Taking in *k1-homo* and *k2-homo*: Group Composition by Types.

| *k1-homo* | | *k2-homo* | |
|---|---|---|---|
| Composition | Turn-Taking | Composition | Turn-Taking |
| FR, OT, OT | No | CC, FR, FR | No |
| CC, FR, OT | Yes | CC, CC, CC | No |
| CC, CC, FR | No | CC, CC, OT | Yes |
| CC, CC, FR | Yes | CC, CC, CC | Yes |
| CC, CC, FR | No | CC, CC, CC | Yes |
| CC, CC, OT | Yes | CC, FR, FR | Yes |
| FR, OT, UC | Yes | CC, CC, CC | Yes |
| CC, CC, CC | Yes | CC, CC, OT | Yes |
| CC, CC, CC | No | CC, CC, FR | No |
| CC, CC, CC | Yes | CC, CC, FR | No |
| CC, CC, OT | Yes | CC, CC, FR | No |
| FR, CC, CC | Yes | CC, CC, CC | Yes |
| CC, CC, CC | Yes | CC, FR, OT | Yes |

Note: CC: conditional cooperator, FR: free-rider, OT: other, UC: unconditional contribution of 20 points in stage 1.

**Result 5.** *Using the classification from the strategy method in a related voluntary contributions game, we find that a group is more likely to take turns if none of it's members are "free-riders" compared to the situation where the group consists of at least one "free-rider".*

## 5 Conclusion

This paper contributes to the emerging literature on the incidence of turn-taking as a form of intertemporal cooperation among individuals. It addresses questions that have not been studied in this literature: in the absence of communication, will turn-taking emerge in a repeated game with more than two players? How the assumptions on the distribution and observability of players' endowments affect the way people cooperate? Using a threshold public goods game as the stage game, we find that people engage in turn-taking or rotation scheme as a way of cooperation only when the endowment values are homogeneous. Thus, if the environment is symmetric, taking turns emerges as a natural path of play. We also find evidence that turn-taking is more likely to be adopted by the groups that have no members who are classified as *free riders* as per the preference elicitation task in the related voluntary contribution game.

Under heterogeneous endowments (and hence, asymmetric environments), we do not find any evidence of usage of rotation schemes. In fact, with publicly observable endowments, individuals come close to following the socially efficient path of play that requires the contribution of exactly threshold number of contributors and the ones having lower endowments contribute. A heterogeneous environment discourages players to use history-dependent strategies: people condition their decisions on current endowment values. However, the availability of an endogenous-move mechanism completely eliminates the play of cutoff strategies when information is private.

Behavioural differences are abound across sessions with publicly observed and privately observed endowments. Individuals tend to delay their decision to contribute when they can observe other group members' endowments. The inability to observe others' values changes the distribution of timing of contributions: significant number of people contribute in the initial few moments thereby signaling their intent as early as possible. Private information divides the individuals into two groups: those who like to decide early and those who act late.

While our focus was on settings without any form of communication, future research could inform us on the effects of introducing communication on the form of cooperation.[20] In the situation with homogeneous endowments, exchange of information is likely to reinforce the play of turn-taking while in settings with publicly observable heterogeneous values, communication is likely to reinforce the play of the socially efficient outcome each round. With private information on endowment values, we conjecture that communication would help players follow the most efficient path of play with the contributors being the ones with the lowest $k$ endowments.[21]

More work remains to be done, especially in the private information scenario. When there is imperfect or no knowledge of the distribution of endowment values or if the environment becomes more ambiguous, does turn-taking emerge as a simple heuristic? Understanding the role of ambiguity on the incidence of turn-taking would be an important study to undertake. Finally, additional studies are necessary to provide a better understanding of conditions under which turn-taking is more likely to be undertaken as a mechanism of inter-temporal cooperation in other games that involve more than two players.

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[20] The effects of communication will depend on the type of message space used to exchange messages. Natural language communication in the form of unrestricted text chat is expected to have a higher impact.

[21] In the context of privately observed endowments and in one-shot games with simultaneous move, Palfrey et al. (2015) report that natural language communication overcomes the difficulties associated with the various forms of inefficiency. Significant efficiency gains are reported (compared to no communication scenario) even though the communication is non-binding and unverifiable.

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# A Experimental Instructions

**GENERAL INFORMATION**

Welcome to all of you! You are now taking part in an interactive study on decision making. **Please pay attention to the information provided here and make your decisions carefully. If at any time you have questions to ask, please raise your hand and we will attend to you in private**.

