Eliciting contributor types to explain behavior in repeated public goods games*

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Abstract

A large number of experimental studies use the strategy method procedure introduced by Fischbacher, Gächter, and Fehr (Econ. Lett. 71:397-404, 2001) to measure individuals' attitudes towards cooperation. The procedure elicits subjects' strategic-form decisions in a one-shot game and classifies each subject as one of several different contributor types. In this paper, we examine the robustness of the procedure and its capacity to help explain the pattern of contributions observed in a separate, repeated game setting. Overall, we show that the elicited contributor types can well explain behavior in the repeated game, provided the possibility of any future interaction after the final period is completely eliminated. Free-rider types contribute less than conditional cooperators, although we observe evidence consistent with strategic cooperation in the early periods of the repeated game. Nevertheless, by the last period, classified free-rider types converge to pure free-riding behavior.

Keywords: Public goods, experimental methodology, strategy method, voluntary contributions, conditional cooperation, free-riding

JEL classification codes: C72, C92

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1 Introduction

The vast majority of experimental research on social dilemmas indicates significant heterogeneity in individuals' attitudes towards cooperation. Evidence suggests that many individuals are conditionally cooperative, with a smaller fraction of individuals who follow the dominant strategy incentive to free ride. In a seminal contribution, Fischbacher, Gächter and Fehr (2001) (hereafter, FGF) introduced an incentive-compatible procedure, using a variant of the strategy method (Selten, 1967), for measuring individuals' attitudes towards cooperation. The procedure elicits subjects' strategic-form decisions in a one-shot, linear public goods game and classifies subjects into different classes of contributor types. In their experiment, FGF classified 50% of their subjects as conditional cooperators and 30% of the subjects as pure free-riders. Several subsequent studies have found similar evidence of conditional cooperation using the FGF procedure.[1] In an extension of the original experiment, Fischbacher and Gächter (2010) used the classifications from the FGF procedure to help explain the decline in cooperation in a multi-period sequence of one-shot public goods games using a random matching protocol. Their results support the conclusion that the well-documented decay in average contributions is driven primarily by an average preference for imperfect conditional cooperation, though also still in part by the downward adjustment of beliefs about the contributions of others.

In this paper, we examine the robustness of the classifications obtained from the FGF procedure and explore whether they can be used to explain the similar pattern of decay in *repeated* public goods games under a *partners* matching protocol. Based on some discouraging results in a previous experiment, we designed two new experiments that more closely coincide with the original FGF study, while addressing two concerns with our previous design. We first examine the robustness of the FGF procedure to different classification criteria, including the original FGF criteria and the statistical classification algorithm introduced by Kurzban and Houser (2005) (hereafter, KH). While both approaches have been well received, we are not aware of any study that has examined the robustness of the elicitation mechanism to the choice of classification criteria.

After comparing the distribution of contributor types across experiments, we examine the contribution decisions of the different contributor types in the repeated linear public goods game. Two recent studies that pursue a similar goal are de Oliveira, Croson and Eckel (2015) and Cotla and Petrie (2015). de Oliveira, Croson and Eckel (2015) examine the effect of group composition (in terms of contributor types) on contributions in a repeated game setting. However, their classification criteria are far less stringent than the original FGF criteria and they concentrate

[1] Although not a comprehensive list, see, e.g., Burlando and Guala (2005), Gächter and Thöni (2005), Chaudhuri and Paichayontvijit (2006), Kocher et al. (2008), Muller et al. (2008), Gächter and Herrmann (2009), Herrmann and Thöni (2009), Fischbacher and Gächter (2010), Fischbacher, Gächter and Quercia (2012), and Martinsson, Pham-Khanh and Villegas-Palacio (2013).

mostly on the effect of free-riders ("bad apples") on cooperation.[2] Cotla and Petrie (2015) also examine the consistency between social preferences elicited by the one-shot FGF procedure and behavior in a repeated linear public goods game. However, rather than use the FGF classification criteria, they use the KH statistical classification algorithm to group participants into classes of contributor type. They find, among other things, that social preferences are relatively stable across the one-shot and repeated environments. Moreover, they argue that the pattern of contributions in the repeated game is best explained by a combination of the effects of classified contributor type on first-period contributions with a simple model of payoff-based reinforcement learning.

We collected data using three separate experimental designs. The first design, which motivates the other two, was implemented for an earlier study reported in Boosey, Isaac and Norton (2016). It included several treatments, introduced in different segments of a 30-period interaction. However, in all treatments, we began each session by eliciting contributor types using the FGF procedure, after which the subjects participated in a standard repeated linear public goods game for 10 periods. Observed behavior in the repeated game differs substantially from the predicted behavior for the main contributor types (classified using the FGF criteria). In particular, the average contributions of free-rider types were higher than for conditional cooperator types in almost all periods, and remained significantly above zero in the last (10th) period (see Figure A.1 in Appendix A). As a result, we omitted the classification data from the analysis in Boosey, Isaac and Norton (2016) and chose to concentrate on the other treatments introduced after the first 10 periods.

While the inconsistency between the classification of contributor types and the repeated game behavior was discouraging, there were at least two key features of our original design that may have affected subject behavior. First, we did not include any control questions to ensure that subjects understood the incentives of the game. As a result, it is possible that the classification of contributor types in our original experiment reflected confusion or misunderstanding among the subjects. Second, the 10-period repeated public goods game was followed by 20 additional periods with various treatment interventions. Even though subjects did not know any details about subsequent periods, they were aware that the experiment would last for a total of 30 periods. Thus, the expectation of some kind of future interaction might have distorted subject behavior during the first 10 periods (and more particularly, in the 10th period) of the experiment.

To address these two concerns, we designed two additional experiments. In both of the newer experimental designs, we ended the experiment after period 10 and made clear to the subjects that there would not be any further interaction. In one of the new designs, we included the original set of control questions used by Fischbacher, Gächter and Fehr (2001), adapted to the game parameters of our experiment. In the other design, we excluded the control questions,

[2] They also systematically vary the composition of the groups and examine the effect of providing information about the elicited types to group members.

as in our original experiment, in order to test the sensitivity of the FGF procedure to the control questions.

Using the original FGF classification criteria, we find that a somewhat higher percentage of subjects are classified as free-riders when the control questions are included. This is also the case using the KH classification approach. However, using multiple sets of classification criteria, including the original FGF and KH approaches, we are unable to reject the hypothesis that the overall type distributions are the same. Thus, overall, the evidence suggests that the FGF procedure is quite robust to several natural adjustments to the classification criteria and to the inclusion or exclusion of control questions in the initial instructions.

We find that explicitly ruling out future interaction is critical for the behavior of free-rider types, especially in the final period of the repeated game. For both new designs, free-rider behavior is highly consistent with predicted free-riding in the final period. Furthermore, the data is consistent with the prediction that free-riders will contribute, on average, lower amounts than conditional cooperators. In particular, even when they behave strategically in earlier periods, as has been argued by Ambrus and Pathak (2011), we expect lower contributions by strategic, selfish types, than by the conditionally cooperative types. Indeed, average contributions in the first period are significantly lower for free-riders than for conditional cooperators, and remain lower across all 10 periods of the game.

