DISPOSITION, HISTORY AND CONTRIBUTIONS IN PUBLIC GOODS EXPERIMENTS*

BY

ANNA GUNNTHORSDOTTIR[1], DANIEL HOUSER[2], KEVIN MCCABE[3]

This Draft: March 7, 2005

Keywords: Public goods; sorting; conditional cooperation; trust; reciprocity; voluntary contribution mechanism

JEL classification: C72, C92

Correspondence to:
Dr. Anna Gunnthorsdottir
Australian Graduate School of Management
Gate 11, Botany Street,
Randwick, NSW 2031
Australia
Email: annag@agsm.edu.au

* We thank the co-editor, David Grether, for comments that substantially improved this paper. Holly Ameden and Robert Kurzban provided useful discussion and ideas for this project. This paper is a substantive revision of Gunnthorsdottir, Houser, McCabe and Ameden (2001).
[1] Australian Graduate School of Management.
[2] Interdisciplinary Center for Economic Science & Department of Economics, George Mason University.
[3] Interdisciplinary Center for Economic Science & Department of Economics, George Mason University.

ABSTRACT

We design novel voluntary contribution mechanism experiments with human subjects to investigate the way previous experience and innate cooperative disposition interact to influence cooperative decision-making. We provide evidence that a subject's initial public contribution is a useful measure of her cooperative disposition. Inference regarding history effects is obtained by comparing treatments where subjects are randomly reassigned to groups, to treatments where subjects are grouped together based on similarities in their contribution decisions. Relative to random grouping, the latter treatment increases the frequency of interaction between subjects with cooperative dispositions, and leads to statistically significant increases in cooperators' investments in the public good. We find that the familiar decay in public contributions over rounds, when subjects are randomly assigned to groups, can be traced to reductions in contributions by those with cooperative dispositions. This reduction in turn results from their frequent interactions with free-riders.

DISPOSITION, HISTORY AND CONTRIBUTIONS IN PUBLIC GOODS EXPERIMENTS

I. Introduction

Property rights can privatize incentives for the provision of goods that confer public benefits. Unfortunately, it is often infeasible to implement a property rights system that truly privatizes incentives by making benefits proportional to investments. Nevertheless, there is substantial evidence, including Ronald Coase's (1974) historical research on Great Britain's lighthouse system, that suggests most public goods can be provided privately even without such a system. How then are public goods provided? We present data from public goods experiments, which suggest that higher rates of interaction among those with cooperative dispositions can lead to higher rates of investment in public goods by privately motivated individuals.

Our experiments are based on the voluntary contribution mechanism (VCM) (see, e.g., the seminal contribution of Isaac and Walker, 1988). The VCM environment includes $i = 1, \ldots, N$ subjects, each with positive endowment w_i. Subject i contributes g_i to the public good and leaves the remainder in a private account. The total contribution to the public good is summed over all the subjects' contributions; we will denote this aggregate by G. The key feature is that the return on investment in the public account differs from that in the private account. In particular, the return to each person on the total investment in the public account is given by r while, without loss of generality, the return on the private account is set to unity. This means that the payoff function for player i is:

$$\Pi(g_i, g_{-i}) = (w_i - g_i) + rG \qquad (1)$$

where g_{-i} represents the vector of contributions of everyone except subject *i*. As long as $r < 1$ it is easy to see that, given any arrangement of contributions by the other subjects, each player *i* maximizes her individual payoff by free-riding, that is, by contributing nothing to the public good. At the same time, if $rN > 1$ then it is Pareto optimal for each subject to contribute everything to the public good. The parameter "r" is the marginal per-capital return (MPCR). When designing VCM experiments the MPCR and the number of subjects are usually chosen to exploit the tension between free-riding and Pareto optimality.

Experimental research with the VCM has generated at least three widely replicated results (see, e.g., Ledyard, 1995 and Davis & Holt, 1993 for reviews). First, cooperation is higher than predicted by the standard theory of free-riding, although there is usually a subset of subjects who contribute very little to the public good. Second, total investment in the public account decays when the VCM is played for several rounds, typically ten, and in the last few rounds contributions are usually much lower than in the first few rounds. Third, there is substantial between-subject variation in contributions at each trial.

More recently, there has appeared mounting evidence that it is both appropriate and useful to classify subjects according to their cooperative dispositions. Andreoni (1995) speculated nearly a decade ago that the cause for the decay in public contributions over rounds might be that cooperators get discouraged by free-riders. In fact, if players can form groups at will at each round, cooperators attempt to cluster while defectors try to join these cooperator groups (Ehrhart and Keser,1999). Also, if given the option to play or not to play a prisoner's dilemma, those who choose to play are more cooperative, apparently because defector types tend to opt out (Orbell and Dawes, 1993; see also Bohnet and Kuebler, 2003, for a related result). Very recently, Ones and Putterman (2004), studying the effects of punishment, showed that the initial cooperative or non-cooperative tendencies that group members bring to a collective action situation affect collective outcomes, and that such tendencies are both heterogeneous and stable. Similarly, Kurzban and Houser (2004) find evidence of stable individual differences in cooperative dispositions.

Our paper experimentally investigates the way disposition and history (experience during the game) interact to affect a subject's cooperative decision-making. We compare contributions in a baseline, standard, 10-round VCM, where in each round subjects are randomly arranged into groups of four, to a condition where in each round subjects are sorted, without their knowledge, into groups of four like-contributors. The effect of this latter condition is to increase the frequency with which cooperators are matched with others who have the same disposition, while holding all other aspects of the environment fixed.

