Are dyads conditionally cooperative? Evidence from a public goods experiment

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Abstract: We analysed dyads strategies in one-shot public goods game. By means of a laboratory experiment, using a variant of the strategy-method, we found that more than one third of the dyads are conditional cooperators, whereas 18% can be categorised as free riders.

Keywords**:** Voluntary contributions; Conditional cooperation; Free riding; Strategy-method; Experiments

JEL classification**:** H41; C91

1. Introduction

In linear public goods experiments it is well established that subjects tend to behave as *conditional cooperators*, that is, people increase their own contribution when other people increase theirs (Ledyard, 1995; Chaudhuri, 2011).

Fischbacher et al. (2001), showed that almost half of subjects are conditional cooperators and one third are free riders. These figures are confirmed by Kocher et al. (2008)[1]. However, the conditional cooperation is not perfect: the presence of free riders results in a decay of contributions over time.

Subjects' behaviour in public goods game may depend on different factors. For instance, on one hand, it might depend on the geographical area where the public good game is played and associated cultural differences – e.g. the level of collectivism (Hofstede, 2001). However, there is abundant literature – see for instance Brandts et al. (2004), Hermann and Thöni (2008), Kocher et al. (2008), and Martinsson et al. (2013) – showing that, regardless to geographical differences, people tend to contribute more as the others' contributions increase, i.e. conditional cooperation is a universal behaviour.

Another factor that may affect the outcome of the public good game is the number of players in decision-units. Indeed, many papers investigated differences between individual and group behaviour in many contexts. For instance, in signalling game Cooper and Kagel (2005) demonstrated that "two heads are better than one", since two-persons' teams played more strategically than individuals. In a beauty-context game Kocher and Sutter (2005) found that two-person groups, when competing against individuals significantly out-perform them. Additionally, Sutter (2005) found that larger groups (i.e. four-person teams) accomplished better results in a beauty-context game than two-person teams and/or individuals. Also in the ultimatum game, teams were more rational than individuals (see Bornstein and Yaniv, 1998). By means of a laboratory experiment, Morone et al. (2016) studied how individuals and groups behave in a simple game such as the dollar auction. They found that groups are closer than individuals to the Nash equilibrium. Similar results were reached by Morone et al. (2014) who provided an experimental test of the

[1] They found that in US 80.6% of the subjects are conditional cooperators and 8.3% are free riders, in Japan 41.7% of the subjects are conditional cooperators and 36.1% are free riders, and in Austria 44.4% of the subjects are conditional cooperators and 22.2% are free riders.

traveller's dilemma using individual and group data, showing that groups behave more rationally, in the sense that they were always closer to the Nash equilibrium.

In public goods game, if the marginal *per capita* return is less then one, the Nash equilibrium is free riding. In this paper we investigate whether the number of players per decisional unit may affect the salience of conditional cooperation. Thus, we report on experimental study, which test if and to what extant dyads are conditional cooperators. To do so, we build on Fischbacher et al. (2001), applying the same variant of the strategy-method (Selten, 1967) to dyads. The experimental design is described in Section 2 and we illustrate our main results in Section 3. In Section 4 we discuss our conclusions.

2. Experimental design and procedure

As mentioned, our experiment replicates Fischbacher et al. (2001) on dyads. It was programmed in z-Tree[2] (Fischbacher, 2007). We run three sessions between April and May 2016 at the ESSE laboratory of the University of Bari, Italy. We enrolled 64 participants (students majoring in Economics and Marketing), i.e. 32 dyads.

At the beginning of each session, subjects were randomly coupled with a partner. In turn, each dyad was randomly matched with other three dyads, so that four dyads make one group.

Each dyad was endowed with 20 tokens. Dyads had to decide how to allocate these tokens. They could either keep tokens for themselves or invest them totally or partially into a "public good". The payoff of each dyad is described by the following function:

$$\pi_i = 20 - g_i + 0.4\Sigma g_j$$

where g_i is the contribution of the dyad i to the public good, and Σg_j is the sum of the contribution of each dyads in the group. The payoff of all the contributions to the public good is 0.4.

