Conditional Cooperation: Review and Refinement*

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Abstract

Fischbacher, Gächter, and Fehr (2001), henceforth FGF, introduced an experimental design to measure conditional cooperation in public goods games. We collected data from 17 replication studies of FGF and observed that the criteria used to identify types are not always consistent. We refine FGF's definition of types to resolve ambiguous cases in FGF and its replications. Using our new classification scheme, we find in our combined data set with more than 7,000 individual observations that FGF's original findings are by-and-large stable: conditional cooperation is the predominant pattern; free-riding is frequent, while non-minimal, unconditional cooperation is very rare.

JEL-Classification: H41; C91; C72

Keywords: Conditional cooperation; public goods game; replication

1 Introduction

With more than 2,000 citations on Google Scholar, Fischbacher, Gächter, and Fehr (2001), henceforth FGF, is among the most impactful contributions on social dilemmas in the field of experimental economics. The design has been widely replicated and serves as the standard tool to identify types of players in public goods games.

We collected data from 17 replication studies of FGF to build a combined data set of 7,107 individual patterns. Reviewing the replications, we noticed that the criteria used to identify types are not always consistent. Based on FGF's classification we propose a refined definition of types, which we apply to all observations available to us. Applying our new classification scheme, we find in our combined data set that FGF's original findings are by-and-large stable across a range of game parameters.

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2 Design & Procedures

In the public goods game n symmetric players simultaneously choose a contribution $g_i \in [0, e]$. Monetary payoffs are

$$\pi_i(g_i, g_{-i}) = e - g_i + a \sum_{j=1}^{n} g_j, \tag{1}$$

where a is the marginal per capita return. In the FGF version this game is played as an extensive form game, where $n-1$ players simultaneously choose their contribution. Then player i learns the average contribution of the other players $\bar{g}_{-i}$, rounded to K increments of the endowment e, and chooses his contribution g_i.

In the experiment, g_i is elicited using the strategy method. Subjects are presented with a vector of rounded average contributions $\bar{\mathbf{g}}_{-i} = \{\bar{g}_1, \bar{g}_2, \ldots, \bar{g}_K\}$, with $\bar{g}_k = \frac{(k-1)e}{K-1}$ for $k = 1, 2, \ldots, K$. Subjects indicate their conditional contribution as a vector $\mathbf{g}_i = \{g_1, g_2, \ldots, g_K\}$. To identify types we will calculate statistics based on the contribution vector $\mathbf{g}_i$. We denote by ρ the Pearson correlation coefficient of the elements in $\mathbf{g}_i$ and $\bar{\mathbf{g}}_{-i}$, and by $\rho_{k]}$ the correlation calculated using only the elements from 1 to k, and by $\rho_{[k}$ using the elements k to K.

2.1 Refining the definition of types

We apply the following definitions of types, which is a refinement of the classification scheme introduced by FGF.[1]

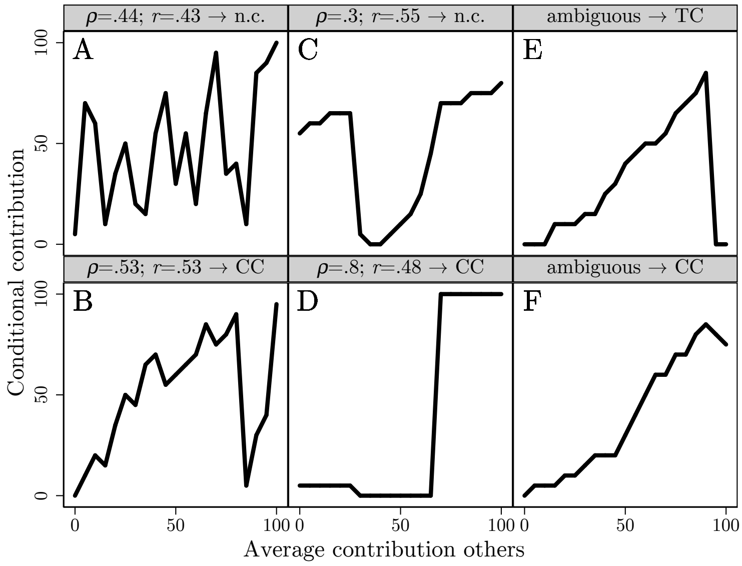
- Free rider (FR):
  $g_k = 0$ for $k = 1, 2, \ldots, K$
- Unconditional cooperator (UC):
  $g_k = c$ with $0 < c \leqslant e$ for $k = 1, 2, \ldots, K$
- Conditional cooperator (CC):
  $\rho \geqslant \frac{1}{2}$, or $g_{k-1} \leqslant g_k$ for $k = 2, \ldots, K$ and $g_1 < g_K$
- Triangle cooperator (TC):
  $\exists\, \kappa \in \{3, 4, \ldots, K-2\}$ such that $\rho_{\kappa]} \geqslant \frac{1}{2}$ and $\rho_{[\kappa} \leqslant \frac{1}{2}$, or
  $\exists\, \kappa \in \{2, 3, \ldots, K-1\}$ such that $g_{k-1} \leqslant g_k$ for $k \leqslant \kappa$ and $g_k \geqslant g_{k+1}$ for $k \geqslant \kappa$ and $g_1 < g_\kappa$ and $g_K < g_\kappa$