We label the different experimental designs based on the two key differences in protocol. Thus, the original design from Boosey, Isaac and Norton (2016) is referred to as NC30 (where NC denotes that there were no control questions, and 30 denotes that the repeated game was part of a longer, 30-period interaction), while the two new experimental designs are denoted by C10 (for control questions, 10 periods) and NC10 (for no control questions, 10 periods).

In the next section, we describe the experimental designs and procedures used in all three experiments, including a review of the FGF procedure. In Section 3, we present the main findings. We first provide a comparison of the type classifications across experiments, using various classification approaches. We then examine whether behavior in the repeated game component of the experiment is consistent with the classified contributor types. We integrate a discussion of our findings into Section 3, then provide a few concluding remarks in Section 4.

2 Experimental Design & Procedures

In this section we describe the FGF procedure and outline the experimental protocols used for each of the three designs. The data for NC30 are drawn from a subset of the treatments reported in Boosey, Isaac and Norton (2016). These sessions were conducted in 2013. The data for C10 and NC10 were collected in 2015 and 2016. All sessions were run in the XS/FS laboratory at Florida State University (FSU) using zTree (Fischbacher, 2007). Subjects were randomly recruited via ORSEE (Greiner, 2015) from a subpopulation of FSU undergraduate students who pre-registered to receive announcements about participating in upcoming experiments. No subject participated in more than one experiment or more than one session.

In all three experiments, subjects first participated in the strategy-method elicitation procedure introduced by Fischbacher, Gächter and Fehr (2001). In each case, instructions for the rest of the experiment were only distributed after the elicitation procedure was complete. Thus, we first provide a brief description of the FGF procedure and describe the differences across experiments.

2.1 The FGF procedure

In order to keep our design as close as possible to the original implementation of the FGF procedure, the instructions were written in virtually identical language to those used in Fischbacher, Gächter and Fehr (2001). The only substantive difference between our experiments and their original design is that we use groups of five players with a marginal per capita return (MPCR) of 0.5 instead of groups of four with an MPCR of 0.4. Given that we used these parameters in Boosey, Isaac and Norton (2016), we opted to keep the same game structure in our two new designs, C10 and NC10, rather than revert to the parameters used in Fischbacher, Gächter and Fehr (2001). Nevertheless, it is worth emphasizing that if the FGF procedure elicits an individual's intrinsic preference for cooperation, it should not be sensitive to the particular parameters of the game, provided the game retains the same social dilemma structure.

The basic decision situation is a linear public goods game with a fixed endowment ω, to be allocated between a private good and a public good. Thus, the payoff to player i is given by

$$\pi_i(y) \quad = \quad \omega - y_i + 0.5\sum_{j=1}^{5} y_j \tag{1}$$

where $y = (y_j)_{j=1}^5$ is the profile of contributions made to the public good by the members of i's group. In this part of the experiment, subjects were given an endowment of $\omega = 20$ tokens.

After explaining the linear public goods setting and the payoff function in (1), the instructions in NC30 and NC10 introduced the elicitation procedure to the subjects. In contrast, in C10, subjects were required to complete the ten control questions used by Fischbacher, Gächter and Fehr (2001), adapted for groups with five players and the MPCR of 0.5, before the elicitation procedure was introduced. We include the list of ten control questions used for C10 in Appendix B, along with a sample of the instructions for C10 and NC10.

Subjects then made two types of decisions referred to as their *unconditional investment* and their *investment table*. For the unconditional investment, each subject made a single decision about how many of their 20 tokens to invest in a project (the public good). Then, for the investment table, subjects indicated their desired investment for each of the 21 possible (rounded) average investment levels of the other four players. Thus, the investment table elicits an investment schedule, using a variant of the strategy method.

In order to make both decisions potentially payoff relevant, subjects were told that, at the end of the experiment, one player in each group would be randomly selected to have their decision determined by their investment table and the average unconditional investment made by the other four players in the group. To make the details of this randomized mechanism clear to the subjects, we included two examples written in the same language as the examples included in the instructions used by Fischbacher, Gächter and Fehr (2001). At the end of the experiment, payoffs were calculated according to equation (1) and the outcome of the random mechanism, then converted into US dollars at the exchange rate of 20 tokens = \$1.

Thus, the only differences between our experiments in the instruction phase were the use of control questions (about the linear public goods game) before the FGF procedure was introduced in C10. In particular, the instructions for the elicitation procedure itself were held constant. Furthermore, the existence of and instructions for the repeated game part of the experiments were not known to subjects until after the FGF procedure was completed.

2.2 NC30 Protocol

In Boosey, Isaac and Norton (2016), we examined the effects of an exogenous preference manipulation and an endogenous tax mechanism on cooperation in repeated public goods experiments. In those experiments, subjects first went through the standard FGF procedure with groups of 5 and an MPCR of 0.5. Subjects were then rematched into new groups of five, and each group played a 30-period sequence of the linear public goods game with various treatment interventions beginning after period 10. Thus, in all sessions the first 10 periods of the sequence consisted of a standard linear public goods game played with the same group members. In each period, subjects received an endowment of $\omega = 100$ tokens and faced a marginal per capita return (MPCR) equal to 0.5. Between periods, players observed the total number of tokens allocated to the public good, their earnings from the public good and private good, and their overall earnings from the period. Importantly, subjects were not shown the individual contributions made by other group members.

We use the truncated data from these initial 10 periods of each session, together with the elicitation data from the FGF procedure, to create the dataset for NC30. This truncation is not without significance, as subjects may have anticipated potential future benefits from cooperating even in the 'last' (tenth) period. Specifically, although subjects were not informed about the interventions until after the initial 10 periods, they were aware that the whole session would last for a total of 30 periods. In total, we collected observations from 130 subjects in 26 groups across 6 sessions.

2.3 C10 Protocol

In C10, we addressed the two problematic design features in NC30. First, we included the original control questions used by Fischbacher, Gächter and Fehr (2001) (adapted to match our game parameters) in the instruction phase before the FGF procedure. Second, for the repeated game part of the experiment which followed, we fixed the number of periods at $T = 10$ and emphasized in the instructions that there would be no additional periods or decisions after period 10 was completed. In each session, subjects were first given the instructions for the basic decision situation, then answered the ten control questions. After the control questions, subjects were given the instructions describing the FGF procedure and asked to make the unconditional investment and investment table decisions.

After the FGF procedure was completed, subjects were randomly rematched into new groups of five players for the second part of the experiment. This part consisted of a standard 10-period repeated linear public goods game, played with a partners matching protocol. Thus, as in the first 10 periods of NC30, groups were kept fixed, subjects received $\omega = 100$ tokens in each period, and the MPCR was 0.5. At the end of the game, the subjects' earnings were calculated by adding together their earnings from all 10 periods and converting the total into US dollars using the exchange rate of 150 tokens = \$1. These dollar earnings were added to the dollar earnings from the FGF procedure and the \$10 show-up fee.

We conducted four sessions for C10, each with 25 subjects (5 groups per session) for a total of 100 participants (20 groups). Each session lasted approximately 90 minutes, with subjects earning \$22.31, on average, including the \$10.00 show-up fee.