We find that both a subject's initial disposition to cooperate as well as the outcomes observed during play influence public contributions. We show that cooperative decay can be traced to reductions in the contributions of cooperators, and that free-riders play an important role in determining the rate of this decay. In particular, if cooperators meet free-riders sufficiently infrequently, then cooperators can often sustain their initial (relatively high) public contributions.

II. Procedures and Design

Our experiments were conducted at the Economic Science Laboratory at the University of Arizona. Subjects were 264 undergraduates recruited from the general student population. Each subject was seated at a private computer terminal, visually separated from others by blinders, and paid privately at the end of the experiment.

Each laboratory session included twelve subjects who made decisions into a standard, ten-round VCM. Subjects were told that each round their group would consist of four people including themselves. Each subject was given one hundred tokens at the beginning of each round to invest in either a private account, which returned one cent per token to that subject alone, or a group account, which returned cents at the specified MPCR to everyone in their group including themselves. After all twelve subjects made their contribution decisions they were separated into three groups of four. Each subject's earnings were calculated based on the group to which they had been assigned. Finally, subjects were given time to review their results. A new period began when all twelve subjects indicated that they were ready.

Our design's main feature is that subjects were grouped according to two different rules. The two group assignment rules were crossed with three MPCR levels, r=0.30, r=0.50 and r=0.75, resulting in a total of six cells. For r= 0.50, there were five experimental sessions per cell; for r = 0.30 and r=0.75, three sessions per cell. In the baseline condition subjects were assigned to groups at random and each round, each subject had an equal chance of being grouped with any three other subjects. In the "sorted" condition we used a different rule. Each round, after subjects had made their decisions, the four highest investors in the public account were placed into one group, the fifth through the eighth highest investors into another group and the four lowest investors into a third group.[1] Thereafter, earnings for that round were computed and earnings messages sent out to subjects. In both conditions the subjects' instructions included the same information about the nature of the assignment rule: "… *once everyone has submitted his or her investment decision, you will be assigned to a group with four members (including yourself). Your total group investment will then be determined and your experimental earnings calculated."*[2]

Our subjects had full information about the way their earnings would be determined: they were only not informed about the way in which their counterparts within their group would be assigned. Knowledge of the assignment rule could have lead to differences in strategic behavior and could have confounded our ability to draw inferences with respect to reciprocity effects. For example, a cooperator in the sorted condition who knows the assignment rule and contributes a relatively large amount might be doing so because she rarely meets free-riders, or she may just wish to be part of the "top" group. We kept our design free of such confounds by ensuring that the same information about assignment to groups was provided in each treatment.

Several additional aspects of our design deserve comment. First, at each round in the "sorted" condition, subjects are grouped according to their *current* contributions only. We do not use any lagged contribution information when we form groups. We will show that this procedure accomplishes our goal of reducing, relative to the random matching condition, the frequency with which free-riders and cooperators meet. Another important feature of our design is that, although subjects under different grouping rules do experience different feedback, the VCM's rules, particularly its payoff structure, are identical in all sessions. Any learning about its incentives should therefore occur in about the same way in all treatments. Finally, there is no reason to suspect that subjects in the sorted treatments knew they were being matched with like-contributors. In principle, a clever subject in the sorted condition could discover something about the grouping rule through systematic experimentation. However, the incentives to experiment are reduced by the fact that subjects knew that play was limited to ten rounds.

III. Results

III.A. Aggregates by Cell

Figure 1 plots mean contributions to the public account per period, separately for each cell of our design. Results from the random treatments are consistent with common findings in the public goods literature. In both the 0.75 and 0.50 MPCR conditions, cooperation in the random treatment seems higher than is plausibly consistent with free-rider theories, particularly in the early rounds. When the MPCR is 0.3, cooperation in the random treatment decays very quickly. Like Isaac and Walker (1988) and others, we find that when the MPCR is higher, contributions to the public account are higher as well, and the rate of cooperative decay is slower. Figure 1 also shows that within each MPCR condition the aggregate contributions in the sorted condition always exceed those in the random condition. Moreover, cooperative decay is slower in the sorted condition. When the MPCR is 0.3, contributions in the sorted condition begin at about 45/100 and decay only to 26/100, and in the two higher MPCR conditions within the sorted treatments there is little evidence of any aggregate decay.

III.B. Classifying Free-Riders and Cooperators

If subjects bring a stable cooperative disposition to a ten-round experiment, as the recent literature cited in section I suggests, then a subject's first-round contribution to the public good could reveal whether she is a free-rider or a cooperator. To explore this possibility, we type-classify someone who contributes 30 percent or less of his endowment *in the first round* as a "free-rider", and someone who contributes more than this as a "cooperator". It is worthwhile to emphasize that a subject is classified only once, and his classification does not change throughout the course of the experiment. Our cutoff value that separates free-riders from cooperators is similar to the one used by Isaac & Walker (1988), who first proposed contribution-based classifications and used a cut-point of 33 percent. Any such cut-point or classification procedure is unavoidably arbitrary to some degree, and other researchers have used different categorization templates (see, e.g., Andreoni & Petrie, 2004) or alternative methodologies (see, e.g., Kurzban and Houser, 2004 for an alternative procedure with the VCM; for alternative classification methodologies in other contexts see El-Gamal and Grether, 1995, Houser and Winter, 2004, Houser, Keane and McCabe, 2004, and Houser et. al., 2004). Our findings are robust both to the specific cutoff point chosen, as well as to the number of types we consider. For example, separating our subjects into three types, free-riders, cooperators and strong-cooperators, leads to conclusions that are substantively identical to those that we report below.

