

The Seeds of Success: The Pivotal Role of First Round Cooperation in Public Goods Games

Mehmet Yiğit Gürdal ¹ Orhan Torul ² Mustafa Yahşi ³

¹Boğaziçi University

²Boğaziçi University

³Koç University

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Outline

- ▶ Motivation
- ▶ Related Literature
- ▶ Research Question
- ▶ Experimental Design
- ▶ Experimental Procedures
- ▶ Results
- ▶ Concluding Remarks

Motivation

- ▶ Cooperation in group settings where individual and collective interests conflict is a challenge
- ▶ Free-rider problem
 - Overfishing
 - Public goods provision
 - Reducing carbon emission
- ▶ Effective cooperation requires aligning individual and group interests through mechanisms such as penalties

Public goods experiments utilizing the voluntary contribution mechanism are a classic way to study cooperation in these social dilemma situations

Related Literature

- ▶ Herrmann et al. [2008] studies the effectiveness of punishment in sustaining cooperation across 16 cities worldwide
 - Punishment raises cooperation in Western cities like Boston, Copenhagen, St. Gallen, Zurich, and Nottingham
 - Istanbul exhibited more antisocial punishment, high contributors were targeted, and overall had low punishment effectiveness
- ▶ Gächter and Herrmann [2009] shows higher cooperation and prosocial punishment in Switzerland versus antisocial punishment in Russia
- ▶ Buchan et al. [2011] finds cooperation with a global group correlates positively with country globalization levels

Research Question

- ▶ Within-subject design of Herrmann et al. [2008]'s might have caused lower contribution levels in P-experiment in Istanbul. Would a between-subject design produce similar results?
- ▶ Focusing on city-level average contributions might be misleading. What is the level of average contributions at the group level?
- ▶ What is the role of initial contribution on the overall evolution of the contributions in a group?

Experimental Design

- ▶ Based on the design by Fehr and Gächter [2000] and involves two treatments.
 - N-experiment
 - P-experiment
- ▶ N-experiment involves contribution stage only whereas P-experiment involves subsequent punishment stage in addition to the contribution stage
- ▶ Between subject design as opposed to within subject design in Herrmann et al. [2008] but the same subject pool
 - Subjects either take part in N-experiment or P-experiment

Experimental Design

The contribution stage

- ▶ Subjects are allocated into groups of 4 and remain within the same group for 10 periods
- ▶ In each period, subjects are given an initial endowment of 20 tokens, and simultaneously choose how much to invest in the group project. For each group, the sum of all contributions made to the group project is multiplied by 0.4 and returned to each group member
- ▶ After the contribution stage, subjects are informed about their individual contributions along with the total payoff for all members in their respective groups without disclosing the identity of the subjects
- ▶ The only stage of the N-experiment and is repeated for 10 periods in both treatments.

Experimental Design

The punishment stage

- ▶ Takes place only in the P-experiment
- ▶ After the contribution stage, all subjects simultaneously make a punishment decision toward other members of their group. For each token player i assigns to player j , the payoff of player i will decrease by 1 token, and the payoff of player j will decrease by 3 tokens.
- ▶ After the punishment stage, subjects are informed about the individual contributions along with the sent and received punishment tokens and the total payoffs of all members in their respective groups without disclosing their identities
- ▶ The punishment stage is repeated for 10 periods after the contribution stage during the P-experiment

Experimental Procedures

- ▶ The experiment was conducted with 120 subjects in a total of 10 sessions at the Economics Laboratory of Boğaziçi University in Istanbul. Each session involved 12 subjects.
- ▶ We implemented a between-subject design
 - 60 subject in N-experiment
 - 60 subject in P-experiment
- ▶ An e-mail was sent to subjects who previously showed interest in participating in economics experiments. Subjects were able to register online for a date and time of their choosing. No subject participated more than once, and the sessions lasted 45 minutes on average. Subjects were paid in cash at the end of the experiment, and the exchange rate was 0.1 Turkish Liras per token