2.4 NC10 Protocol

NC10 was identical to C10 except for the fact that we did not include the control questions in the instructions phase at the beginning of the experiment. Thus, the main difference between NC10 and NC30 is that we fixed $T = 10$ and emphasized to subjects that no additional interaction would take place after period 10. We conducted four sessions for NC10, with 20 subjects each in two sessions (4 groups per session) and 25 subjects each in the other two sessions (5 groups per session) for a total of 90 participants (18 groups). These sessions lasted for approximately 55 minutes, with subjects earning \$22.11, on average, including the \$10.00 show-up fee.

3 Results

3.1 Classification of contributor types

We begin by summarizing the classification of contributor types in our data. We consider both the original FGF classification criteria and the KH classification approach. Therefore, it is instructive to outline the two approaches before presenting the results.

FGF Classification Criteria. The original criteria used by Fischbacher, Gächter and Fehr (2001) classify each subject using their investment table decisions as follows. A subject is classified as (1) a *pure free-rider* (F) if she entered 0 in every cell of the investment table; (2) a *conditional cooperator* (CC) if either the entries in her investment table are weakly monotonically increasing *or* the Pearson correlation coefficient between the subject's desired investment and the corresponding average investment of others is significantly positive (at the 1% level of significance); (3) a *triangle contributor* (T) if the entries in her investment table are increasing with the average investment of others up to a point, and decreasing thereafter; (4) *other* (O) if she cannot be classified as any of the three previous types.

KH Classification Criteria. The main alternative approach to classifying contributor types is to use the statistical classification algorithm introduced by Kurzban and Houser (2005). For each subject, we estimate the slope coefficient and intercept for an OLS regression of conditional investment on others' average investment in the FGF elicitation procedure. These two coefficient estimates are used to construct a linear contribution profile (LCP) for each subject. Then we apply the following criteria. A subject is classified as (1) a *free-rider* (F) if the LCP is (strictly) less than half of the endowment everywhere; (2) an *unconditional cooperator* (U) if the LCP is (strictly) greater than half of the endowment everywhere; (3) a *conditional cooperator* (CC) if the LCP has a positive slope, starts below half of the endowment, and ends above half of the endowment; and (4) a *noisy contributor* or *other* (O) if she cannot be classified as any of the previous three types. Note that these criteria are much weaker than the FGF criteria.

Comparison of Distributions. Table 1 summarizes the number of subjects classified into each category for each of the experimental designs. The top panel uses the FGF criteria, while the bottom panel uses the KH criteria. The first main observation is that the distribution of contributor types is quite different between NC30 and the other two designs, regardless of which criteria are used. The differences are especially notable using the FGF criteria, under which almost 37% of the subjects are unable to be classified into one of the three main classes of contributor type. Non-parametric tests confirm that, using either criteria, the distribution in NC30 is significantly different from both C10 and NC10 (all $p < 0.001$, Fisher-Exact test).

Recall that the sessions for NC30 were conducted two years before the C10 and NC10 sessions. Furthermore, the instructions included some minor differences in terms of the language, and were read aloud to the participants by a different experimenter. In light of these factors, the cleanest identification of the effect of control questions comes from comparing the type distributions in C10 and NC10.

In contrast with the comparisons to NC30, the distributions for C10 and NC10 are very similar and do not differ significantly from one another, whether we use the FGF criteria ($p = 0.347$, Fisher-Exact test) or the KH criteria ($p = 0.173$, Fisher-Exact test). It is worth noting that

Table 1: Classification of subjects by treatment.

FGF Criteria	Treatment		
	NC30	C10	NC10
Pure free-rider (F)	3.1	12.0	6.7
Conditional cooperator (CC)	54.6	73.0	81.1
Triangle (T)	5.4	6.0	0.0
Other (O)	36.9	9.0	12.2
N	130	100	90
KH Criteria	Treatment		
	NC30	C10	NC10
Pure free-rider (F)	37.7	33.0	25.6
Conditional cooperator (CC)	43.8	64.0	70.0
Unconditional cooperator (U)	7.7	1.0	4.4
Other (O)	10.8	2.0	0.0
N	130	100	90

Note: Frequencies are reported as percentages.

the percentage of free-riders (conditional cooperators) is slightly higher (lower) in C10 than in NC10, regardless of criteria, even though these differences are not statistically significant.[3] To summarize, whether we use the original FGF criteria, or the alternative KH classification approach, we find no differences between C10 and NC10 in terms of the distribution of contributor types.

For robustness, we also consider two variations on the original FGF criteria. Note that Fischbacher, Gächter and Fehr (2001) require a strict definition for a pure free-rider (F), but a more relaxed definition for conditional cooperators (CC). We examine the natural alternatives, whereby either both definitions are strict or both definitions are relaxed (weak).[4] The frequencies are reported in Table A.1 in Appendix A. Using either alternative approach, we still find no significant differences between the distributions for C10 and NC10.

[3]Compared with Fischbacher, Gächter and Fehr (2001), we find a much lower percentage of pure free-riders in our experiments (6.7% and 12%, compared to 29.5% in FGF) and a much higher percentage of conditional cooperator types (73% and 81%, compared to 50% in FGF). However, these percentages are more in line with those obtained in replication studies that followed FGF, including Herrmann and Thöni (2009), who find that across different subject pools, the percentage of free-rider types varies between 2 and 11%, while the percentage of conditional cooperator types varies between 48 and 60%.

[4]Formally, our Strict criteria modify the requirements for a conditional cooperator (CC) to have an investment table that is weakly monotonically increasing *and* that exhibits a significantly positive Pearson correlation coefficient between desired investment and average others' investment (using the 1% level of significance). In contrast, for the Weak criteria, we modify the original FGF criteria for a pure free-rider (F) by requiring only that the entries be less than or equal to 2 (10% of the endowment) in every cell of the investment table. In our view, consistency in the level of stringency is more easily justified than enforcing a strict criterion for one type and a weak criterion for another, as in the original FGF classification.

We summarize these results as follows.

Finding 1 *The exclusion of control questions during the initial instructions phase does not significantly affect the distribution of classified contributor types.*

Nevertheless, there are clear differences between the distribution of contributor types in our original experiment, NC30, and the distributions obtained in C10 and NC10. One possible explanation for these differences may be subject pool turnover, since NC30 sessions were conducted almost two years prior to the sessions for C10 and NC10. Another possibility is that the procedure is sensitive to minor changes in the language and examples used in the instructions (compared to NC30), or to the use of a different experimenter to read the instructions. All in all, our findings using the more carefully controlled C10 and NC10 treatments indicate that the earlier NC30 sessions may have been affected by differences in factors other than the absence of control questions.

3.2 Average contributions in the repeated game

In this section, we examine the observed behavior in the 10-period repeated public goods game. Recall that our C10 and NC10 designs were motivated by the inconsistencies we observed in NC30 (see Figure A.1 in Appendix A). In particular, in period 10 of the game, where players classified as pure free riders (according to the FGF criteria) would be expected to contribute 0 if it were truly understood as the final period, we observed average contributions at close to 30% of the endowment. Furthermore, in seven of the ten periods, average contributions were *higher* for the free-rider types than for the conditional cooperator types, when they should be lower, even after accounting for the possibility of strategic contributions in the early periods.