As a practical matter, we will show that our classification procedure is quite useful in helping to organize and to understand our experiment's data. In particular, a subject's initial contribution reveals whether she is a free-rider or a cooperator, and controlling for this allows us to substantially clarify the sources of patterns observed in our data.

III.C. Comparing History Effects Between Treatments

We define a subject's round-t "history" as their experience of aggregate contributions by others she has been grouped with during the experiment up to and including round t-1. We naturally expect that a subject's history will affect her decisions, and that this effect will be different for cooperators and free-riders. In particular, given any history, we expect that a subject classified as a free-rider should contribute less on average than a cooperator with that same history. Moreover, the vast reciprocity literature leads us to expect that subjects who have experienced more cooperative histories will tend to be more cooperative than otherwise identical subjects who have experienced less cooperative histories.

Our two different group assignment rules (random and sorted) provide exogenous variation in the nature of histories that cooperators and free-riders experience. We hope to use this variation to draw direct inferences about the effects of history on cooperative decision-making. Before doing this, it is important to establish that behavioral responses to history are not systematically different between the random and sorted conditions. We discussed above that our design was chosen to mitigate the possibility of such differences by not detailing the group assignment rule to subjects. Nevertheless, given its importance a brief but formal examination of this issue is worthwhile. A straightforward approach is to estimate and statistically compare the decision rules used by free-riders and cooperators in each treatment, as follows.

We assume that decision rules for both cooperators and free-riders can be accurately represented by a model that includes the following variables: an intercept, a dummy for the 0.5 and 0.75 MPCR conditions, an indicator for the round, the one-period lagged individual contribution and its square, the one-period lagged contribution of the group to which the subject was assigned, (net of the subject's own contribution) and its square, and the interaction of the lagged individual and group contribution. We account for the restriction that contributions must lie between zero and 100, and that there are a substantial number of contributions at both boundaries, by estimating a Tobit specification. That is, we assume that the decision rule that determines the contribution made by subject n at round t depends on their type, denoted by "*a*" and representing either cooperator or free-rider, the vector of state-variables $\mathbf{X}_{nt}$ and an idiosyncratic component ε_{nat} according to

$$c_{nat} = \begin{cases} \mathbf{X}_{nt}^{/}\beta_a + \varepsilon_{nat} & \text{if } \mathbf{X}_{nt}^{/}\beta_a + \varepsilon_{nat} \in [0,100]. \\ 0 & \text{if } \mathbf{X}_{nt}^{/}\beta_a + \varepsilon_{nat} < 0. \\ 100 & \text{if } \mathbf{X}_{nt}^{/}\beta_a + \varepsilon_{nat} > 100. \end{cases} \qquad (2)$$
$$\varepsilon_{nat} \sim N(0, \sigma_a^2).$$

Here, c_{nat} is the contribution assuming the type is "*a*", β_a is a type-dependent vector of regressor coefficients, and σ_a^2 is the variance of the appropriate idiosyncratic component. Under regularity conditions, the parameter estimates obtained by maximizing the log-likelihood implied by (2) are known to be consistent and asymptotically normally distributed (see, e.g., Amemiya (1985)).

Our analysis does not include individual (random or fixed) effects. The reason is that many of our free-riders exhibit very little variation in the amount they contribute to the public good. For example, five of 14 free-riders contribute zero every round in the sorted condition when the MPCR is 0.3. Hence, individual effects are only weakly separately identified from lagged individual contribution effects for many of our subjects. Ashley, Ball and Eckel (2003) report on this same issue in their examination of similar public goods game data.[3]

To investigate the similarity of decision rules between the random and sorted treatments, we estimated (2) by taking the first round observations as given, and under a regressor structure that interacted a dummy that took the value one in the sorted condition with the round, the lagged individual and group contributions and their square and interaction.[4] Evidence in favor of similar decision rules (within types and between conditions) is found if the coefficients of these six terms are jointly statistically insignificant. For free-riders the six terms are jointly significant (F(6,679)=4.62, p<0.01). This result is not surprising in light of the behavior of free-riders in the sorted condition when the MPCR is 0.5 (See section III.D. below). More important for our purposes is that, for cooperators, the terms are jointly insignificant at standard significance levels

(F(6,1669)=2.10, p>0.05).[5] This provides evidence that cooperators respond to others' contributions in the same way in both the random and sorted treatments. Consequently, it seems reasonable to trace differences in cooperators' contributions between the random and sorted treatments to differences in the histories that cooperators experience in those two treatments. The remainder of our analysis will focus on the link between history, cooperators' decisions and aggregate rates of cooperation.

III.D. History and Cooperation

In the random matching condition free-rider and cooperator group contribution histories (net of own contribution), should be very similar on average within each MPCR. Table 1, which details the mean net group contributions per cell for both types of subjects,[6] shows that this is the case.

