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Does the Size of the Action Set Matter for Cooperation?

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Abstract

We use the voluntary contribution mechanism to investigate whether smaller action sets lead to higher cooperation rates. We find that this is the case for groups of four players.

JEL Classification: C92, D70, H41

Keywords: action set, voluntary contribution mechanism, prisoner's dilemma.

1 Introduction

The voluntary contribution mechanism (VCM) is often referred to as the "n-person Prisoner's Dilemma". The two games share similar payoff properties and both have a unique Pareto-inefficient Nash equilibrium. However, despite this affinity, actual behavior in the two games is often different: Sally (1995, p.62) writes that "there are numerous [prisoner's dilemma] experiments in which subjects cooperated very frequently and effectively". In contrast, cooperation almost always unravels with repetition in VCM experiments (e.g. Zelmer, 2003).[1]

The most notable difference between the two games is the size of the action set. Players in prisoners' dilemmas (PDs) can select from two actions (cooperate, defect), while players in the VCM usually have many more actions from which to choose. It is therefore possible that the higher rates of cooperation in PD are (partly) due to the smaller size of the action set. However, given that experiments tend to differ on more than one dimension (e.g. group size, relative payoffs) it is difficult to draw robust conclusions from the existing data.

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[1] To the best of our knowledge, this difference has not been previously mentioned in the literature. Roth (1988) writes: "Curiously, the experimental literatures concerned with the two problems seldom refer to each other" (p.991).

This paper investigates whether the size of the action set matters for cooperation. This fundamental question has surprisingly been overlooked despite the large body of research examining factors that promote cooperative behaviour in social-dilemma experiments and inspite of the observed differences in behaviour in PD and VCM. Our paper aims to fill this gap in the literature.

2 The Experiment

2.1 The Voluntary Contribution Mechanism

Individuals are randomly divided into groups of size G. Every participant is given an endowment of 10 EMU (Experimental Monetary Units). Players decide simultaneously and without communication how much of the endowment to contribute to a public account, c_i, where $0 \leq c_i \leq 10$. The rest $(10 - c_i)$ remains in the player's own account. In addition to the money that player i keeps, i receives a fixed percentage of the group's total contribution to the public account, α, where $0 < \alpha < 1 < n\alpha$. This implies that the earnings of player i are given by

$$\pi_i = 10 - c_i + \alpha \sum_{j=1}^{n} c_j. \tag{1}$$

The treatment variable is the size of the action set. In the (R)estricted treatments players have two actions, $c_i \epsilon \{0, 10\}$. In the (U)nrestricted treatments players have eleven actions, $c_i \epsilon \{0, 1, 2, ..., 10\}$. In essence, the former is a PD, while the latter is a standard VCM.

2.2 Procedures

The game is repeated 20 times without changing group composition. As PDs are typically studied using groups of two individuals and VCMs using groups of four individuals we decided to examine the impact of the action set under both group sizes. That is, $G \epsilon \{2.4\}$. This provides a robustness check for our findings.

In the treatments with $G = 2$, the return from the public account is $\alpha = 0.7$. In treatments with $G = 4$, $\alpha = 0.4$. Note that our aim is to test the impact of the action set in two different cases and not to compare differences across group sizes. Hence, the experiment does not control for the increase in the social benefit that results from the increase of the group size (see Isaac et al., 1994). Table 1 summarizes the experimental design.

The number of repetitions, equation 1, the instructions, and the values of α and G were common knowledge amongst participants. The conversion rate used was 7 EMU= 1 Australian

Dollar. Sessions lasted approximately one hour and average earnings were A$34.6 for group size $G = 2$, and A$32.4 for $G = 4$. The experiment was conducted using z-Tree (Fischbacher, 2007).

3 Results

The fact that the choice variable is discrete in treatment U and binary in treatment R raises the question of how to compare behavior across treatments. One way of doing this is by comparing the number of times that subjects contributed zero (or ten) in each treatment. This comparison is however not informative as there are many cases in U where $0 < c_i < 10$. As a result, the number of observations where $c_i = 0$ and $c_i = 10$, is higher in treatment R for all G.