Please note that **unauthorized communication is prohibited**. Failure to adhere to this rule would force us to stop this study and you will be asked to leave the experiment without pay. You have the right to withdraw from the experiment at any point in time, and if you decide to do so your payments earned during this study will be forfeited.

By participating in this study, you will be able to earn a considerable amount of money in addition to your show-up fee of $2. The amount of your earnings depends on the decisions you and others make.

At the end of this session, your earnings will be paid to you privately and in cash. It would be contained in an envelope (indicated with your unique user ID). You will need to sign the "participant payment sheet" given to you and submit it to us at the end of the experiment.

**GENERAL INSTRUCTIONS**

Each of you will be given **a unique user ID** and it **will be clearly stated on your computer screen (once the experiment starts)**. You **dont have to write this unique user ID anywhere** but remember that **you will be called by this unique ID at the end of the experiment for payment purpose**. At the end of the study, you will be asked to fill in your NTU student ID and other information pertaining to your earnings from this study in the "participant payment sheet". **Please fill in the correct NTU student ID and NRIC/FIN to make sure that you will get the correct amount of payment**.

Rest assured that your **anonymity will be preserved** throughout the study. You will **never be aware of** the personal identities of other participants **during or after** the study. Similarly, other participants will **not be aware** of your personal identities **during or after** the study. You will only be identified by your user ID in our data collection. All information collected will **strictly be kept confidential** for the sole purpose of this study.

**SPECIFIC INSTRUCTIONS**

There are three stages in this experiment and your total payment will be as follows:

Your total payment =

earnings from decisions you make in stage 1

+ earnings from decisions you make in stage 2

+ earnings from choices you make in stage 3

+ show-up fee ($2)

## STAGE 1

In this stage, you will be a member of a **group of 3 people**. Each member has to decide on the **division of 20 points**. You can put these 20 points on a **private account** or you can invest them fully or partially into a **group project**. Each point you do not invest into the group project will automatically be transferred to your private account.

For each point you put on your **private account** you will **get exactly one point**. For example, if you put 20 points on your private account you will get exactly 20 points from the private account. If you put 6 points into the private account, you will receive a payoff of 6 points from the private account. **Nobody except you earns anything from your private account**.

From the points you invest into the **group project, each group member regardless of who invests into the group project, will get the same payoff**. Thus, for each group member the payoff from the group project will be determined as follows:

**Payoff from the group project = (0.5)*(sum of contributions to the project)**.

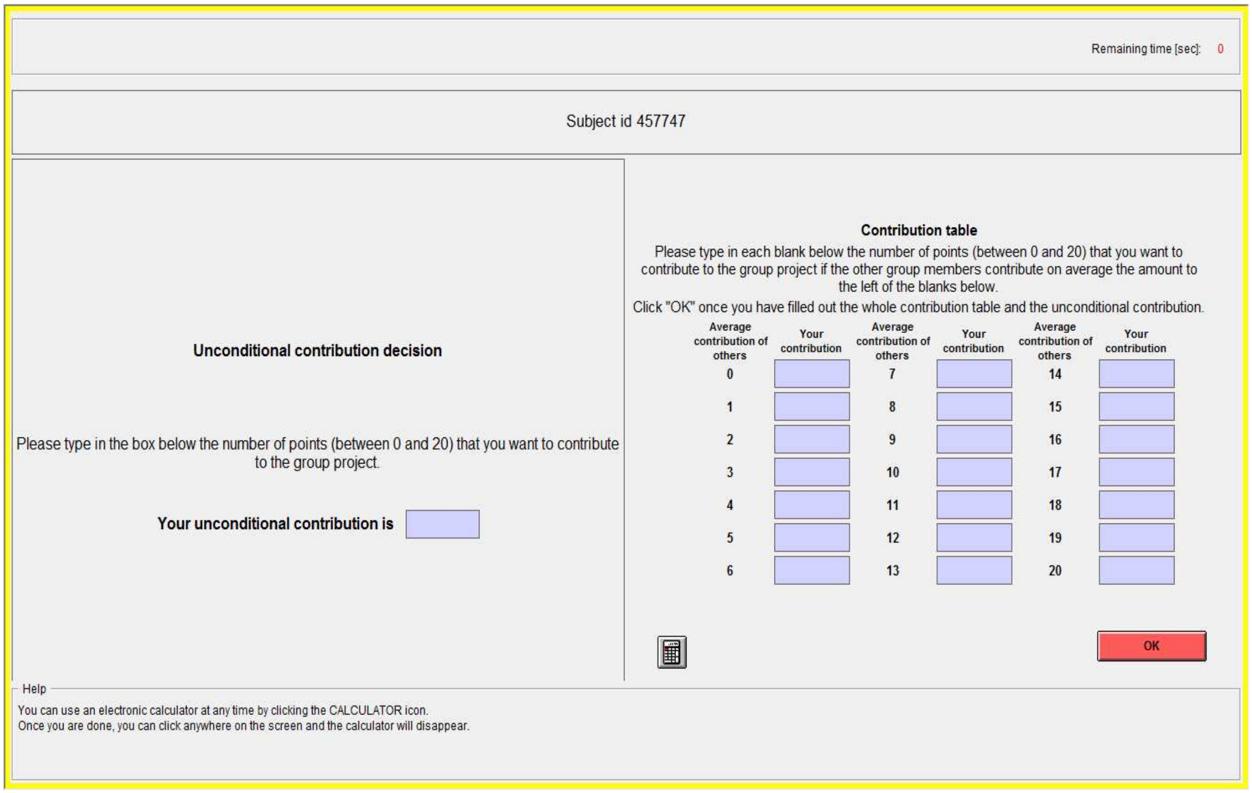
For example, if the sum of all contributions to the group project is 40 points, then you and all other group members will get a payoff of (0.5)*(40)=20 points from the group project. If the three group members contribute 10 points in total to the group project, you and all others in your group will get a payoff of (0.5)*(10) =5 points from the group project.