Figure 2 plots, for each cell, mean contributions per round for free-riders and cooperators. The top graphs show the three random conditions, the bottom graphs the three sorted conditions. In the random condition under every MPCR and in every round, even though their histories are on average identical to the histories of free-riders, cooperators contribute more than free-riders. In the lowest MPCR condition (r = 0.3) all contributions collapse to zero. When the MPCR is 0.5 the difference in contributions between types is statistically significant in all rounds, and when the MPCR is 0.75 the difference is significant in all rounds but one.[7]

The upper part of Figure 2 (depicting the three random conditions) begins to shed light on the source of the general decay in average contributions over rounds shown in Figure 1 (as well as reported widely in the literature, e.g., Houser and Kurzban, 2002). In all cells of the random condition, most of the overall decrease in contributions between the first and last rounds is due to decay in contributions by cooperators. Returning once more to Table 1, which shows average histories of cooperators in each experimental condition, note that within each MPCR of the sorted condition net group contributions observed by cooperators (their histories) are significantly higher than in the random condition.[8] Finally, our data also show that within each MPCR, cooperator contributions in the sorted condition exceed cooperator contributions in the random conditions no later than the fourth round, and continue to do so until round 10. Nonparametric Jonckheere (1954) tests (see, e.g., Siegel and Castellan, 1988) of the significance of the difference between random and sorted conditions show that the distribution of cooperator distributions in the sorted treatments has a significantly higher median within each round, at the 5% significance level, from rounds five through ten when the MPCR is 0.3 and 0.5, and from rounds five through nine when the MPCR is 0.75. [9] In view of the analysis reported in section III.C, we are comfortable in asserting that the higher cooperator contributions in the sorted conditions are due to the improved histories that they experience in that condition.

These improved cooperator histories stem from a reduction in the frequency of encounters with free-riders. The average number of free-riders that each cooperator met per round varied from a high of 1.71 in the random, lowest MPCR treatment to a low 0.40 in the highest MPCR, sorted treatment.[10] Hence, the sorted treatment provided cooperators with better net group contribution histories by reducing their encounters with free-riders, and this is the source of their relatively higher public contributions in the sorted treatment.

To further explore the link between type interaction and cooperation, we begin by using the difference between average group contributions in the first and last rounds as a simple metric for cooperative decay. By this measure, it is clear from Figure 2 that aggregate decay in the random conditions is due almost entirely to decay in cooperators' contributions and that this decay nearly vanishes in the two higher MPCR conditions of the sorted treatments.

Finally, Figure 3 plots the relationship between the rate of decay in cooperators' contributions and the frequency of their encounters with free-riders. Again, decay is measured as the difference between initial and final average public contributions. The vertical axis in Figure 3 measures decay, the horizontal axis measures the frequency of encountering a free-rider. The pattern makes clear that as the frequency of encounters with free-riders increases, the rate at which cooperators' public contributions decay also increases. The OLS regression line fit to these six data points has a negative but statistically insignificant intercept estimate of -15.3 (s.e.=8.9) but statistically significantly positive slope of 47.2 (s.e.=9.8). R^2 =0.85.

Figure 3 also shows that when the MPCR is 0.5 and subjects are sorted according to their contributions, decay in cooperators' contributions is smaller than might be expected, given the frequency of encounters between cooperators and free-riders. This is also the only case in which free- rider contributions are significantly higher in the sorted than in the random treatment.[11] These results can be viewed as further support for the relationship between cooperator contributions and their experimental histories. It suggests that increasing free-riders' contributions, and therefore raising net group contributions, leads cooperators to reduce their contributions more slowly.

IV. Conclusion

We found that it is appropriate to classify experimental subjects as either free-riders or cooperators based on their initial contributions to a public good. We then compared contributions between treatments that differed only in the frequency with which free-riders and cooperators interacted. This process enabled us to provide direct evidence on the joint effects of history and disposition on cooperation in multi-round public goods games, as well as to provide an explanation for the decay in contributions typically observed in public goods experiments. We find that almost all cooperative decay can be attributed to reductions in cooperators' contributions. In treatments where cooperators meet free-riders less often, we found much slower rates of decay and, in some cases, cooperators' public contributions were sustained over repeated trials.

It is straightforward to see that such sustained cooperation offers the greatest benefits when the MPCR is high. In particular, in such environments the efficient payoff, defined as the payoff all group members receive when everybody contributes all their tokens to the public account, is substantially greater than the payoff obtained when nobody contributes.

Our laboratory results lend support and additional explanation for Ostrom's (1990, 1992) eight design principles for long-enduring, self-organized commons systems from these observations. One of these is the Minimal Recognition of Rights to Organize. This paper's findings provide convergent evidence for the view that commons systems are more likely to be enduring if cooperators are given a right to organize into groups of similarly disposed individuals.

References

Amemiya, T. (1985), Advanced Econometrics, Harvard University Press, Cambridge, Massachusetts.

Andreoni, James (1995), Cooperation in Public-Goods Experiments: Kindness or Confusion? The American Economic Review, 85 (4), 891-904.

Andreoni, James, and Petrie, Ragan (2004). Public goods experiments without confidentiality: A glimpse into fund-raising. Journal of Public Economics, 88 (7-8), 2004, 1605-1623.

Ashley, R., S. Ball and C. Eckel (2003), "Analysis of Public Goods Experiments using Dynamic Panel Regression Models: Working Paper, Department of Economics, Virginia Tech, Blacksburg, VA.

Bohnet, Iris and Dorothea Kuebler (2003). Compensating the Cooperators: Is Sorting in the Prisoner's Dilemma Possible? Forthcoming in Journal of Economic Behavior and Organization.

Coase, R. (1974). "The Lighthouse in Economics." The Journal of Law and Economics. 17, 357-76.

Davis, D. and Charles Holt. (1993). Experimental Economics. Princeton University Press. Princeton, NJ.

Ehrhart, Karl-Martin and Claudia Keser (1999). Mobility and Cooperation: On the Run. Working Paper, CIRANO, University of Montreal.

El-Gamal, M. and D. Grether (1995). Are people Bayesian? Uncovering behavioral strategies. Journal of the American Statistical Association 90, 1137-1145.

Houser, D. and R. Kurzban (2002), Revisiting Kindness and Confusion in Public Goods Experiments. American Economic Review. September, 92 (4), 1062-1069.