The definition of the type free rider (FR) is identical to the definition given in FGF. Unconditional cooperators (UC) contribute a constant amount irrespective of the others' contributions.[2] Like FGF, we characterize conditional cooperators (CC) by either a monotonically increasing pattern or a strongly positive correlation. We differ from FGF in the criterion we apply to measure

[1] We implemented this classification scheme as a Stata procedure (`cctype`), available upon request.

[2] FGF did not discuss the type UC, possibly because there was none in their data. We introduce this type because the fact that it is only rarely observed is informative for theories of social preferences. It suggests that only a small fraction of cooperative behavior is motivated by (unconditional) altruism.

Figure 1: Examples for the classification of patterns.



Notes. The title of the panels indicate Pearson correlation (ρ) and Spearman correlation (r) of the respective pattern, and the type according to our classification. **A**: weak correlation, not classified (n.c.); **B**: sufficient correlation, classified as CC; **C**: strong Spearman but weak Pearson correlation, n.c.; **D**: weak Spearman but strong Pearson correlation, CC; **E** is compatible with CC and TC, the ambiguity is resolved in favor of TC; for **F** the ambiguity is resolved in favor of CC.

positive correlations. The original definition of CC types in FGF required a positive and significant rank correlation ($r > 0$, $p < .01$). As there is a one-to-one correspondence between the p-value and $|r|$ (for a given number of observations), the two requirements are equivalent to asking for $r > .5487$ in case of $K = 21$. We depart from this definition in three ways: (i) we use only the correlation coefficient, (ii) we propose a slightly more generous threshold; and (iii) we use the Pearson correlation (ρ) instead of the Spearman rank correlation (r).

Using ρ instead of the p-value has the advantage that the former does not depend on the number of observations and can be used for experiments with any K. As threshold for what constitutes a strong correlation we demand $|\rho| \geqslant \frac{1}{2}$. This threshold corresponds to what Cohen (1992) defines as a large effect size. In Figure 1 we plot patterns to illustrate the definition of types. Panel A shows a pattern with a correlation below the threshold and is therefore not classified (n.c.). Panel B shows a case that we classify as CC, but does not reach the threshold set by FGF. Panel C and D illustrate why we deem Pearson correlation (ρ) preferable to Spearman rank correlation (r). Panel C shows a pattern that would qualify as CC under rank correlation but not with Pearson correlation. The ranking of the Spearman procedure reduces the weight of the strong deviations in the intermediate range. Panel D shows a case that would not be classified as CC when using rank correlation, although being highly positively correlated according to Pearson correlation. The reason is that the relatively modest decrease of contributions at low average contributions of others has a high weight when the correlation is based on ranks.

Finally, the patterns of triangle cooperators (TC) reach a maximum contribution at κ. The criteria demands either strong positive (negative) correlation to the left (right) of κ (using at least three contributions), or monotonically increasing (decreasing) contributions to the left (right) of κ (using at least two contributions).

The definitions of CC and TC are not mutually exclusive. To get an unambiguous classification we apply the following additional criterion, which relates the rightmost conditional contribution to the average contribution in the pattern, $\hat{g}_i = \frac{1}{K}\sum_{k=1}^{K} g_k$:

- For patterns qualifying as TC and CC:
  Classify as CC if $g_K > \hat{g}_i$, else classify as TC

The idea behind this criterion is to separate cases where the drop in contributions is relatively strong (TC) from those which exhibit only a modest drop at high average contributions of others (CC). Figure 1 provides two examples for which the ambiguity is resolved in favor of TC (Panel E) and CC (Panel F).

2.2 Data

We collected data of studies closely replicating FGF with a sample of at least the original FGF study (44). Table 1 provides an overview of the studies, including the number of observations and the game parameters used. Each study is assigned a short key consisting of the authors' initials and the year of publication, in some cases followed by a lowercase letter. No letter indicates standard conditions (student sample), r indicates that the data stem from experiments with representative samples, and m indicates experiments using a Mechanical Turk sample. In addition, t indicates that the game was framed as a common pool problem, where subjects can take money from the common project instead of contributing.