Participants received the sheet with instructions. Once they read it, they had to answer some control questions (an English translation of instructions and control questions is reported in annex A). Afterwards, the actual experiment began. Dyads went through two steps: the first step was called *"unconditional contribution"*, while the second step was called *"contribution table"*. During the unconditional

[2] We would like to thanks Urs Fischbacher to share with us the original software used in 2001.

contribution step, each dyad had to state how many of the 20 tokens they wanted to allocate for the public good. There was no time limit for this decision. Once the first decision was taken, they passed to the second. In this step, dyads had to fill out a contribution table, indicating how many tokens they would allocate to the public good for each possible average contribution level of other dyads in the same group (ranging from 0 to 20 tokens). Again, no time limit was applied. When all the dyads in the same group completed all the tasks, one dyad per group was picked randomly. Only for this dyad, the contribution table was used to calculate the payoff. For the other three dyads in the group, the unconditional contribution decision was the relevant one for the payoff calculation. On average, each dyad earned 30€ (25€ + 5€ of show up fee).

3. Results

As can be noticed from Figure 1, the average dyad's contribution to the public good (squared-line) increases as the average contribution of other dyads increases too.

The main result of our study is that also little groups (such as dyads) tend to behave as conditional cooperators, in contrast with the expectation of group's behaviour closer to the Nash equilibrium of contributing zero.

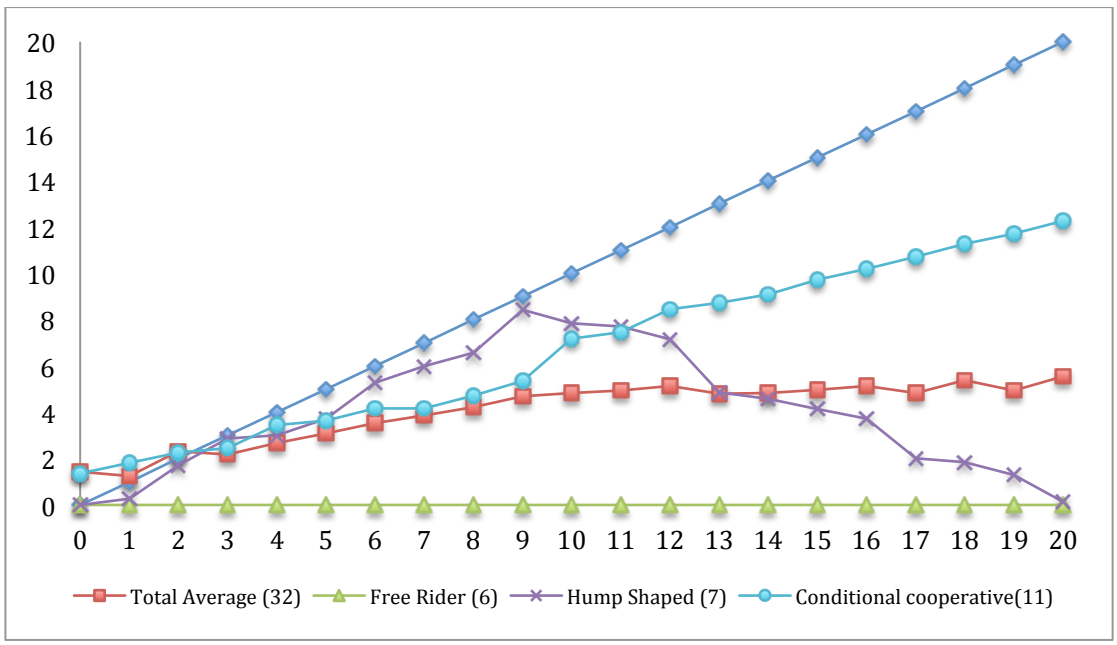

FIGURE 1 - Average contribution of the single couples for each average contribution level of other dyads in the group

A breakdown of findings showed us the same heterogeneity of subjects found in Fischbacher et al. (2001), and confirmed by Kocher et al. (2008). We classified

them in four categories. We defined "conditional cooperators" those couples whose contribution increased monotonically with the increasing of other couples' contribution; in line with Fischbacher et al. (2001), we also considered "conditional cooperators" those couples whose contribution did not follow a perfect monotonic trend, but obtained a positive and significant (at 1% level) Spearman rank correlation coefficient when compared to others' contribution. In our sample, eleven dyads (34.4%) behaved conditionally, even though no one played a perfect conditional cooperation.