In Figure 1, we compare the average contributions in the repeated game by conditional cooperators and free-rider types in C10 and NC10, where types are classified using the FGF criteria. Consistent with their dominant strategy, free-rider types contribute *exactly* zero in the last period in NC10. Similarly, the average contribution of the free-rider types in C10 is indistinguishable from zero in the last period (mean = 2.5, s.d. = 6.22, median = 0). In both C10 and NC10, average contributions of free-riders are non-zero in the early periods, consistent with strategic behavior of selfish types, but exhibit the expected decay over time. Similarly, we observe the familiar pattern of decay over time in the average contributions for conditional cooperator types, from between 50% and 60% of the endowment in period 1, to approximately 30% of the endowment in period 10.

In addition, average contributions are lower for F types than for the CC types in all 10 periods, consistent with the model developed by Ambrus and Pathak (2011), in which free-riders strategically contribute positive, but below-average amounts in order to manipulate the beliefs of the conditional cooperator types. Restricting attention to the first period of the repeated

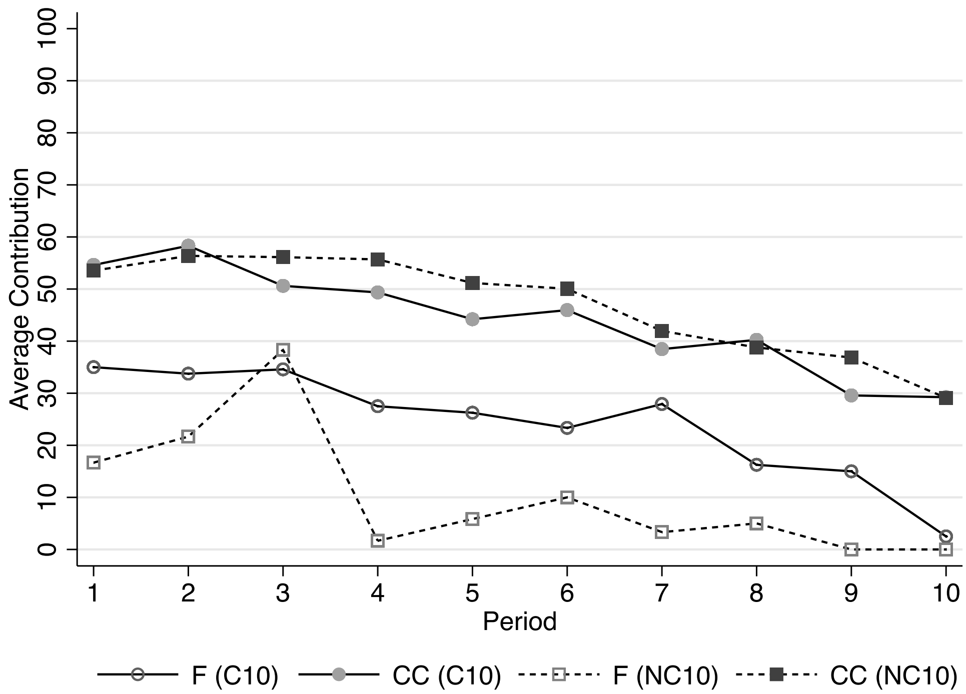

Figure 1: Average contributions by period according to FGF type classification.

game, we find that average contributions are significantly higher for CC types than for F types, in both C10 ($p = 0.091$, Wilcoxon ranksum test) and NC10 ($p = 0.008$, Wilcoxon ranksum test).[5] In contrast, as suggested by Figure A.1, first-period contributions are indistinguishable for these two types in the NC30 experiment ($p = 0.767$, Wilcoxon ranksum test).

We summarize our results as follows.

Finding 2 *Average contributions in the repeated game are consistent with the predicted pattern of contributions for the main contributor types (using FGF criteria) in C10 and NC10, where the possibility of future interaction beyond period 10 has been eliminated.*

This finding confirms the importance of careful experimental design. Even when subjects know only that there is some possibility of future interaction, it may be enough to distort the incentives at the "end" of a repeated game stage.[6] Comparing the average contributions across C10 and NC10, we find no qualitative differences between repeated game behavior with or without control questions. However, as shown by Figure 1, average contributions of free-riders are lower in NC10 than in C10, despite little difference between the average behavior of

[5]If we pool the data from C10 and NC10, the difference is also strongly significant, with $p = 0.003$, Wilcoxon ranksum test.

[6]A different way to interpret this is that FGF classified free-rider types in NC30 are simply playing as if they are in one long, 30-period game, and therefore continue to play strategically in period 10.

conditional cooperators. This may be partly explained by the fact that there are twice as many observations for C10 as for NC10, which results in a smoother graph.

Finally, if we use the KH classification criteria, the results are slightly different, although the predictions for the different types, which are more loosely defined, are also not as sharp. Thus, the relevant analyses and figures are relegated to Appendix A. Figures A.2 - A.4 plot the average contributions over time for free-riders and conditional cooperators (using the KH criteria) in the three treatments.

4 Conclusion

In this paper, we examine the validity of the FGF procedure as a tool for explaining behavior in repeated game public goods games. First, we find that the elicitation of contributor types is robust to alternative classification criteria and to the inclusion or exclusion of control questions in the instructions phase of the experiment. Second, our findings also reinforce the importance of careful experimental design when dealing with finitely repeated games. While average contributions in our original experiment were poorly explained by the classified contributor types, the possibility of future interaction beyond the last period of the game might have distorted individual decisions. Using our two new experimental designs, C10 and NC10, we confirm that when the possibility of subsequent interaction beyond period 10 is explicitly ruled out, behavior is strikingly more consistent with the predicted behavior for the two main classified contributor types. Overall, our findings suggest that, while researchers should exercise care when using the FGF procedure, the classification of types using this method can help to explain the behavior of subjects in later periods of a repeated game with partners as well as in one-shot and strangers environments.

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A Additional tables and figures

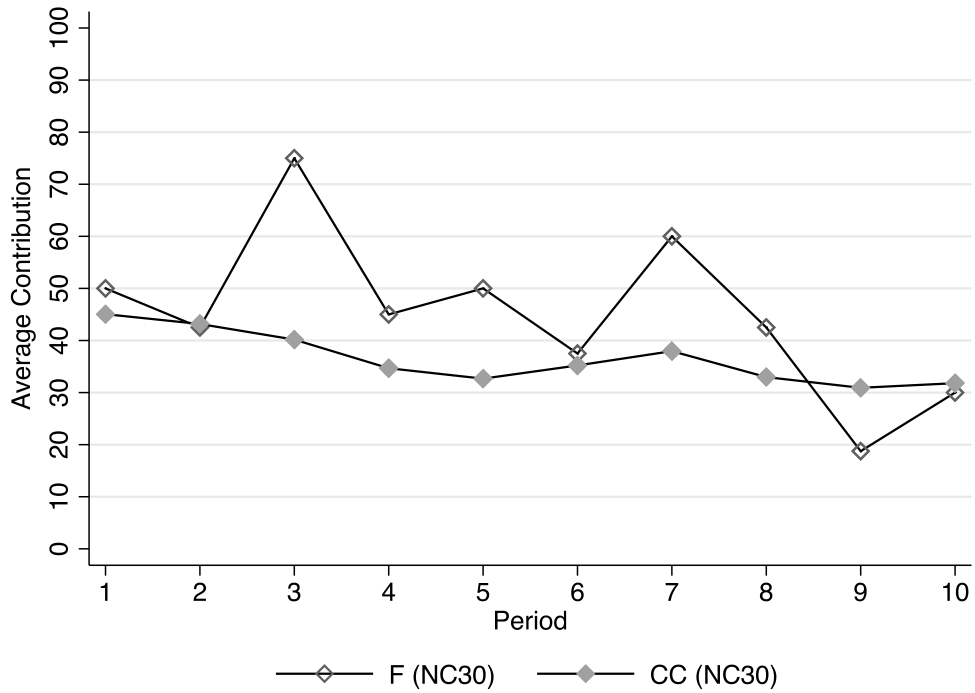


Figure A.1: Average contribution by period according to FGF classified type in NC30.

