Experiments on Linear Public Goods Games: Introduction

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1 Introduction: Public Goods and Free Riding

- Definition: Public goods
  - **Non Rival -** Increasing the number of consumers does not diminsh the consumption of anyone else
  - **Non Exclusion -** It is impossible (or prohibitively expensive) to exclude anyone from consuming it.

- Model:
  - $m_i = x_i + g_i$ Budgets for each i
  - $G = \sum_{i=1}^{n} g_i$ Public Good
  - $U_i = U_i(x_i, G)$ preferences
  - Nash assumption:
    * Let $G_{-i} = \sum_{j \neq i} g_j$ be giving by everyone else.
    * Assume individuals take G_{-i} as fixed and independent of own choice.
    * Note $G = g_i + G_{-i}$
  - Optimization :

$$\max U(x_i, g_i + G_{-i})$$
$$s.t.\ \ x_i + g_i = m_i$$

  - Problem: Free riding

2 Question: Do people free ride?

How do we design an experiment to test this?

Use a real public good? What's wrong with that?

3 Question: Do people free ride?

How do we design an experiment to test this?

Use a real public good? What's wrong with that?

- You need to know when it is efficient to give and when not.
- With a real public good, can't see preferences
- Need to control the values my making up a payoff with same incentives as a real public good, but where you know the true values

4 Basic Public Goods Experiment

- $n =$ number of players
- $M =$ endowment of money (chips)
- $x_i =$ consumption of private goods
- $g_i =$ gift to the public good
- $G = \sum_{i=1}^{n} g_i =$ total supply of the public good
- $\pi_i =$ payoff to person i
- $\alpha =$ marginal return from the public good

$$\pi_j = x_j + \alpha \sum_{i=1}^{n} g_i$$

- Assume If $0 < \alpha < 1$ and $n\alpha > 1$
- What is the Nash Equilibrium?
- What is Pareto Efficient?

- What is the Nash Equilibrium? What is Pareto Efficient?

$$\begin{aligned}\pi_j &= x_j + \alpha \sum_{i=1}^{n} g_i \\ &= M - g_j + \alpha \sum_{i=1}^{n} g_i \\ &= M - (1-\alpha) g_j + \alpha \sum_{i \neq j} g_i\end{aligned}$$

- If $0 < \alpha < 1$, then $g = 0$ is a dominant strategy Nash equilibrium
- If $n\alpha > 1$, then $g = M$ is Pareto Efficient

5 Background Results

Marwell and Ames, "Economists Free Ride, Does Anyone Else." *Journal of Public Economics,* 1980.

- Used High School Students in Madison
- Mostly Single-Shot games
- Results: No significant Free Riding
- Replicated with 1st year econ grad students, and found much more free riding.

Isaac and Walker, *QJE,* 1988

- They want to consider Group Size and MR effects
- Consider payoffs

$$\pi_j = M - g_j + \frac{\beta}{n}\sum_{i=1}^{n} g_i$$

  where they increase β or n keeping the other constant, or increasing both in order to keep β/n constant.

- They call this the *Voluntary Contribution Mechanism (VCM)* and call β/n the *Marginal Per Capita Return (MPCR).*
- They consider $n = 4, 10,\ \ \beta/n = \alpha = 0.3, 0.75$
- Played 10 periods with the same partners.

TABLE I
EXPERIMENT PARAMETERS

Experiment type	Group size	Group payoff function	MPCR	Individual tokens per period (Z_i)	Number of experiments
$4L$	4	$1.2(\Sigma m_i)$¢	0.30	62	6
$4H$	4	$3.0(\Sigma m_i)$¢	0.75	25	6
$10L$	10	$3.0(\Sigma m_i)$¢	0.30	25	6
$10H$	10	$7.5(\Sigma m_i)$¢	0.75	10	6

Define **Strong Free Riders** as giving less than 1/3 of endowment to the public good. (Why define it that way? Don't we really want to know the fraction that are $g = 0$?)