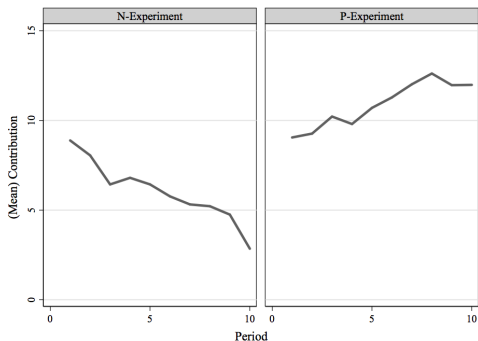
Mean Contributions and Earnings

	Contribution in Period 1			Contribution in All Periods			Earnings	
	N	P	<i>p</i> -value	N	P	<i>p</i> -value	N	P
Istanbul - This study	8.9	9.1	0.950	6.1	10.9	0.019	23.6	19.4
Istanbul - Herrmann et al. [2008]	8.9	6.5	0.034	5.4	7.1	0.326	23.3	17.0
Boston - Herrmann et al. [2008]	13.0	16.0	0.012	9.3	18.0	0.002	25.6	27.9
Copenhagen - Herrmann et al. [2008]	14.1	15.4	0.088	11.5	17.7	0.001	26.9	27.7

Between-subject design increases the effectiveness of the punishment mechanism in Istanbul

Results

Timeline of Average Contribution by Treatment



- ▶ The decline of contributions over period in the N-experiment
- ▶ The evolution of contributions in the P-Experiment exhibits a great deal of heterogeneity among groups

Contribution Change by Group Average in P-experiment

Group Average	Next Period Contribution		
	Increases	Remains the Same	Decreases
Lower	39 (16.5%)	81 (34.3%)	116 (49.2%)
Equal	9 (13.4%)	53 (79.1%)	5 (7.5%)
Higher	161 (67.9%)	45 (19.0%)	31 (13.1%)

- ▶ When a group member observes that her contribution falls short of the group average, she almost always either increases her contribution or keeps it the same
- ▶ On the other hand, when her contribution exceeds the group average, the next period's contribution is frequently either lower or the same

Group members update their contributions in the P-experiment that follows a close relationship with the respective group average

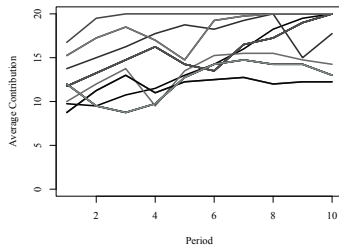
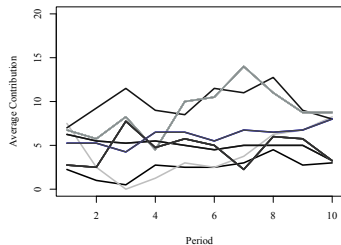
Social versus Antisocial Punishment

Sender's Contribution	Punishment			
	Non-zero	Zero	Mean	Median
Higher	338 (52.3%)	308 (47.7%)	1.09	1
Not Higher	204 (17.7%)	950 (82.3%)	0.33	0

- ▶ While punishment expenditures are often not high, subjects punish those who contributed less than them around 52% of the time.
- ▶ On the contrary, antisocial punishment is not prevalent and occurs only in around 18% of cases when a subject observes that a group member contributed at least as much as herself

Results

Evolution of Average Contributions in the P-experiment



- ▶ We cluster groups with respect to their first-period average contributions (lowest 7 on the left and highest 8 on the right panel)
- ▶ If a group's average contribution rate is above 43.75% in the initial round, its average contribution rate by the end of the P-experiment is no less than 61.25%.