Houser, D. and J. Winter (2004), How do behavioral assumptions affect structural inference: Evidence from the laboratory. Journal of Business and Economic Statistics. 22 (1), 62-79.

Houser, D., M. Keane and K. McCabe (2004). Behavior in a dynamic decision problem: An analysis of experimental evidence using a Bayesian type-classification algorithm. Econometrica, 72 (3), 781-822.

Houser, D., A. Bechara, M. Keane, K. McCabe and V. Smith (2004). Identifying individual differences: An algorithm with application to Phineas Gage. Games and Economic Behavior. Forthcoming.

Isaac, Mark and James Walker (1988), Group Size Effects in VCM Provision: The Voluntary Contributions Mechanism. The Quarterly Journal of Economics, 179-199.

Jonckheere, A. R. (1954). "A distribution-free k-sample test against ordered alternatives." Biometrika, 41, 133-145.

Kurzban, R. and D. Houser (2004). An experimental investigation of cooperative types in human groups: A complement to evolutionary theory and simulation. Proceedings of the National Academy of Sciences of the United States of America. Forthcoming.

Ledyard, J. (1995). "Public Goods: A Survey of Experimental Research." In J. Kagel and A. E. Roth, Eds., The Handbook of Experimental Economics. Princeton University Press. Princeton, NJ.

Ones, Umut and Louis Putterman (2004), The Ecology of Collective Action: A Public Goods and Sanctions Experiment with Controlled Group Formation, Brown University Department of Economics Working Paper.

Orbell, J. and R. Dawes. (1993). "Social welfare, cooperator's advantage and the option of not playing the game." American Sociological Review, 58, 787-800.

Ostrom, Elinor (1990), Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, New York, New York.

Ostrom, Elinor (1992), Crafting Institutions for Self-Governing Irrigation Systems, Institute for Contemporary Studies Press, San Francisco, California.

Siegel, S. and N. J. Castellan, Jr. (1988), Nonparametric Statistics for the Behavioral Sciences. (2nd edition.) McGraw Hill.

[1] Ties were broken at random.

[2] Full instructions can be viewed at http://www2.agsm.edu.au/agsm/web.nsf/Content/Faculty-FacultyDirectory-AnnaGunnthorsdottir

[3] Ashley, Ball and Eckel's (2003) analysis, which is a useful extension of our own, lends support to the type-classification results we report in this paper (See their section 7, titled "Does the initial contribution level signal type?").

[4] There are a total of 1683 observations on cooperators and 693 for free-riders. There were 197 and 255 "0" contributions for cooperators and free-riders, respectively, while the counts for "100" (full) contributions were 364 and 30, respectively.

[5] The pseudo-R^2 values for these cooperator and free-rider regressions are 0.09 and 0.14, respectively. Detailed estimation results are available from the authors on request.

[6] Assessing the significance of the difference is cumbersome since the net group contribution series are not independent, and seems unnecessary since the design implies that differences in the series are primarily due to randomness.

[7] We tested the Hypothesis that, within each round, the medians of the free-rider and cooperator contribution distributions are the same against the alternative that the median of the cooperator distributions are higher, using nonparametric Jonckheere tests. When the MPCR is 0.5 we find in favor of the alternative at the 1% significance level in all of the rounds. When the MPCR is 0.75 we find in favor of the alternative at the 5% level except in round six.

[8] Jonckheere tests (see, e.g., Siegel and Castellan, 1988) find that the median of the distribution in the sorted treatments is significantly higher at the 5% level except in round four when the MPCR is 0.3, rounds one and two when the MPCR is 0.5 and rounds one, two, three and ten when the MPCR is 0.75.

[9] Note also that Jonckheere tests reject in all rounds and MPCR conditions the hypothesis that the median of the free-rider distribution exceeds the median of the cooperator distribution in the sorted treatment.

[10] The values for each of the six cells are: MPCR = 0.3, Random:1.71; Sorted: 0.71. MPCR = 0.5: Random: 0.70, Sorted, 0.82. MPCR = 0.75 Random:0.51, Sorted,: 0.40.

[11] Based on Jonckheere tests, the medians of the free-riders' contribution distributions in the random and sorted condition are indistinguishable in every round when the MPCR is 0.3, but are higher at the 5% significance level in the sorted condition in rounds five, seven, nine and ten when the MPCR is 0.5, and are higher in the random condition at the 5% significance level in rounds three, five, six, nine and ten when the MPCR is 0.75.

Table 1
Mean net group contributions (net of own contribution) by condition and by type

Condition/Round	1	2	3	4	5	6	7	8	9	10
MPCR=0.3										
Random-CO*	126	93	91	100	39	25	33	17	13	14
Random-FR*	120	84	100	68	62	37	29	29	25	12
Sorted-CO	193	180	166	134	147	128	130	133	118	118
Sorted-FR	45	37	41	35	46	24	36	23	27	15
MPCR=0.5										
Random-CO	172	189	178	148	133	144	131	113	104	94
Random-FR	154	148	142	145	110	105	118	91	73	92
Sorted-CO	192	194	205	205	213	218	202	203	218	197
Sorted-FR	67	96	143	144	156	159	139	154	126	117
MPCR=0.75										
Random-CO	203	188	212	203	202	187	176	165	168	177
Random-FR	153	180	222	203	198	201	148	147	142	158
Sorted-CO	203	209	205	221	230	236	239	231	224	194
Sorted-FR	65	87	91	79	119	103	89	128	76	85