Your total payoff results from the summation of your payoff from the private account and your payoff from the group project:

**TOTAL PAYOFF = Payoff from the private account (=20 - contribution to the project) + Payoff from the group project (=0.5*sum of contributions to the project)**

In this stage, each of you has to make **TWO types of decisions**. We will call them as, respectively, "**unconditional contribution**" and "**contribution table**".

- With the **unconditional contribution** to the group project you have to decide **how many of the 20 points you want to invest into the group project**. You will enter this amount on the left hand side of the following screen:




- Your second task is to fill out a "**contribution table**". In the contribution table you have to indicate **for each possible average contribution of the other group members** (rounded to the next integer) **how many points you want to contribute to the project**. You can condition your contribution on the average contribution of the other group members. This is shown in **the right hand side** of the above figure. The numbers next to the input boxes are the possible (rounded) average contributions of the other two group members to the project.

  **You simply have to insert into each box how many points you will contribute to the project conditional on the indicated average contribution**.

  You have to make an entry into each input box. For example, you will have to indicate how much you contribute if the average contribution of others is 1, 2, or 3 points etc. **In each input box you can insert all integer numbers from 0 to 20**.

After all participants have made an unconditional contribution and have filled out their contribution table, in **each group a group member is selected randomly. For this randomly selected member, ONLY the contribution table will be the payoff-relevant decision**.

**For the other two group members** who are not selected by the random mechanism, only the **unconditional contribution will be the payoff-relevant decision**.

**You will therefore have to think carefully about both types of decisions because both can become relevant for you**. The following example should make that clear.

Example: **Assume that you are the group member who has been randomly selected. This implies that your relevant decision will be your contribution table. For the other two group members the unconditional contribution is the relevant decision**. Assume they have made unconditional contributions of 2 and 4 points. The average contribution of these two group members, therefore, is 3 points. If you have indicated in your contribution table that you will contribute 2 points if the others contribute 3 points on average, then the total contribution to the project is given by 2+4+2=8 points. All group members, therefore, earn (0.5)*(8) =4.0 points from the project plus their respective payoff from the private account. If you have instead indicated in your contribution table that you will contribute 19 points if the others contribute 3 points on average, then the total contribution of the group to the project is 2+4+19=25. All group members therefore earn (0.5)*25 =12.5 points from the project plus their respective payoff from the private account.

Your earnings in Stage 1 will eventually be converted into Singapore Dollars at the rate of

**6 points = $1**.

## STAGE 2

In this stage, you will be **randomly assigned into 3-member groups (your group members are different from that of stage 1)** and you will make choices over a sequence of **30 rounds**.