GROUP SIZE HYPOTHESES OF PUBLIC GOODS PROVISION

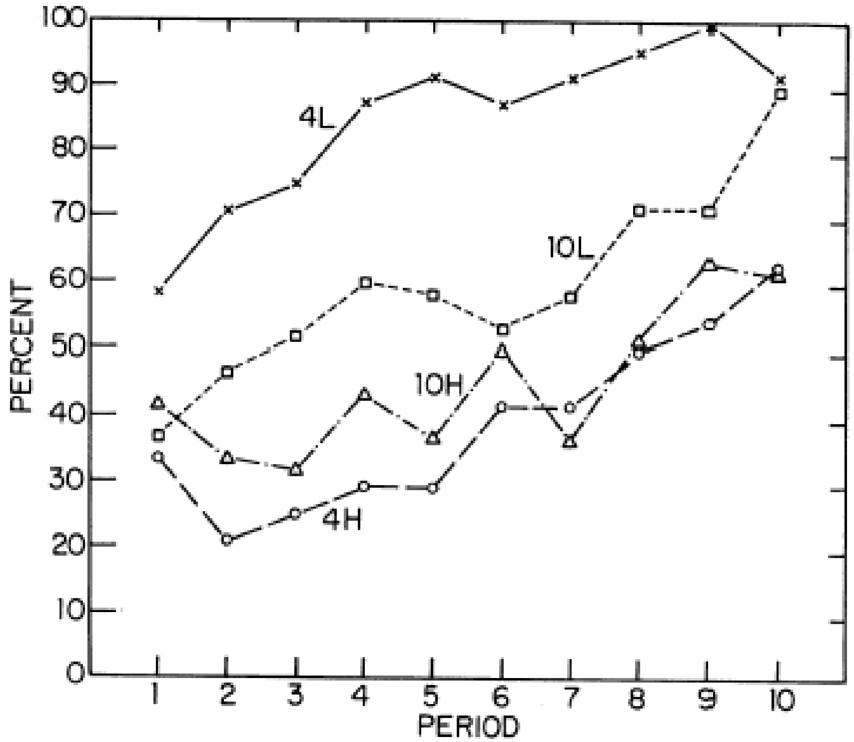


FIGURE I
Mean Percent of Individuals Acting as Strong Free Riders

Average g :

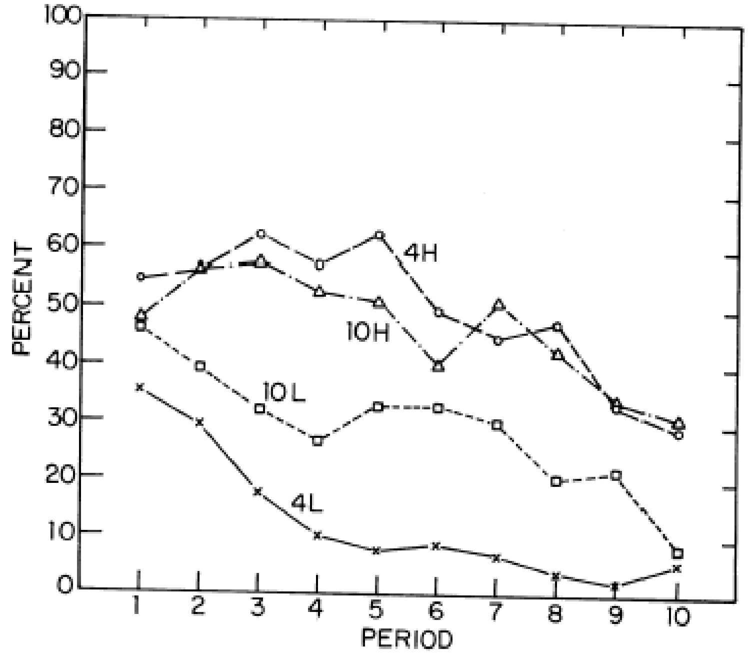


FIGURE II
Mean Percent of Tokens Contributed to the Public Good

- **Significant Giving at the start:** Note about 35-55% giving at the start.
- **Decay :** A decline in giving occurs across periods, steepest with low marginal returns
- **Significant Group Size Effect:** At the low α there is a significant group size effect.
- **Significant Marginal Return Effect:** Give More when there is a high α.

What Explains these results?

- **Learning?** Could be that subjects figure out free riding as the game goes on. Note that you can test for this.
- **Reputations?** Since the game is really a finitely repeated game, reputation effects could matter.
- **Altruism?** Subjects may have a real preference for giving to each other.

Andreoni, “Why Free Ride? Strategy and Learning in Public Goods Experiments?”