3 Results

The last two columns of Table 1 show the distribution of cooperation types, the left column according to the original studies, the right column according to our refined classification scheme.[3] The percentage of FRs is identical in both columns for all studies except for Aimone et al. (2013), whose criteria for FRs allowed for one deviation. For CCs our classification leads sometimes to higher percentages (e.g., Kocher et al. 2008; Makowsky et al. 2014) and sometimes to lower percentages (e.g., Fischbacher and Gächter 2010; Fischbacher, Gächter, and Quercia 2012). For TCs our classification leads generally to higher percentages. Overall, while the overlap of the classification schemes is substantial, there are still important differences: 96.4 percent of all CCs according to the refined classification were also classified as such by the authors of the respective study. For TCs the variation is more substantial with 71.6 percent of the patterns we classify as TCs are classified as the same type in the respective original study.[4]

[3]UCs are not included in Table 1 because they are not treated as a separate category in most of the studies.

[4]For this analysis we restrict the sample to those studies for which the respective type information was available.

Table 1: Game parameters and type distribution by study

Study	Key	obs.	Game parameters a	e	n	K	Types (in %) Original (CC/FR/TC)	Refined CC/FR/TC
Aimone et al. (2013)	AIMR13	272	.4	10	4	11	(47.8/23.3/15.1)	51.5/21.3/17.6
Abeler and Nosenzo (2015)	AN15	174	.4	20	4	21	(67.8/15.5/ 4.0)	66.7/15.5/12.6
Cubitt et al. (2017)	CGQ17	592	.4	20	4	21	(62.7/22.3/ n.a.)	60.8/22.3/12.2
	CGQ17m	959	.4	20	4	21	(77.6/12.0/ n.a.)	77.0/12.0/ 3.0
Dariel and Nikiforakis (2014)	DN14	96	.5	20	3	21	[67.7/18.8/10.4]	68.8/18.8/10.4
Fischbacher and Gächter (2010)	FG10	140	.4	20	4	21	(55.0/22.9/12.1)	53.6/22.9/15.0
Fischbacher, Gächter, and Fehr (2001)	FGF01	44	.4	20	4	21	(50.0/29.5/13.6)	50.0/29.5/13.6
Fischbacher, Gächter, and Quercia (2012)	FGQ12	136	.4	20	4	21	(72.8/14.7/ 4.4)	69.9/14.7/11.0
Fosgaard et al. (2014)	FHW14rt	676	.5	50	4	11	(56.8/21.3/ 6.2)	56.5/21.3/ 8.3
Fischbacher, Schudy, et al. (2014)	FST14	228	.4	20	4	21	(63.2/22.8/ 9.6)	61.0/22.8/12.7
Gächter et al. (2017)	GKQ17	444	.4	20	4	21	(62.2/17.6/ n.a.)	58.6/17.6/14.9
	GKQ17t	432	.4	20	4	21	(40.7/28.9/ n.a.)	39.6/28.9/14.4
Herrmann and Thöni (2009)	HT09	160	.4	20	4	21	(55.6/ 6.3/ 7.5)	55.0/ 6.3/14.4
Kamei (2012)	K12	350	.3/.4	20	5	21	(50.0/25.7/14.0)	53.1/25.7/15.7
Kocher et al. (2008)	KCKNS08	108	.6	20	3	21	(55.6/22.2/ 7.4)	60.2/22.2/ 9.3
Makowsky et al. (2014)	MOP14	96	.4	10	4	11	(51.0/13.5/17.7)	61.5/13.5/20.8
Thöni et al. (2012)	TTW12r	1488	.5	50	4	11	(69.2/14.6/ 6.2)	69.0/14.6/ 7.3
van Miltenburg et al. (2014)	VBBR14	184	.4	20	4	21	[51.1/30.4/12.0]	51.1/30.4/12.0
Volk et al. (2012)	VTR12	72	.4	20	4	21	(58.3/25.0/ 2.8)	59.7/25.0/ 4.2
Weber et al. (2018)	WWG18	456	.4	20	4	21	(52.9/27.4/ n.a.)	51.3/27.4/13.4
Total		7107					(61.7/19.3/ n.a.)	61.3/19.2/10.4

Notes. Overview of the studies. Key identifies the data set in Figure 2. The key is constructed from the authors initials and the year of publication. The final lowercase letter(s) indicate subject pool and framing variations. No letter: standard FGF design in a laboratory environment with student subjects; r: internet experiment with representative sample; m: Mechanical Turk sample; t: take frame. The intermediate columns show the number of observations (obs.) and the parameters used in the respective study. The last two columns show the distribution of CC, FR, and TC types in percentages. Numbers in parentheses show the types as reported in the orginal article (), or as imputed by us using the FGF scheme []. Rightmost column shows the distribution of types according to the refined definition.