We identified six "free riders" (18.8%), namely dyads that did not contribute at all to the public good, regardless others' contribution level. Finally, according to the categorization made in Kocher et al. (2008), we classified as "hump-shaped" seven dyads (21.9%) whose contribution was first monotonically increasing when others' average contribution was $x<20$ tokens and then decreasing above this value x.

Trends of other dyads did not match any recognizable pattern (Table 1). Figure B1 in the annex B shows the behaviour of single dyads.

In conclusion, to a complete knowledge of our research, the total average unconditional contribution of dyads to the public good has been 7,03 tokens (35,2% of endowment).

Contributors	Distribution	Avg. unconditional contribution
Conditional cooperatives	34,4%	8,3
Free Riders	18,8%	0,8
Hump-shaped	21,9%	8,4
Others	25%	8,8

TABLE 1: Distribution of dyads categories

4. Discussion and conclusions

A growing body of experimental research is focusing on differences between individual and groups behaviour in different context. Previous literature highlights that groups in different strategic games tend to make choices closer to the Nash equilibrium. However, in the present experiment, we found that dyads mostly exhibited a conditional cooperative behaviour (34.4% of cases), in line with findings obtained with individuals (Fischbacher et al., 2001). Nevertheless, no one dyad acted as a perfect conditional cooperative team and – on average – their contributions were lower than others'. Free riders percentage stopped at 18.8%.

Future research should investigate whether larger groups (e.g. four members)

tend to make choices closer to the Nash equilibrium, increasing the number of free riders when a one-shot public good game is played.

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Annex A

Experimental Instructions

You are now taking part in an experiment which has been financed by various foundations for research promotion. If you read the following instructions carefully, you can, depending on your decision, earn a considerable amount of money. It is therefore very important that you read these instructions with care.

The instructions which we have distributed to you, are solely for your private information. It is prohibited to communicate with the other participants during the experiment. Should you have any questions please ask us. If you violate this rule, we shall have to exclude you from the experiment and from all payments.

During the experiment we will not speak of Euro but rather of points. During the experiment your entire earnings will be calculated in points. At the end of the experiment the total amount of points you have earned will be converted to Euro at the following rate:

1 point = 0.50 Euro.

All participants will be divided in groups of four members. Except us, the experimenters, nobody knows who is in which group.

The decision situation

You will learn later on how the experiment will be conducted. We first introduce you to the basic decision situation. At the end of the description of the decision you will find control questions that help you to gain an understanding of the decision situation.

You will be a member of a group of 4 people. Each member has to decide on the division of 20 tokens. You can put these 20 tokens on a private account or you can invest them fully or partially into a project. Each token you do not invest into the project will automatically be transferred to your private account.

Your income from the private account:

For each token you put on your private account you will earn exactly one point. For example, if you put twenty tokens on your private account (which implies

that you do not invest anything into the project) you will earn exactly twenty tokens from the private account. If you put 6 tokens into the private account, you will receive an income of 6 tokens from the private account. Nobody except you earns something from your private account.

Your income from the project

From the token amount you invest into the project each group member will get the same payoff. Of course, you will also get a payoff from the tokens the other group members invest into the project. For each group member the income from the project will be determined as follows:

Income from the project = sum of contributions to the project × 0.4.

For example, if the sum of all contributions to the project is 60 tokens, then you and all other group members will get a payoff of 60 × 0.4 = 24 points from the project. If the four group members together contribute 10 tokens to the project, you and all the others will get a payoff of 10 × 0.4 = 4 points from the project.

Your total income

Your total income results from the summation of your income from the private account and your income from the project.

Income from the private account (= 20 – contribution to the project) + Income from the project (= 0.4 × Sum of contributions to the project) = total income.

Control Questions

Please answer the following control questions. Their purpose is to make you familiar with the calculation of incomes that accrue from different decisions about the allocation of 20 tokens.

1. Each group member has 20 tokens at his or her disposal. Assume that none of the four group members (including you) contributes anything to the project.
    a. What will your total income be?
    b. What is the total income of the other group members?