Table A.1: Classification of subjects in C10 and NC10 using our Strict and Weak criteria.

	Strict		Weak	
	C10	NC10	C10	NC10
Pure free-rider (F)	12.0	6.7	13.0	8 .9
Conditional cooperator (CC)	55.0	64.4	73.0	81.1
Triangle (T)	6.0	2.2	6.0	0.0
Other (O)	27.0	26.7	8.0	10.0
N	100	90	100	90

Note: Frequencies are reported as percentages.

A.1 Average contributions using the KH classification approach

In the NC30 treatment (see Figure A.2), average contributions for free-riders are still greater than 25% of the endowment in period 10. However, in all periods, average contributions are lower for free-rider types than for conditional cooperator types. In terms of first period contributions, free-riders contribute less than conditional cooperators ($p = 0.045$, Wilcoxon ranksum test). The results for NC10 are very similar to those obtained using the FGF criteria (see Figure A.4). Free-riders contribute less than conditional cooperators in the first period ($p < 0.001$, Wilcoxon ranksum test) and converge to less than 10% of the endowment in the last period. However, the results for C10 are quite different. As illustrated by Figure A.3, average contributions for free-riders and conditional cooperators are indistinguishable in all periods. Free-riders contribute almost 30% of the endowment in the last period, and first-period contributions are not statistically different for free-riders and conditional cooperators ($p = 0.715$, Wilcoxon ranksum test). Nevertheless, we are reluctant to place too much emphasis on these comparisons, given the relatively loose classification of free-riders under the KH classification criteria. Instead, we attribute the differences in the pattern of behavior for free-riders in C10 to be driven more by misclassification of subjects who are "impure" free-riders, as opposed to the pure free-riders identified by the FGF criteria.

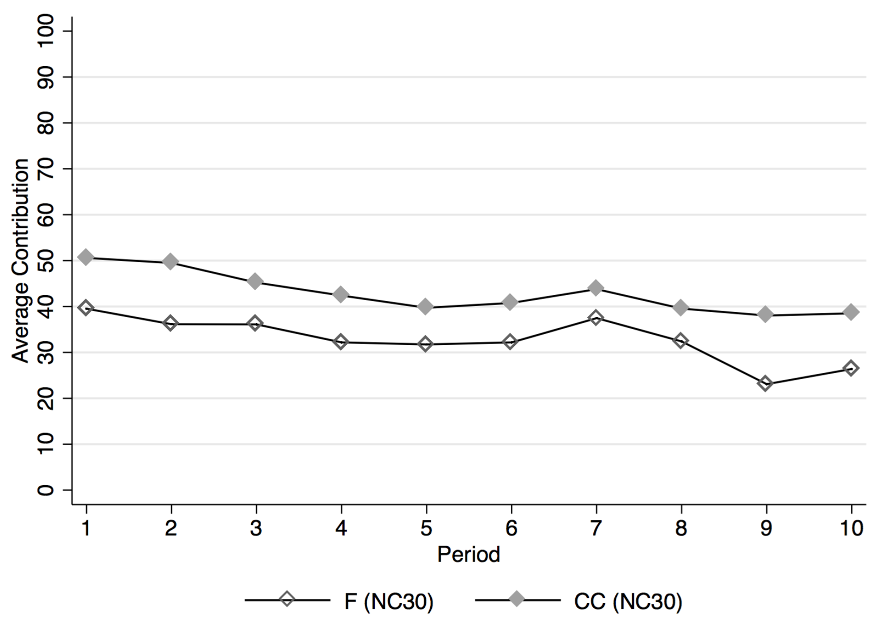


Figure A.2: Average contribution by period according to KH type classification in NC30.

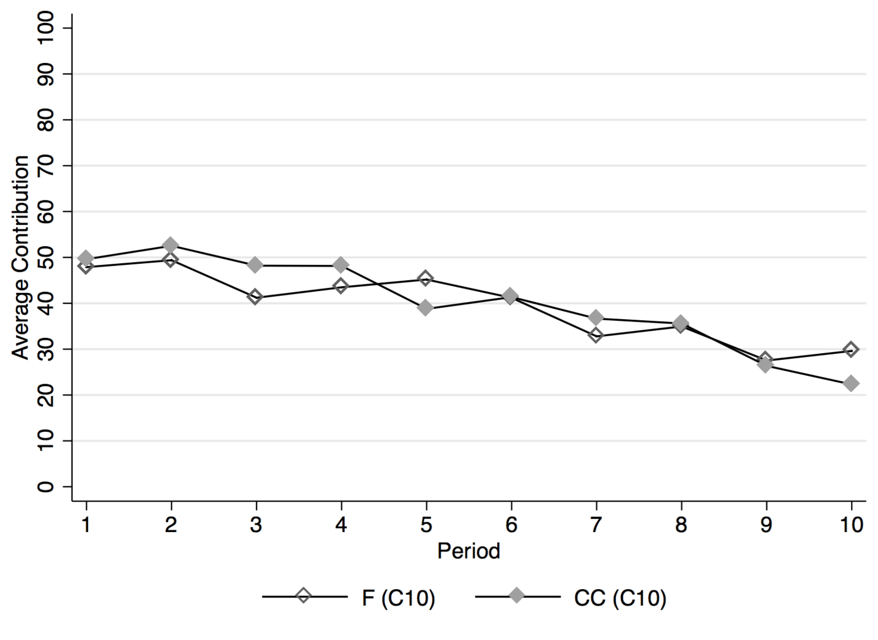


Figure A.3: Average contribution by period according to KH type classification in C10.

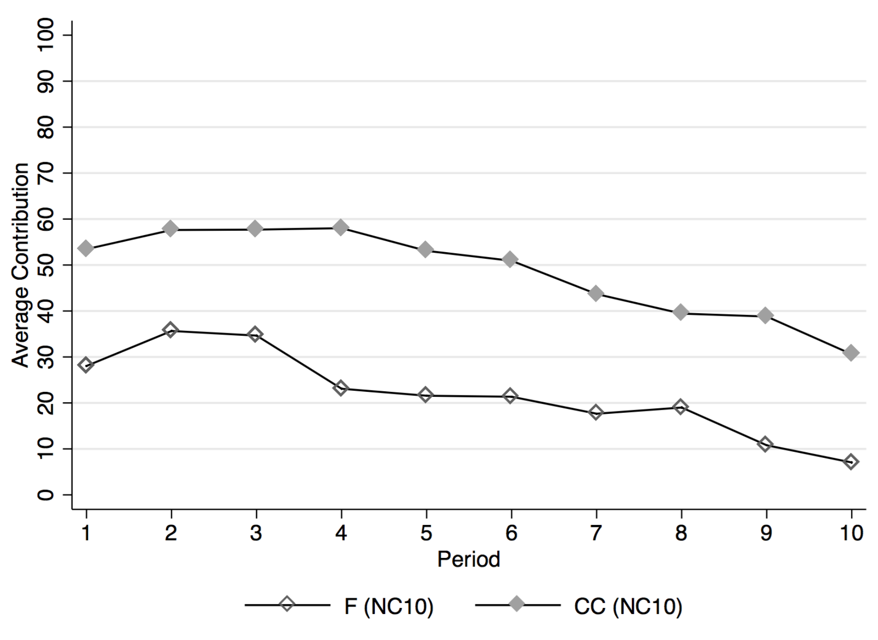


Figure A.4: Average contribution by period according to KH type classification in NC10.