Another way to compare behavior is to transform the discrete variable to a binary one. We define variable $C_i^{U,t}$ which takes the value 1 if individual i in treatment U contributes more than 5 EMU in period t and the value 0 otherwise. Variable $C_i^{R,t}$ is constructed analogously taking the value 1 if individual i in treatment R contributes 10 and the value 0 otherwise. This definition is simple and we believe it is the most appropriate for comparing behavior across treatments. The idea is that an individual who contributes more than 5 EMU in treatment U would be more likely to have contributed all of his endowment in treatment R than not.

Figures 1 and 2 plot the frequency of $C_i^{T,t}$, $T \epsilon \{U, R\}$, over time in each treatment for $G = 4$ and $G = 2$, respectively. For simplicity, we say that an action is "cooperative" when $C_i^{T,t} = 1$. Figure 1 shows that, despite the lax definition in treatment U, there are more cooperative actions when the action set is restricted (p-value$= .04$; Fisher's exact test). In total, 24 percent of the actions in R can be classified as cooperative, in contrast to 12 percent in U. The frequency of $C_i^{T,t}$ declines over time in both treatments.

Figure 2 shows that the size of the action set does not affect behavior when $G = 2$. While there seems to be some difference in the number of cooperative actions in the first 5 periods this difference disappears over time (p-value$= .67$; Fisher's exact test).[2] In both treatments, nearly half of the actions can be classified as cooperative for most of the experiment.[3]

Table 2 reports the results from probit regressions with group random effects. The regression analysis allows us to control for time effects, individual characteristics and also the decisions of other group members in the previous period. The dependent variable is $C_i^{T,t}$. As in-

[2] This is consistent with the findings in Huck et. al. (2002) who study two-person Stackelberg experiments and action sets of size three and fifteen.

[3] For completeness we report that the average group contribution to the public account across periods was 9.45 in R and 8.04 in U when $G = 4$, and 10.37 in R and 10.53 in U when $G = 2$. These differences are not significant accordin to a Mann-Whitney test (p-value$> .3$).

dependent variables we include *Average Contribution of Others in t-1* $\equiv (\sum_{j=1,j\neq i}^{n} c_j^{t-1})/(n-1)$, and the interaction of this variable with treatment dummy U, a gender dummy (*Male*), a dummy for academic background in Economics (*Economics*), and period dummies.

The results show that when $G = 4$, individuals are more likely to take a cooperative action in treatment R the higher the contribution of their peers is. However, this is not the case in treatment U as indicated by the negative coefficient of the interaction term. When $G = 2$, the likelihood that an individual takes a cooperative action increases with the contribution of his peers irrespective of the size of the action set. This likelihood is even greater in treatment R.

4 Discussion

The results from the experiment show that groups of four individuals cooperate more with a restricted action set. No effect is observed for groups of two individuals. What could explain these findings?

One explanation could be that individuals make errors. Restricting the available choices, however, should help subjects in discovering their dominant strategy. Moreover, the "error" of contributing the full endowment is more costly than the "error" of contributing a smaller fraction of the endowment. Therefore, quantal-response equilibrium predicts that subjects in our experiment should be less likely to err when the action set is restricted (see Palfrey and Prisbrey, 1996). Hence, this explanation cannot account for our results.

Another explanation is that individuals are forward-looking and believe that their contributions have a signaling value. Hence, by contributing they might encourage others to do the same. Isaac et al. (1994) propose such a model in which each individual is assumed to have a subjective probability function about the likelihood of his signal being successful.[4] A well-known fact is that many individuals are willing to contribute to the public account as long as others do the same (Croson, 2007; Fischbacher et al., 2001). Conditional cooperators should be more likely to respond to a signal when there are only two actions available (contribute fully, don't contribute), as they know that all conditional cooperators will take the same action if they decide to reciprocate the signal. This is supported by the regression results for groups of four players in Table 2. Consequently, forward-looking individuals will also be more willing to signal when the action set is restricted.