**Your group members will remain FIXED throughout this stage for all 30 rounds**.

You will be identified through a **member ID** within your group, which will be either 1 or 2 or 3. This member ID remains **fixed** throughout this stage. Your payoff for the 30 rounds will depend on all three group members decisions, but are completely unaffected by the decisions made by participants assigned to other groups.

At the beginning of each round, each group member is given **a single token** and can either **spend** it on a **group project** or **keep** it privately. **The value of the token varies across group members**. Token values are **randomly drawn** from **nine numbers {10, 20, 30, 40, 50, 60, 70, 80, 90}** such that **each group member has a value that is distinct from the token values assigned to the other two members in his group**. For example, if $(x, y, z)$ denote the token values assigned to all the three members of a group, then $x, y, z \in \{10, 20, 30, 40, 50, 60, 70, 80, 90\}$ and $x \neq y \neq z$.

**ONLY the owner of the token would know the value, but NOT the other group members**. Your token value **CANNOT** be seen by other members in your group. Also, you will **NOT** be able to observe the token values of the two members in your group.

If you decide to **KEEP** your token:

- If the 2 other members of your group decide to spend their token, the group project is implemented and you earn **your token value** in that round and additional **100** points from your group project.
- If fewer than 2 members of your group decide to spend their token, the group project is not implemented and you earn **your token value** for that round.

If you decide to **SPEND** your token:

- If at least one other member of your group decides to spend their token, the group project is implemented and you earn **100** points from the group project.
- If none of the other members of your group decide to spend their token, the group project is not implemented and you earn **0 points** for that round.

This is summarized in the following table:

| Your Decision | No. of Other Members who SPEND | Your Earnings |
|---|---|---|
| SPEND | 0 | 0 |
| | 1 | 100 |
| | 2 | 100 |
| KEEP | 0 | YOUR TOKEN VALUE |
| | 1 | YOUR TOKEN VALUE |
| | 2 | YOUR TOKEN VALUE + 100 |

In each round, you will be given **60 seconds to make your decision**. If you decide to **spend your token** then you have to click the "**SPEND TOKEN**" button on your screen at any time within the time limit of 60 seconds.

**Remember ONCE YOU HAVE CLICKED THE BUTTON, YOUR TOKEN WILL BE SPENT AND YOU CANNOT CHANGE YOUR DECISION ANYMORE**.

If you do not want to spend your token, that is, **if you want to keep your token then you have to DO NOTHING**.

Also, you will receive an **instant update** of the decision made by your group members at any time within the time limit. In addition, you will be given information about the **cumulative count of the number of times your group members have decided to spend their token** in all of the previous rounds and its **corresponding percentage** (that is, how many times a group member decided to spend his/her token as a fraction of the total number of decisions). It will be shown on the right portion of your screen.

When the 60 second time ends, the outcome and the choices of the other members of your groups are revealed, and this determines your earnings for the round. We then go to the next round and each round proceeds according to exactly the same rules as described above. At the end of the experiment, your payoff from **all 30 rounds** will be added together. This sum will be your earnings from Stage 2. Your earnings from Stage 2 will be added to your final earnings from this experiment when the experiment is completed.

Your earnings in Stage 2 will eventually be converted into Singapore Dollars at the rate of

**200 points = $1.**

## STAGE 3

In this part of the study you will be asked to make a series of choices. How much you receive will depend partly on chance and partly on the choices you make. The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

For each line in the table you will see in this stage, please indicate whether you prefer option A or option B. There will be a total of 10 lines in the table but just one line will be randomly selected for payment. You do not know which line will be paid when you make your choices. Hence you should pay attention to the choice you make in every line. After you have completed all your choices, the computer will randomly generate a number, which determines which line is going to be paid out.

Your **earnings for the selected line depend on which option you chose**: If you chose **option A** in that line, you will receive **$1**. If you chose **option B** in that line, you will receive either **$3 or 0 (nothing)**. To determine your earnings in the case you chose option B, there will be a second random draw. The computer will randomly determine if your payoff is 0 or 3, with the chances set by the computer as they are stated in Option B.

Your earnings from Stage 3 will be added to your final earnings from this experiment when the experiment is completed.

## STAGE 4

In this final part of the experiment, we will ask you to answer a questionnaire. When you are finished, we will prepare your earnings, and ask you to sign a receipt, and the experiment will be over. **Please remain seated; we will call you one by one by your unique user ID**. Thank you again for your participation!