B Experimental Instructions for C10 and NC10

Each experimental session consisted of two parts. First, the instructions for Part 1 were distributed and read aloud by the same person in every session. After the basic decision situation was described, subjects in C10 were given time to answer the control questions on the screen. The experiment did not advance until all subjects were able to correctly answer each control question. Subjects were permitted to ask for assistance or clarification from the person reading the instructions. After all subjects had correctly answered each control question, the remaining instructions were read aloud and subjects made their Part 1 decisions (the FGF strategy method). Subjects in NC10 proceeded directly from the description of the basic decision situation to the remaining instructions and then made their Part 1 decisions (the FGF strategy method). Only after Part 1 was completed, were the subjects informed about Part 2 of the experiment. Instructions for Part 2 were distributed and read aloud, then subjects made their decisions. At the end of the experiment, subjects were paid privately by check.

In this appendix, we first reproduce the experimental instructions (for both Part 1 and Part 2) for C10. The instructions for NC10 were identical except for the part labeled **Control Questions**, which was removed. After the instructions, we provide screenshots showing the 10 control questions that were asked in C10.

Experimental Instructions

Thank you for participating in this experiment. Please give us your full attention and follow the instructions carefully. Please do not attempt to communicate with other subjects, or engage in any other activities during the course of the experiment.

At the end of the experiment, you will be paid privately, based on the payoffs you earn and the show-up fee of $10. How much you earn depends partly on your own decisions, and partly on the decisions of others. Your earnings in the experiment will be denominated in **tokens**. At the end of the experiment, these earnings will be converted to US dollars according to the exchange rate **20 tokens = 1 US Dollar**.

All participants will be divided into groups of five members. **Other than the experimenters, nobody knows the identity of the other members in their group.**

B.1 The decision situation

You will learn how the experiment will be conducted in a moment. We first introduce you to the basic decision situation. After the decision situation is described, you will have the opportunity to answer some control questions that will be displayed on your screen that help you to understand the decision situation.

You will be a member of a group consisting of **5 people**. Each group member will be given **20 tokens** and must decide how to allocate these 20 tokens between a **group account** and an **individual account**. Your investment to your individual account can be any integer from a minimum of 0 up to the maximum of 20 tokens. Likewise, your investment to the group account can be any integer from a minimum of 0 up to a maximum of 20 tokens. However, the sum of your investments into the two accounts must be exactly 20 tokens. Thus, if you invest some number x tokens into the individual account, the other $20 - x$ tokens will be invested in the group account.

B.1.1 Your income from your individual account

You will earn one token for each token you put into your individual account. For example, if you put 20 tokens into your individual account (and therefore put 0 tokens into the group account) your income from the individual account will be 20 tokens. If you put 6 tokens into your individual account your income from the individual account will be 6 tokens. **Only you can earn income from your individual account.**

B.1.2 Your income from the group account

Each group member will profit equally from the amount you invest into the group account. At the same time, you will also earn some income from the other group members' investments in the group account. Specifically, the income **for each group member** from the group account will be determined as follows:

Income from the group account
= (*sum of all tokens invested in the group account*) $\times 0.5$

If, for example, the sum total of all investments in the group account is 60, then you and the other members of your group will each earn $60 \times 0.5 = 30$ tokens from the group account. If the sum total of all investments in the group account is 10, then you and the other members of your group will each earn $10 \times 0.5 = 5$ tokens from the group account.

B.1.3 Total Income

Your total income is the sum of your income from your individual account and your income from the group account:

Total Income
= *Income from your individual account* + *Income from the group account*
= (20 - your investment in group account) + $0.5 \times$ (sum total of all tokens invested in the group account)

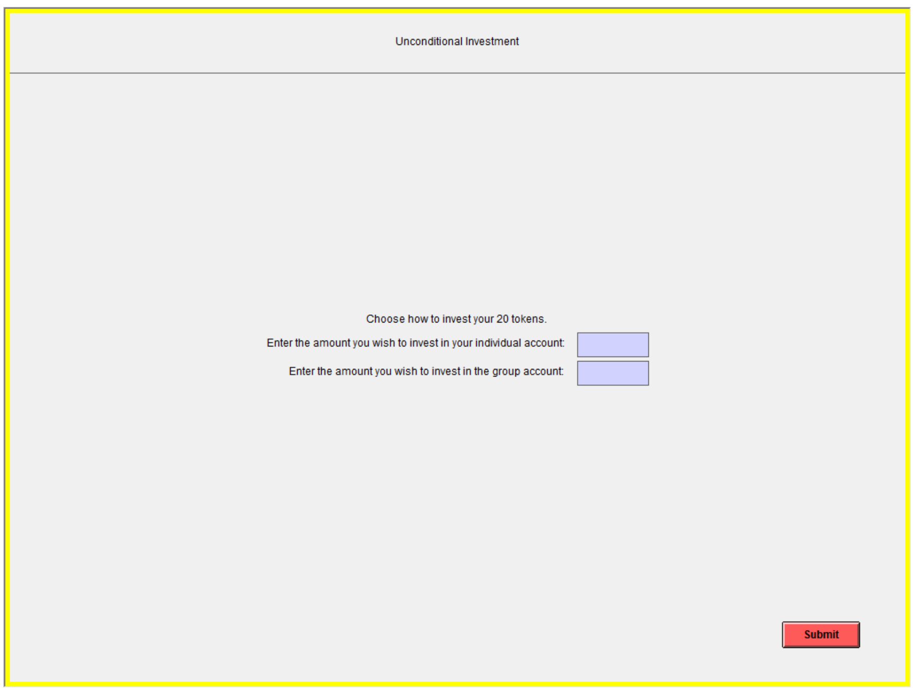
B.1.4 Control Questions

Please answer the control questions that appear on your screen. They will help you to gain an understanding of the calculation of your income, which varies with your decision about how to allocate your 20 tokens. *Once everyone has correctly answered all of the questions, we will proceed with the instructions.*