*** "CO" indicates cooperator, and "FR" indicates free-rider.**

Figure 1
Mean contribution for each round by grouping mechanism and MPCR

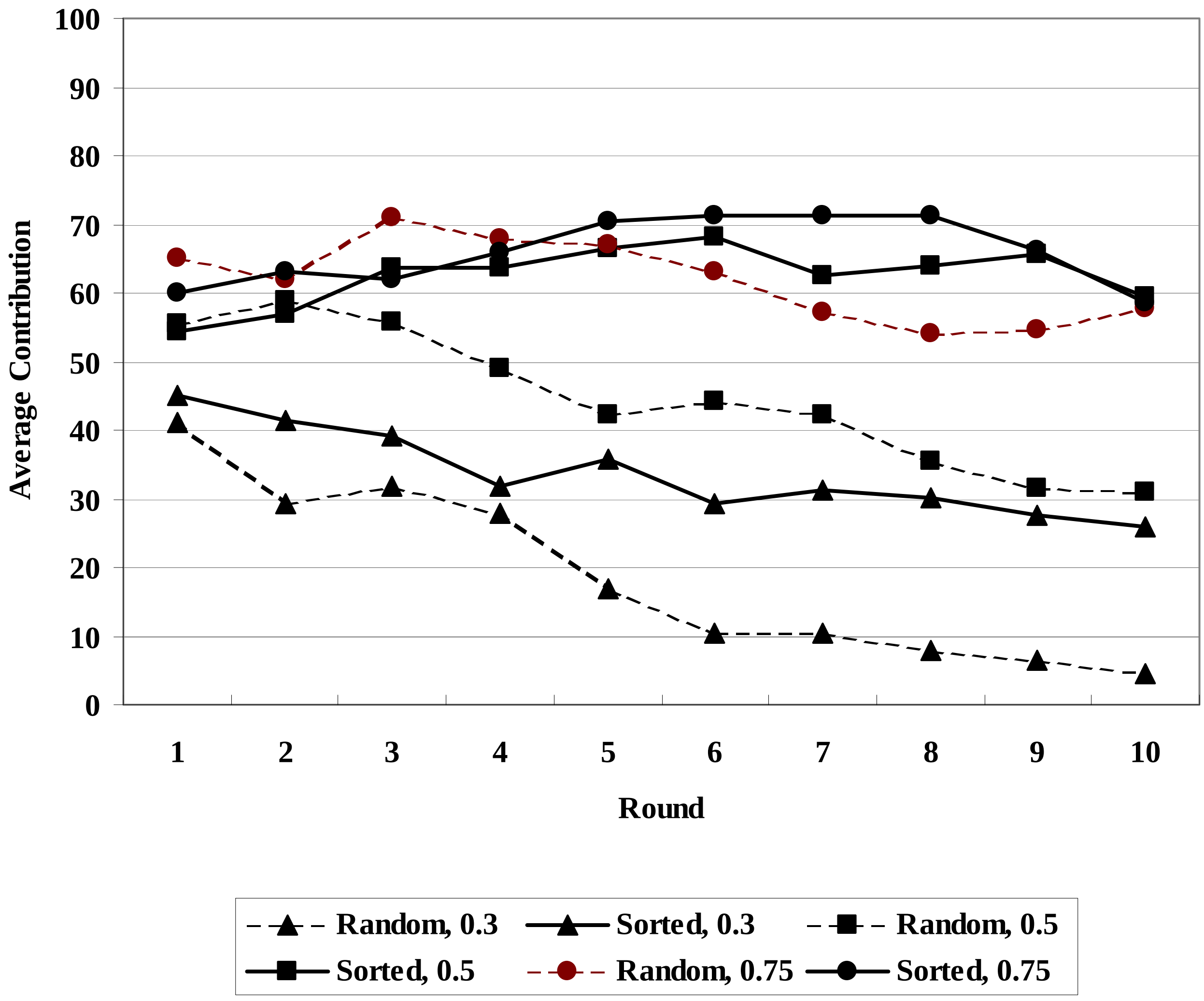
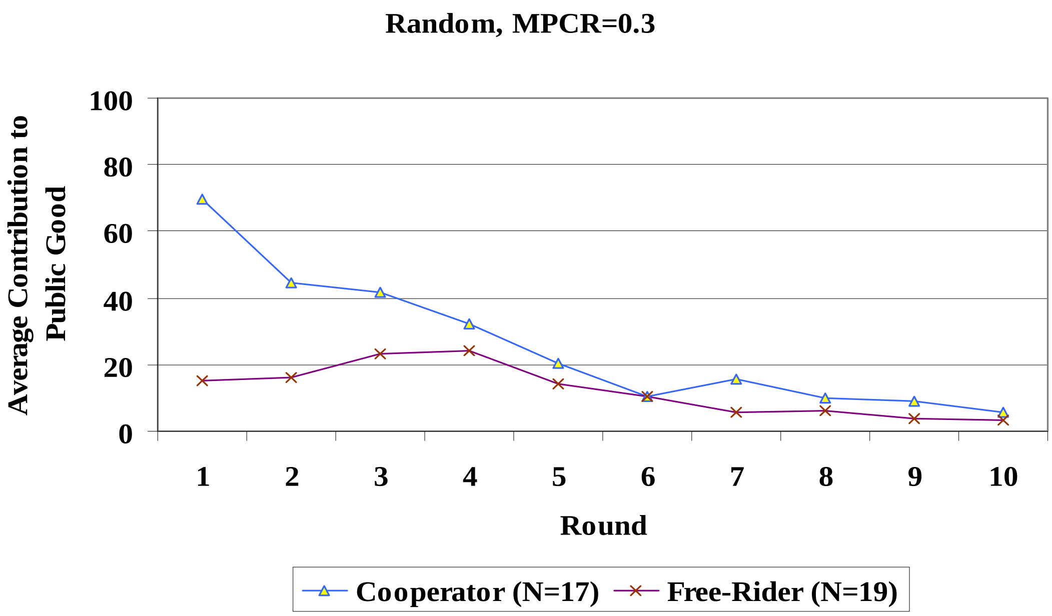