Figure 2 shows the distribution of types graphically. We sort the data by frequency of CCs, which range from around 40% up to 77%, with an overall average of 62%. The extremes of the distribution stem from non-standard replications. The lowest share of CCs is observed in an experiment using the take-frame, which consistently lowers the share of CCs (and increases the share of FRs).[5] The highest share is observed in an experiment conducted with an Mechanical Turk subject pool. Considering only standard replications (normal frame, convenience sample), the fraction of CCs ranges from 50% up to 70%. FRs range from seven to 30%, with an average of 18.7%.

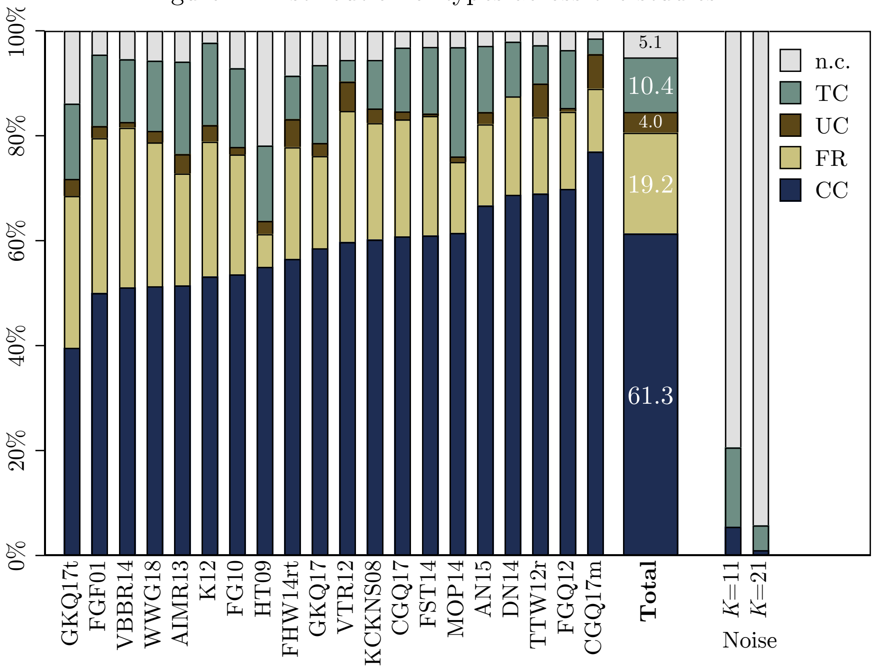
Despite the variability of game parameters across studies, we reliably find the following to be true: (i) CC is by far the most frequent pattern. In fact, in almost all standard replications of FGF, CC is at least twice as frequent as the second most frequent type (including the residual category); (ii) the second most frequent type is typically FR followed by TC, (iii) UC is very rare.

Thus, while there seem to be differences in the distribution of types across studies, we argue that the results should be read as a remarkable demonstration of the replicability of the FGF design. Figure 2 also demonstrates that the 30% of FRs reported in FGF is roughly the upper bound and that the 50% of CCs reported in FGF is the lower bound of what replications of the standard design find.

Given the relatively broad definition of CC and TC types one might wonder whether these categories capture just about any pattern. The two rightmost bars in Figure 2 show the frequency of types in a large set of randomly gener-

[5] This effect is observed in two large data sets from convenience samples (cf. GKQ17 and GKQ17t), and in representative samples (cf. TTW12r and FHW14rt, whose data stem from the same online experiment).

Figure 2: Distribution of types across the studies.



Notes. Thin bars on the left indicate results for individual studies, the bold bar shows the overall average. Thin bars on the right indicate the distribution of types for randomly generated conditional contribution patterns for games with 11 and 21 conditional contributions. CC: Conditional cooperator; FR: Free rider; UC: Unconditional cooperator; TC: Triangle cooperator; n.c.: not classified.

ated patterns, for $K = 11$ and 21 respectively. While TC occur in frequencies comparable to the empirical data, CC (and all other categories) are much more frequent in the empirical data.

4 Conclusion

We collected and combined data from 17 replication studies of FGF and offered a refined classification scheme to resolve ambiguities in previous research about how to define cooperation types. Using this classification, we find that FGF's original findings about the relative frequency of types are very stable.

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