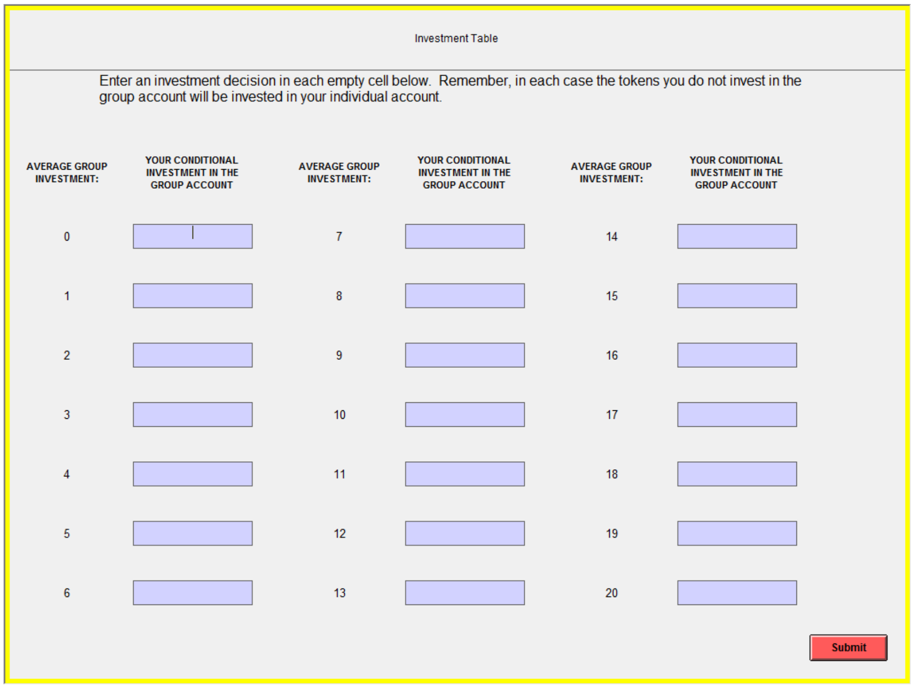
B.2 Instructions for the experiment

Part 1 of the experiment includes the decision situation just described to you. You will be paid at the end of the experiment based on the decisions you make. The experiment will only be conducted **once**. You will have 20 tokens to allocate. You can invest them into your individual account or into the group account. Each group member has to make **two types** of decisions in this experiment, which we will refer to below as the **"unconditional investment"** and **"investment table"**.

- You will first decide how many of the 20 tokens you want to invest into your individual account and how many tokens you want to invest into the group account. Your investment into the group account will be called your **unconditional investment**. You will indicate your decision in the following computer screen:



- Your second task is to fill in an **"investment table"** where you indicate how many tokens **you want to invest** in the group account, **for each possible average investment of the OTHER group members** (rounded to the next integer). Thus, you can condition your investment on the average investment made by the other group members. This should become more clear to you if you look at the table in the screenshot below.



In the table, the numbers in each column are all of the possible (rounded) average investments that could be made by the **other** group members to the group account. Your task is to insert, into each input box, the number of tokens you wish to invest in the group account, if the average investment chosen by the other group members is the amount listed to the left of that input box.

You need to make an entry into each input box. You can insert **any integer numbers from 0 to 20** in *each* input box. Note that, for each input box, you only need to enter the amount you would like to invest into the group account. The remaining tokens will be automatically placed into your individual account.

After all participants in the experiment have made an unconditional investment and have filled in their investment table, a random mechanism will select **one group member** from every group. For the randomly selected subject in your group, the **payoff-relevant decision will be determined by their investment table**. For the other subjects in your group, the payoff-relevant decision will be their **unconditional investment**.

You do not know whether the random mechanism will select you when you make your unconditional investment decision or when you fill in the investment table. You will therefore have to think carefully about both types of decisions because either one can become payoff-relevant for you. Two examples should make this clear.

Example 1. Assume that **the random mechanism selects you. This means that your payoff-relevant decision will be determined from your investment table.** The relevant decisions for the other four group members will be their unconditional investments.

Suppose that the others in your group chose unconditional investments of 0, 2, 4, and 6 tokens into the group account. Then the average investment of these four **others** is 3 tokens. If you indicated in your investment table that you will invest 2 tokens if the others contribute 3 tokens on average, then the total investment in the group account is given by $0+2+4+6+2=14$ tokens. Therefore, all the members of your group will earn $0.5\times 14=7$ tokens in income from the group account, in addition to their respective incomes from their individual accounts.

Example 2. Assume that **the random mechanism did not select you. This means that your payoff-relevant decision is your unconditional investment.** Likewise, for three of the other group members (who were not selected by the random mechanism), the payoff-relevant decisions are their unconditional investments.

Suppose that your unconditional investment is 14 tokens, while the unconditional investments for the other three are 16, 18, and 20 tokens. Thus, the average investment in the group account made by you and these three other players is 17 tokens. For the other remaining group member, who is selected by the random mechanism, the payoff-relevant decision will be determined from their investment table. If the randomly selected group member indicated in their investment table that they will invest 18 tokens if the average investment by the others is 17 tokens, then the total investment in the group account is given by $14+16+18+20+18=86$ tokens. Thus, all group members will earn $0.5\times 86=43$ tokens from the group account, plus their respective income from their individual accounts.

B.3 A second experiment

We will now conduct another experiment. For this experiment, the exchange rate will be **150 tokens = US $1**. This experiment lasts for **10 periods**, in which you and the other members of a group have to make decisions.

As in the other experiment, every group consists of **5 people**. Your group in this experiment will be different from your group in the other experiment. That is, before this experiment begins, you will be randomly rematched into a new group of five subjects. However, this is the only time you will be rematched. Your group will consist of the same people in all 10 periods. There are no additional experiments after these 10 periods.

The decision situation is the same as that described in Section 1 of these instructions. However, instead of having 20 tokens to allocate, each member of the group has to decide how to allocate **100 tokens** between their individual account and a group account. Your income will be determined in the same way as before, accounting for this one main difference. That is,

Total Income
= *Income from your individual account* + *Income from the group account*
= (100 - your investment in the group account) + 0.5 × (sum of all tokens invested in the group account)

The decision screen, which you will see in every period, looks like this:

In every period, you face the same decision situation. On the decision screen, in the input boxes provided, you must indicate how many of your 100 tokens you want to invest in your individual account, and how many tokens you want to invest in the group account. Your investments can be any integer numbers from 0 to 100, with the restriction that the sum of your investments must be exactly 100 tokens.

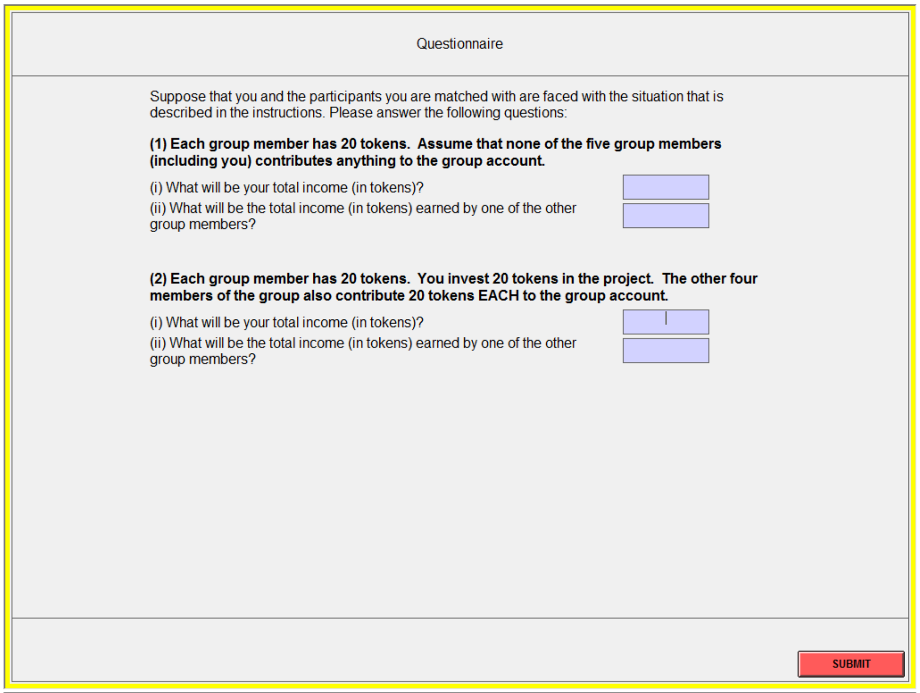
B.4 Overall Earnings

After the 10 periods of the second experiment are over, the whole experiment is finished and your overall earnings will be calculated as follows.