Figure 2
Contributions by type



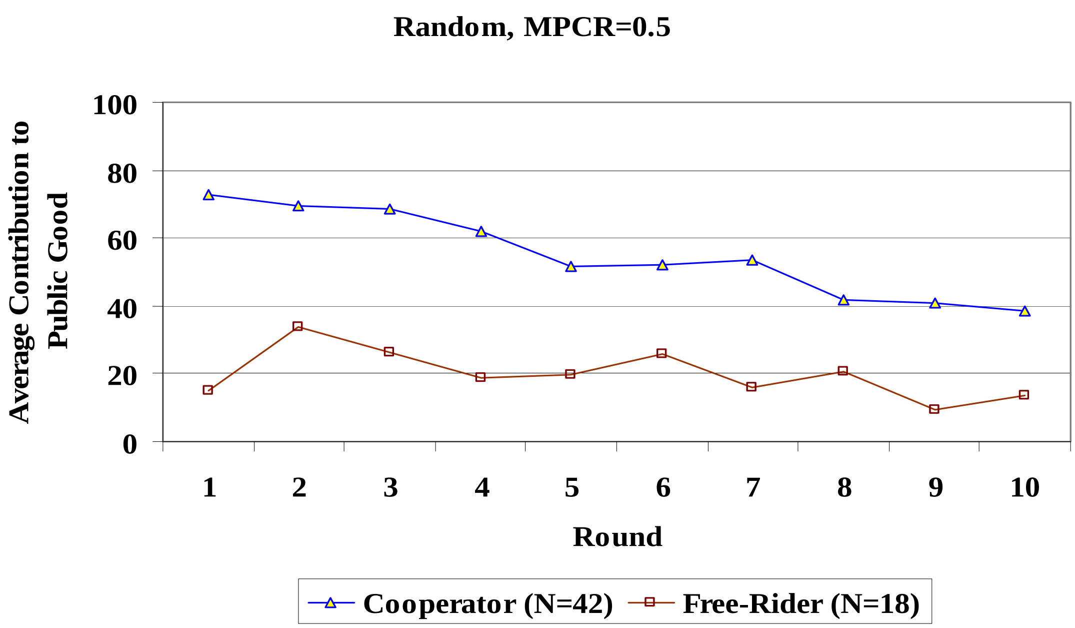
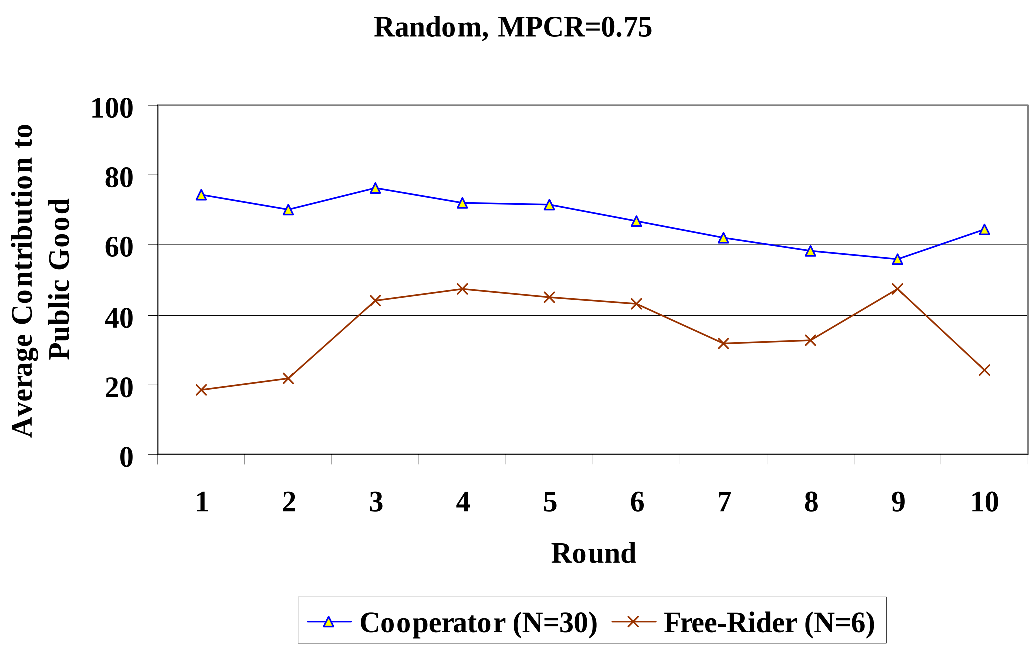


Figure 2 cont.