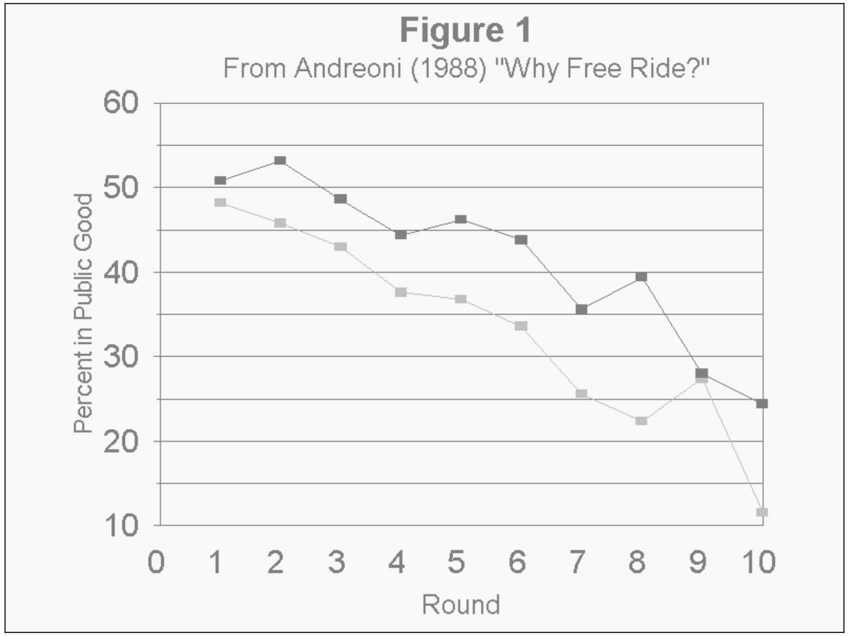
- **Idea:** To try to identify which of the three hypotheses above could explain the data. In particular, test for the presence of Learning or Reputations.
- **Reputations:** The way to test this is to face compare finitely repeated play to repeated single-shot play, “*Partners versus Strangers.*”
  - Partners: Same groups for 10 periods, as in Isaac and Walker
  - Strangers: Randomly re-matched for every period.
  - If reputations matter, then we should see more giving among Partners than Strangers, at least until the end of the experiment.

- **Learning:** There are two ways to test this.
  - First with a re-start. Subjects are told, after the first 10 rounds are over, that there are 10 more “surprise” rounds. The surprise rounds will be under the same rules. Partners will stay in same groups. If you revealed.
  - If subjects contributions “decay” because of learning, then the restart should not matter, not even for the Strangers. They’ve already revealed they are selfish (in theory) and have “blown their cover.”
  - Second, with a post-quiz. We can ask subjects at the end of the experiment to calculate earnings of the players and to identify the way to make the most money.

- **Methods**
  - – 35 Subjects recruited at once (wanted 40)
  - – 15 to partners, 20 to strangers
  - – play 10 rounds
  - – restart for 10 rounds, but quit after 3 (grad student budget constraints)
  - – repeat

Results:

- Strategies: Strangers in dark, partners in grey



- Strangers give significantly more than partners—Opposite of the prediction!
- Partners free ride significantly more—Opposite of the prediction!
- Restart: Evidence of learning among strangers, but partners go right back to where they started in round 1
- Conclusion: Neither Strategies or Learning could explain the data. This leaves intentional altruism as the best alternative.

6 Errors or Real Intentions?

Andreoni, "Cooperation in Public Goods Experiments: Kindness or Confusion?" AER, September 1995.

- Question: Rather than altruism, subjects could also just be making errors. If the Nash Equilibrium is for $g = 0$, then the only type of "error" is to cooperate. Hence, errors could be mistakenly viewed as cooperation.
- Must design a study that allows for learning and errors, but does not allow for altruism.
  - This subtracting of altruism allows one to estimate the amount of error in behavior.

Design: Three Conditions:

- *Regular:* These subjects played a standard linear public goods game, as above. They have both kindness and confusion possible.
- *Rank:* These subject play a linear public goods game for points, then the points are converted to cash by how they rank compared to others.
- *Regrank:* These subjects play a regular game, but we inform them about their rank. Thus they have the same information that Rank subjects do, but the same payoff structure that the Regular subjects do. This is there to allow us to measure the effects of changing only one thing at a time.

- 20 Subjects recruited, play as Strangers in groups of 5. 10 rounds. $M = 60$, $\alpha = 0.5$
- Did each session twice. Total of 120 subjects.
- Rank payoff are

Your Cash Earnings Based on Your Rank

	Highest				*Lowest*
YOUR RANK	1	2	3	4	5
YOUR CASH EARNINGS	.95	.87	.80	.73	.65

FIGURE 1. MONETARY EARNINGS FOR SUBJECTS IN THE RANK CONDITION

- Mean payoff set to be the same as regular
- Spread is the difference in payoff from $g = 0$ to $g = 60$.

Predictions:

- Cooperation in *Rank* is a lower bound estimate of confusion.
- *Regrank* – *Rank* Cooperation is lower bound estimate of Kindness
- *Regular* – *Regrank* Cooperation is either.