> **Overall Earnings** = Total Income from the first experiment (in dollars) + Total Income from all 10 periods of the second experiment (in dollars) + **Show-up Fee (which is $10)**.

Control Questions

Below, we reproduce screenshots of the control questions used in C10.



Questionnaire

Suppose that you and the participants you are matched with are faced with the situation that is described in the instructions. Please answer the following questions:

(1) Each group member has 20 tokens. Assume that none of the five group members (including you) contributes anything to the group account.

(i) What will be your total income (in tokens)?

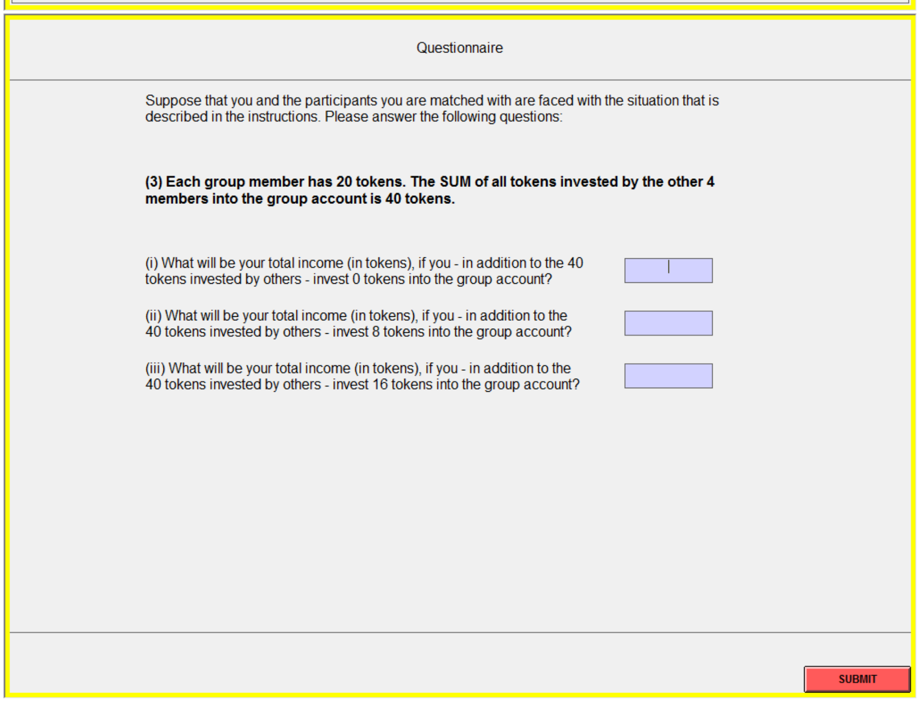
(ii) What will be the total income (in tokens) earned by one of the other group members?

(2) Each group member has 20 tokens. You invest 20 tokens in the project. The other four members of the group also contribute 20 tokens EACH to the group account.

(i) What will be your total income (in tokens)?

(ii) What will be the total income (in tokens) earned by one of the other group members?

SUBMIT



Questionnaire

Suppose that you and the participants you are matched with are faced with the situation that is described in the instructions. Please answer the following questions:

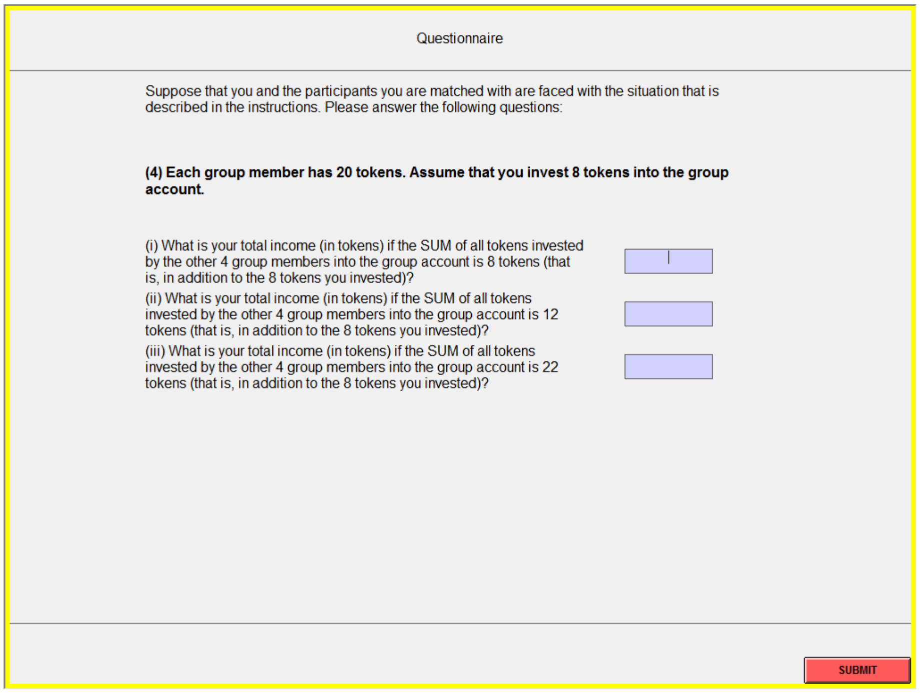
(3) Each group member has 20 tokens. The SUM of all tokens invested by the other 4 members into the group account is 40 tokens.

(i) What will be your total income (in tokens), if you - in addition to the 40 tokens invested by others - invest 0 tokens into the group account?

(ii) What will be your total income (in tokens), if you - in addition to the 40 tokens invested by others - invest 8 tokens into the group account?

(iii) What will be your total income (in tokens), if you - in addition to the 40 tokens invested by others - invest 16 tokens into the group account?

SUBMIT


Questionnaire

Suppose that you and the participants you are matched with are faced with the situation that is described in the instructions. Please answer the following questions:

(4) Each group member has 20 tokens. Assume that you invest 8 tokens into the group account.

(i) What is your total income (in tokens) if the SUM of all tokens invested by the other 4 group members into the group account is 8 tokens (that is, in addition to the 8 tokens you invested)?

(ii) What is your total income (in tokens) if the SUM of all tokens invested by the other 4 group members into the group account is 12 tokens (that is, in addition to the 8 tokens you invested)?

(iii) What is your total income (in tokens) if the SUM of all tokens invested by the other 4 group members into the group account is 22 tokens (that is, in addition to the 8 tokens you invested)?

SUBMIT