The size of the action set is less important in the special case of two-player groups: player i can signal his intention to cooperate simply by continuing to contribute a high fraction of

[4] Players consider their signal to be successful if their profit in the following period exceeds their profit when everyone free rides.

his endowment even after player j contributes little to the public account. That is, player j's response does not depend on her expectation about how other's will react to the signal. In fact, for two-player groups, the unrestricted action set permits players to send less costly signals and makes responding less risky. This is supported by Figure 2 and the positive coefficient of the interaction term in Table 2.

Our results suggest that the size of the action set should not be ignored when analyzing situations where signaling could occur: larger action sets could make collusion more difficult, but also lead to efficiency losses in gift-exchange relations and social dilemmas.

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Table 1 – Experimental Design

Treatment	Action set size	Group size (G)	MPCR (α)	# of groups	% of cases in which c_i =0	% of cases in which c_i =10
1	2	2	0.7	15	48.2	51.8
2	11	2	0.7	14	23.4	34.8
3	2	4	0.4	10	76.4	23.6
4	11	4	0.4	10	52.9	5.8

Table 2 – Determinants of $C_i^{T,t}$

Dependent variable: $C_i^{T,t}$	G=2	G=4
Average Contribution of Others in *t-1*	0.06***	0.01*
	(0.02)	(0.01)
U * Average Contribution of Others in *t-1*	0.08***	-0.03**
	(0.03)	(0.01)
Male	0.30**	-0.07
	(0.14)	(0.10)
Economics	-0.27	-0.25***
	(0.17)	(0.10)
Constant	-0.22	-0.61**
	(0.34)	(0.22)
N	1102	1520
Log likelihood	-458.53	-608.24

Probit regressions with group random effects, Standard errors in parentheses, Regression includes period dummies, ** significant at 5%; *** significant at 1%

Figure 1 – Frequency of $C_i^{T,t}$ when G=4

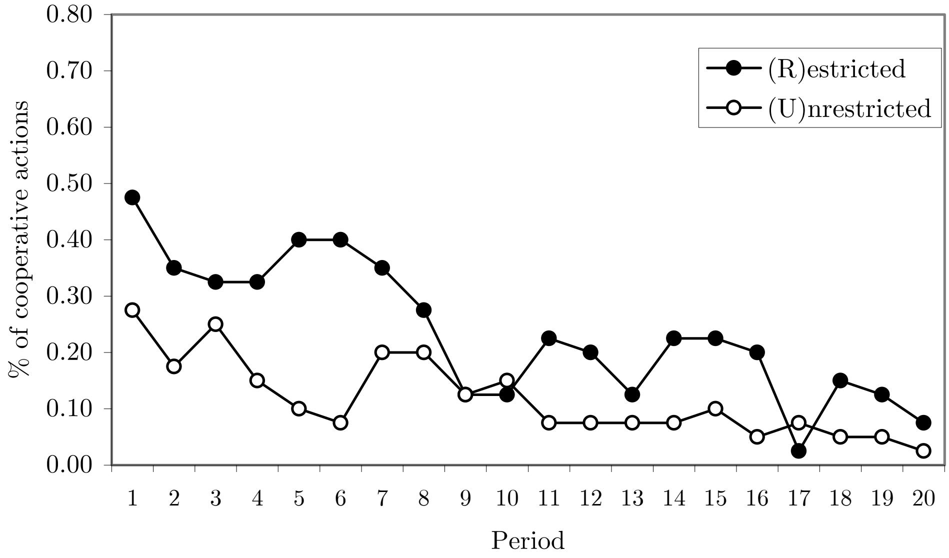

Figure 2 – Frequency of $C_i^{T,t}$ when G=2