2. Each group member has 20 tokens at his or her disposal. Assume that you invest 20 tokens into the project and each of the other group members also invest 20 tokens.
    a. What will your total income be?
    b. What is the total income of the other group members?
3. Each group member has 20 tokens at his or her disposal. Assume that the other three group members together contribute 30 tokens to the project.
    a. What is your total income if you – in addition to the 30 tokens – contribute 0 tokens to the project?
    b. What is your total income if you – in addition to the 30 tokens – contribute 8 tokens to the project?
    c. What is your total income if you – in addition to the 30 tokens – contribute 15 tokens to the project?
4. Each group member has 20 tokens at his or her disposal. Assume that you invest 8 tokens to the project:
    a. What is your total income if the other group members – in addition to your 8 tokens – together contribute 7 tokens to the project?
    b. What is your total income if the other group members – in addition to your 8 tokens – together contribute 12 tokens to the project?
    c. What is your total income if the other group members – in addition to your 8 tokens – together contribute 22 tokens to the project?

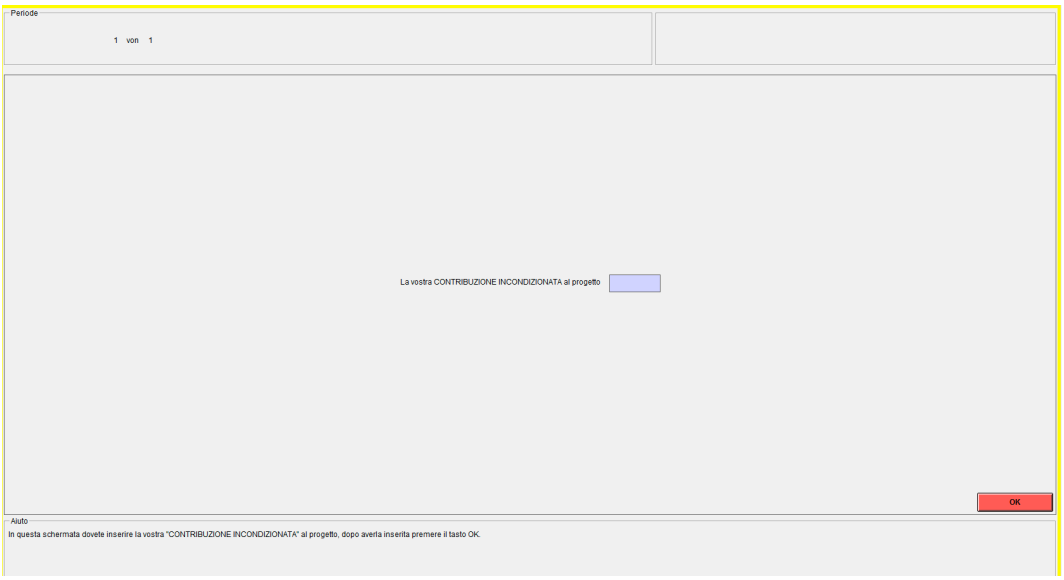
If you finish these questions before the others, we advise to think about additional examples to further familiarize yourself with the decision situation.

The Experiment

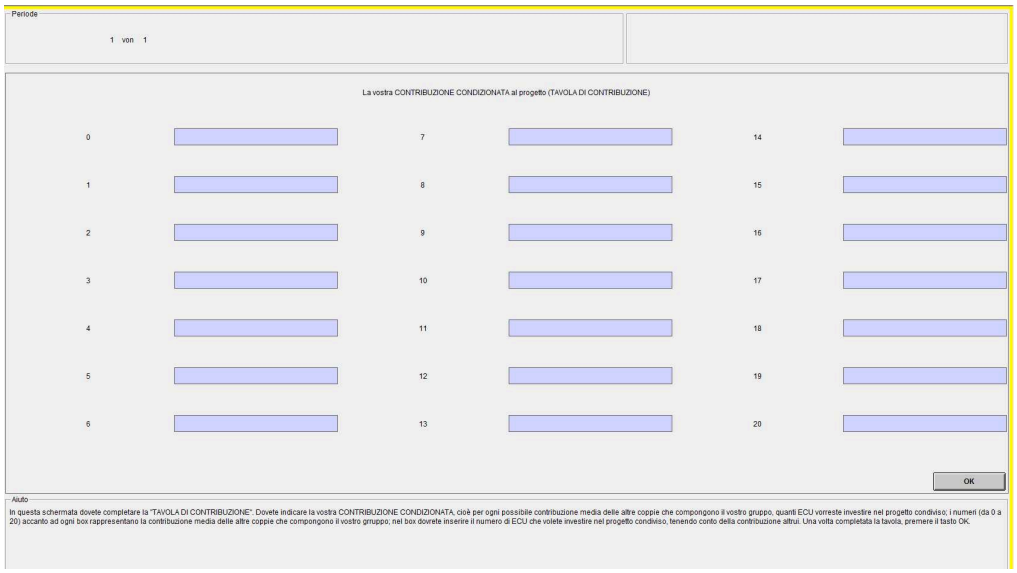
The experiment contains the decision situation that we have just described to you. At the end of the experiment you will get paid according to the decision you make in this experiment. The experiment will only be conducted once.