Agent Based Modeling

- ▶ We take the first-period contributions from the P-experiment data
- ▶ We impose a simple state-dependent set of linear decision rules motivated by the data, and we run Monte Carlo simulations for each of the 15 groups in our sample

The decision rule we impose on subjects not only mimics final-round average contributions accurately but also does a fairly good job of capturing the evolution of group averages

▶ Agent-Based Model Details

▶ Timeline of the Model

▶ Agent-Based Model Simulation Results

▶ Determinants of Contributions Changes (Logit)

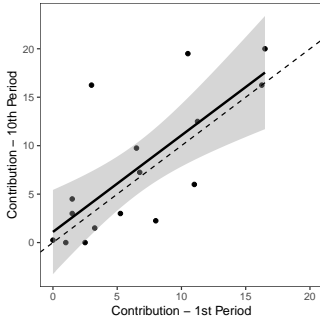
▶ Determinants of Contributions (OLS)

▶ Punishment Decisions

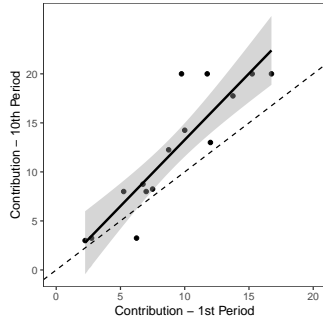
Results

Comparison of Average Contributions in the P-experiment

GERMANY



TURKEY



- ▶ First-period average group contributions by Herrmann et al. [2008] also exhibit a high degree of variability, as do our data
- ▶ Disparities stem from the difference due to our between-subject design versus Herrmann et al. [2008]'s within-subject

Concluding Remarks

- ▶ In a public good game with punishment, contributions are significantly higher in Istanbul under a between-subject design compared to a within-subject design where the no-punishment condition precedes the punishment condition
 - The detrimental effect of prior experience without punishment on cooperation
- ▶ Two critical factors behind cooperation patterns:
 - Heterogeneous initial contributions
 - Simple contribution updating rules based on prior actions estimated from the data via an agent-based model verifies that the interaction of these factors generates strong persistence in contribution levels over time
- ▶ The importance of initial contributions in shaping subsequent cooperation within a group

Concluding Remarks

Our contributions:

- ▶ The pivotal impact of experimental design and initial conditions on cooperation outcomes.
- ▶ Guidance for robust cross-society experiment design by underscoring within-group heterogeneity.
- ▶ Our findings uniquely isolate the effect of first-round divergence, complementing research on culture and conditional cooperation in social dilemmas
- ▶ The insights into contribution updating rules and belief formation advance theoretical understanding of how cooperation evolves.

References

- Buchan, N. R., Brewer, M. B., Grimalda, G., Wilson, R. K., Fatas, E., and Foddy, M. (2011). Global social identity and global cooperation. *Psychological science*, 22(6):821–828.
- Fehr, E. and Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review*, 90(4):980–994.
- Gächter, S. and Herrmann, B. (2009). Reciprocity, culture and human cooperation: previous insights and a new cross-cultural experiment. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1518):791–806.
- Herrmann, B., Thöni, C., and Gächter, S. (2008). Antisocial punishment across societies. *Science*, 319(5868):1362–1367.

Appendix

Results

◀ Timeline of Average Contribution by Treatment

N-experiment

- ▶ During the first half, the frequency of subjects who contribute zero is 27%, whereas in the second half, this frequency reaches 46%
- ▶ By the 10th period, among the 15 distinct groups in this experiment:
 - 11 groups end up at very low (3 tokens or fewer) average contribution
 - 3 groups end up at moderate (between 6.75 and 8.5 tokens) levels
 - Only one group manages to reach a contribution level of 12

There exists a some degree of heterogeneity in the average contribution in N-experiment