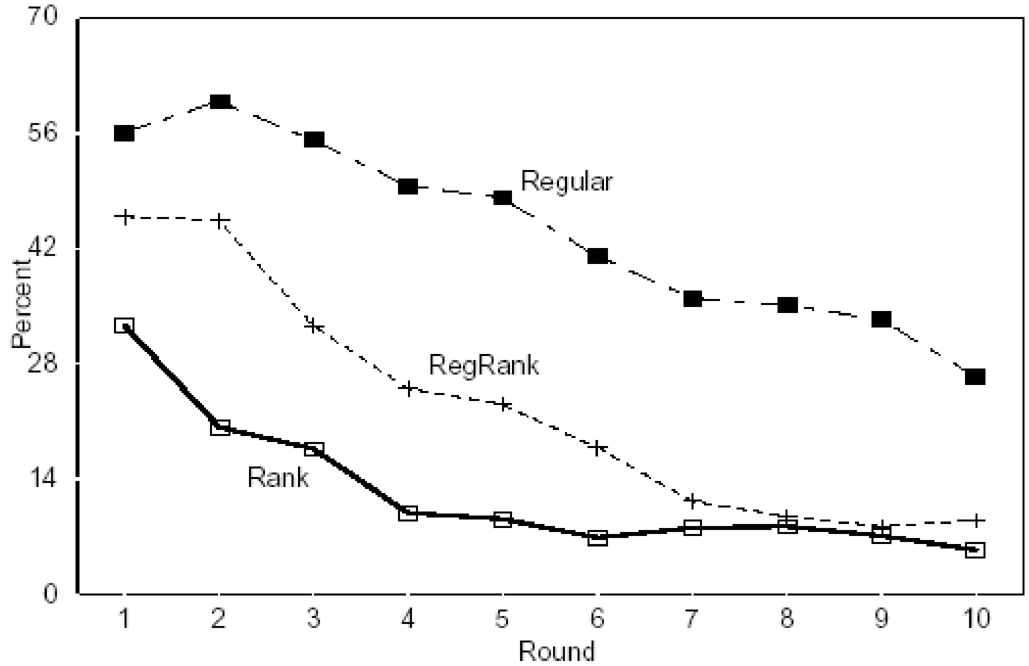
Results:

TABLE 1—PERCENTAGES OF ENDOWMENT CONTRIBUTED TO THE PUBLIC GOOD PER ROUND

	Round										
Condition	1	2	3	4	5	6	7	8	9	10	All
Regular	56.0	59.8	55.2	49.6	48.1	41.0	36.0	35.1	33.4	26.5	44.07
RegRank	45.8	45.4	32.6	25.0	23.1	17.8	11.3	9.5	8.3	9.0	22.79
Rank	32.7	20.3	17.7	9.9	9.2	6.9	8.1	8.3	7.1	5.4	12.55
RegRank − Rank	13.2	25.1	15.0	15.1	13.9	11.0	3.2	1.3	1.2	3.6	10.24
As percentage of Regular	23.5	42.0	27.1	30.4	28.9	26.7	8.9	3.6	3.6	13.5	20.82

TABLE 2—PERCENTAGE OF SUBJECTS CONTRIBUTING ZERO TO THE PUBLIC GOOD PER ROUND

	Round										
Condition	1	2	3	4	5	6	7	8	9	10	All
Regular	20	12.5	17.5	25	25	30	30	37.5	35	45	27.75
RegRank	10	22.5	27.5	40	35	45	50	67.5	70	65	43.25
Rank	35	52.5	65	72.5	80	85	85	85	92.5	92.5	74.50
Kindness:											
Rank − RegRank	25	30	37.5	32.5	45	40	35	17.5	22.5	27.5	31.25
As percentage of 100 − Regular	31.3	34.3	45.5	43.3	60.0	57.1	50.0	28.0	34.6	50.0	43.41
Confusion:											
100 − Rank	65	47.5	35	27.5	20	15	15	15	7.5	7.5	25.50
As percentage of 100 − Regular	81.3	54.3	42.4	36.7	26.7	21.4	21.4	24.0	11.5	13.6	33.33
Either:											
RegRank − Regular	−10	10	10	15	10	15	20	30	35	20	15.5
As percentage of 100 − Regular	−13.0	11.4	12.1	20.0	13.3	21.4	28.6	48.0	53.8	36.4	23.26



Percent of Endowment Contributed
to the Public Good Per Round

Conclusion:

- About 20% of all money given is from confusion.
- About half of all cooperators are confused, about half are kind.
- So, we can take seriously that people have a preference for kindness.