As you know you will have 20 tokens at your disposal. You can put them into a private account or you can invest them into a project. In this experiment each subject has to make two types of decisions. In the following we will call them “unconditional contribution” and “contribution table”.

- Whit the unconditional contribution to the project you have to decide how many of the 20 tokens you want to invest into the project. You will enter this amount into the following computer screen:



- After you have determined your unconditional contribution you press the "OK" button.
- 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 tokens you want to contribute to the project. You can condition your contribution on the contribution of the other group members. This will be immediately clear to you if you take a look at the following screen. This screen will show up immediately after you have determined your unconditional contribution.



The numbers next to the input boxes are the possible (rounded) average contributions of the other group members to the project. You simply have to insert into each input box how many tokens you will contribute to the project – conditional on the indicated average. You have to make an entry into each input box. For example, you will have to indicate how much you contribute to the project if the others contribute 0 tokens to the project, how much you contribute if the others contribute 1, 2, or 3 tokens etc. In each input box you can insert all integer numbers from 0 to 20. If you have made an entry in each input box, press the OK-button.

After all participants of the experiment have made an unconditional contribution and have filled out their contribution table, in each group a random mechanism will select a group member. For the randomly determined subject only the contribution table will be the payoff-relevant decision. For the other three group members that are not selected by the random mechanism, only the unconditional contribution will be the payoff-relevant decision. When you make your unconditional contribution and when you fill out the contribution table you of course do not know whether you will be selected by the random mechanism. You will therefore have to think carefully about both types of decision because both can become relevant for you. Two examples should make that clear.

- EXAMPLE 1: Assume that you have been selected by the random mechanism. This implies that your relevant decision will be your contribution table. For the other three group members the unconditional contribution is the relevant decision. Assume they have made

unconditional contributions of 0, 2, and 4 tokens. If you have indicated in your contribution table that you will contribute 1 token if the others contribute 2 tokens on average, then the total contribution to the project is given by 0+2+4+1 = 7 tokens. All group members, therefore, earn 0.4 × 7 = 2.8 points from the project plus their respective income from the private account. If you have instead indicated in your contribution table that you will contribute 19 tokens if the other contribute two tokens on average, then the total contribution of the group to the project is given by 0+2+4+19 = 25. All group members therefore earn 0.4 × 25 = 10 points from the project plus their respective income from the private account.