Agent-Based Modeling Steps

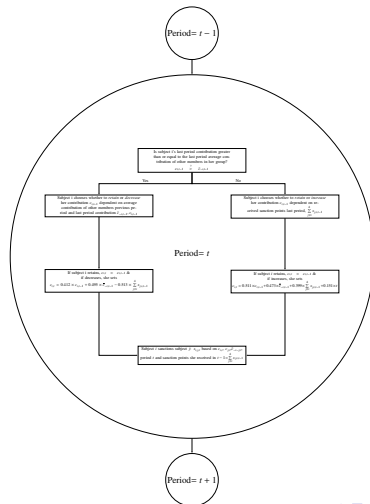
- ▶ We start our counter-factual analysis by feeding the agent-based model with actual first-period contribution data of our 60 subjects in the 15 groups
- ▶ If a subject's last period contribution is less than the group average, she either raises her contribution or keeps contributing the same amount in the next period; and if her last period contribution is at least equal to the group average, she either reduces her contribution or contributes same
- ▶ We see that subject i 's sanctioning decision on subject j depends significantly on subject i 's received sanction points last period, the average contribution of the remaining members in the respective group in the current period and the round of the current period, as well as her and subject j 's contribution in the current period. Based on the estimated sanction probabilities from the data, we simulate if subject i assigns subject j a sanction point (of unity) or not
- ▶ We move on to the next period and recursively conduct the same steps over periods

Appendix

Results

Agent-Based Modeling

Timeline of the Model

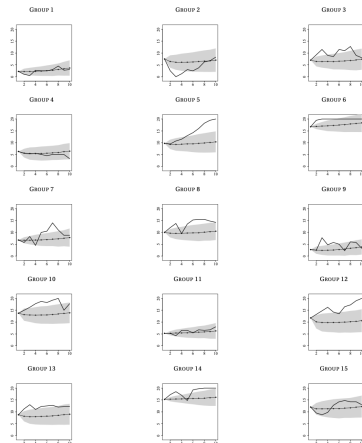


Appendix

Results

▶ Agent Based Modeling

Agent-Based Model Simulation Results



Notes: The horizontal axis denotes periods, and the vertical axis denotes average group contribution. The solid line refers to group averages by the P-experiment data, the dotted line refers to group-specific average agent-based model results by Monte-Carlo simulations, with the shaded gray areas referring to resultant 2-standard-deviation confidence intervals.

Determinants of Contributions Changes (Logit)

- ▶ The dependent variable, increase, takes the value of 1 if a subject's contribution in the current period is larger than her contribution in the previous period and 0 otherwise. Sample includes a subset of observations featuring only subjects contributing less than the previous period's group average
 - The only variable with a significant effect is the number of punishment points received from other group members in the previous period
- ▶ The dependent variable, decrease, takes the value of 1 if a subject's contribution in the current period is less than her contribution in the previous period and 0 otherwise. Sample includes a subset of observations, featuring only subjects contributing more than or equal to the previous period's group average
 - The average contribution of other group members in the previous period and contribution in the previous period significantly affects the next period's contributions

Determinants of Contributions Changes (OLS)

- ▶ Sample of observations featuring subjects who contribute less than the group average in the previous period and raise their contributions in the current period
 - The number of punishment points received from other group members in the previous period, the average contribution of other group members in the previous period, the last period contribution, and the period variable has a significant effect on the next period contributions
- ▶ Sample of observations featuring subjects who contribute more than or equal to the group average in the previous period and reduce their contributions in the current period
 - The number of punishment points received from other group members in the previous period, the average contribution of other group members in the previous period, and the last period's contribution have a significant effect on the next period's contributions

Punishment Decisions

- ▶ Since punishment expenditures are often low and zero-punishment commonly observed, we employ a series of probit models
- ▶ When we use the first-period observations in the P-experiment:
 - We first restrict our sample to observations in which the receiver's contribution is less than that of the sender
 - The contribution of the target subject (i.e., receiver) and the average contribution of the two remaining group members are significant
 - When the sender's contribution is less than or equal to the receiver
 - Only the contribution of the target subject (i.e., receiver) significantly affects anti-social punishment
- ▶ When use all observations in the P-experiment:
 - The sender's contribution, the average contribution of the two remaining group members, the punishment points that the subjects received in the previous period, the receiver's contribution, and the period have a significant effect on the punishment decision