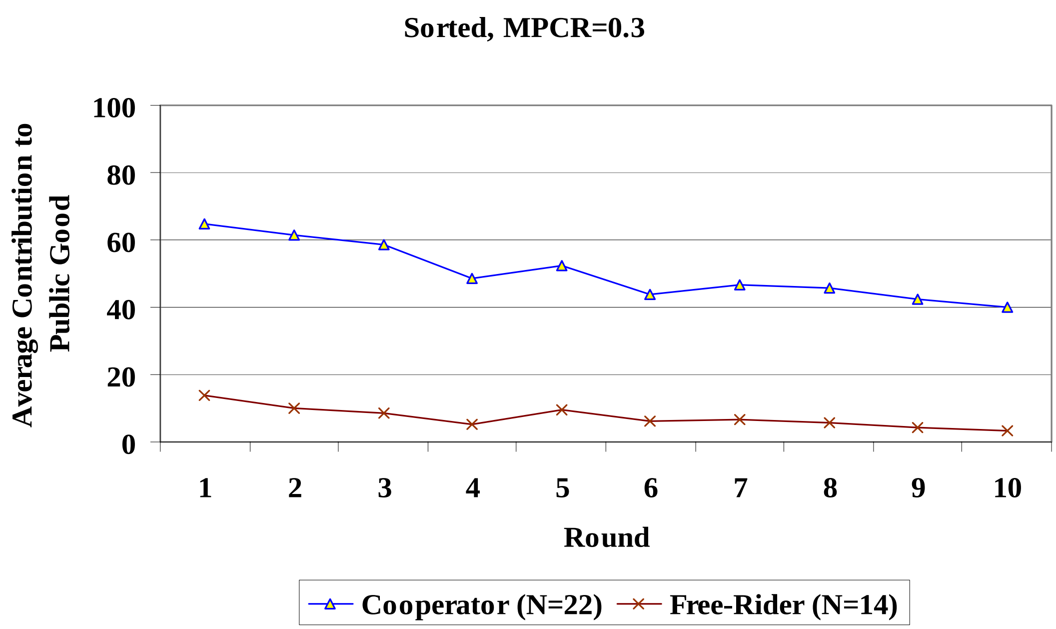
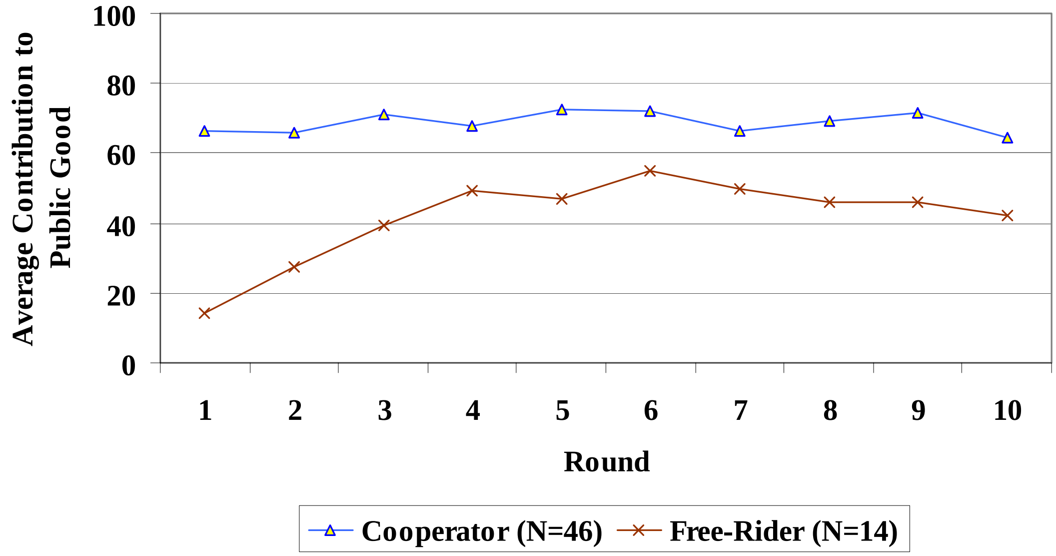


Figure 2 cont.

Sorted, MPCR=0.5



Sorted, MPCR=0.75

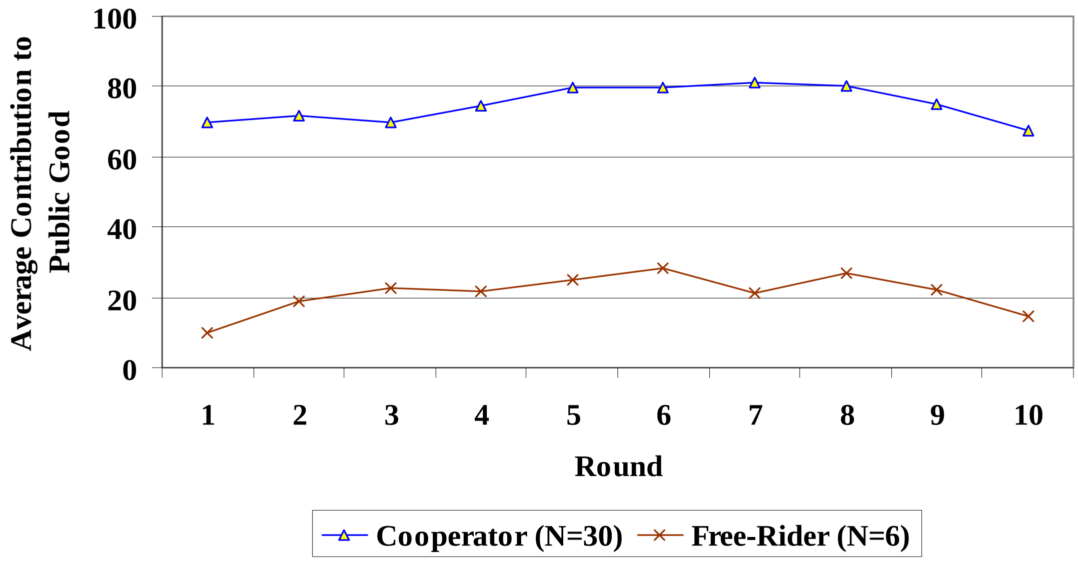


Figure 3
Free riding and cooperative decay by grouping condition