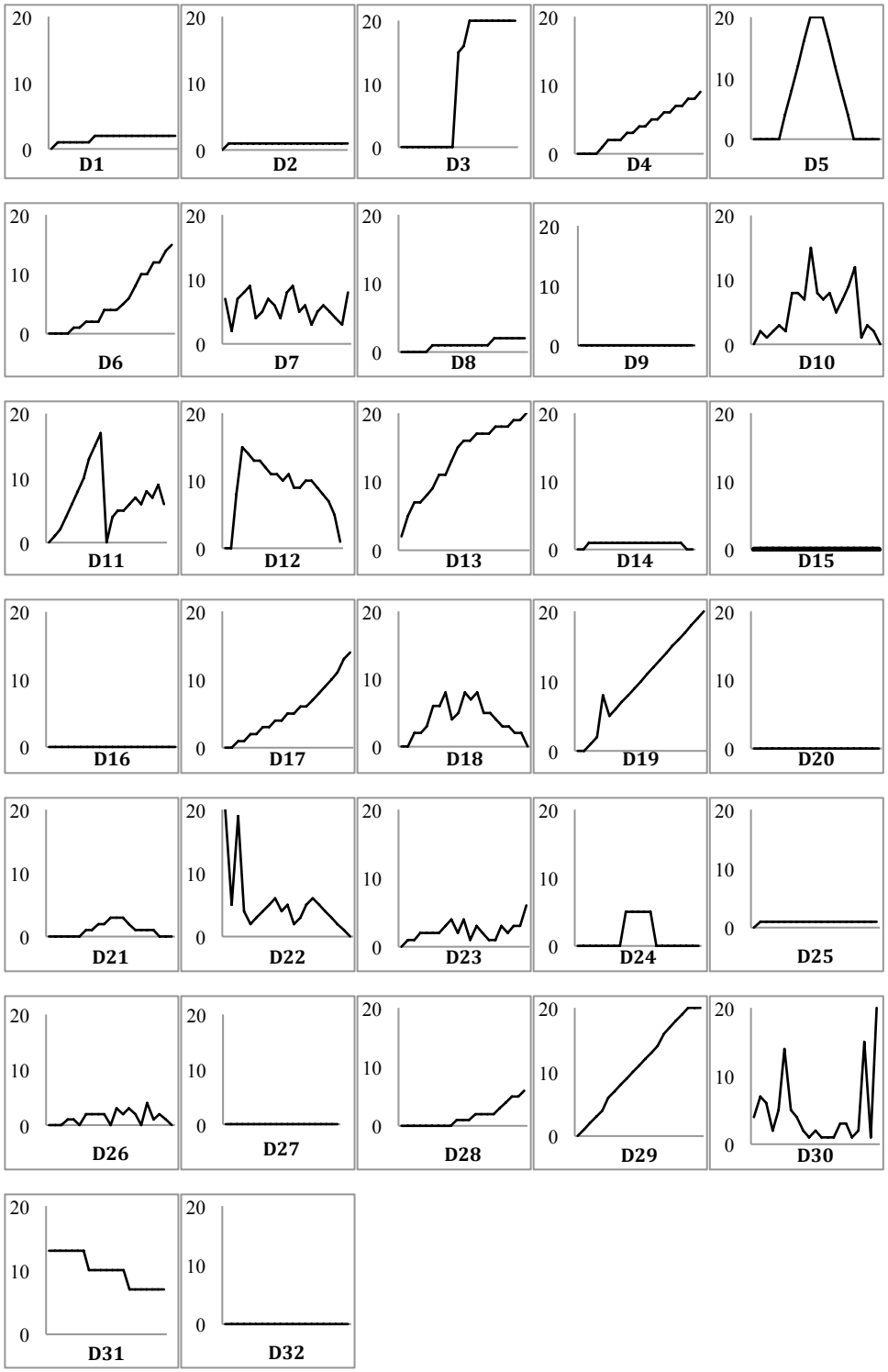
- EXAMPLE 2: Assume that you have not been selected by the random mechanism which implies that for you and two other group members the unconditional contribution is taken as the payoff-relevant decision. Assume your unconditional contribution is 16 tokens and those of the other two group members are 18 and 20 tokens. The average unconditional contribution of you and the other two group members, therefore, is 18 tokens. If the group member who has been selected by the random mechanism indicates in her contribution table that she will contribute 1 token if the other three group members contribute on average 18 tokens, then the total contribution of the group to the project is given by 16 + 18 + 20 + 1 = 55 tokens. All group members will therefore earn 0.4 × 55 = 22 points from the project plus their respective income from the private account. If instead the random number selected group member indicates in her contribution table that she contributes 19 if the other contribute on average 18 tokens, then the total contribution of that group to the project is 16 + 18 + 20 + 19 = 73 tokens. All group members will therefore earn 0.4 × 73 = 29.2 points from the project plus their respective income from the private account.

The random selection of the participants will be implemented as follows. Each group member is assigned a number between 1 and 4. As you remember, at the very beginning a participant, namely B2, was randomly selected. This participant will, after all participants have made their unconditional contribution and filled out their contribution table, throw a 4-sided die. The number that shows up will be entered into the computer. If B2 throw the membership number that has been assigned to you then

for you your contribution table will be relevant and for the other group members the unconditional contribution will be the payoff-relevant decision. Otherwise, your unconditional contribution is the relevant decision.

Annex B

Figure B1 – The contribution trends of all single dyads[1]



[1] Conditional cooperators: dyads no. 1, 3, 4, 6, 8, 13, 17, 19, 28, 29, 31. Free riders: dyads no. 9, 15, 16, 20, 27, 32. Hump-shaped: dyads no. 5, 10, 12, 14, 18, 21, 24.
Others: dyads no. 2, 25 (unconditional cooperation of 1 token) and dyads no. 7, 11, 22, 23, 26, 30 (random patterns).