Evolution of Conventions in an Experimental Public Goods Game with Private and Public Knowledge of Advice[1]

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[1] We thank Wellesley College for providing the funds to run the experiments for this study. We are grateful to Andrew Schotter, Barry Sopher, Al Roth, Brit Grosskopf, Phil Levine and seminar participants at Wellesley College and the Center for Experimental Social Sciences at New York University for their feedback and advice.

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Abstract

We adopt an inter-generational approach to the public goods game where at the end of each session one generation of subjects leave advice for the succeeding generation via free form messages. Such advice can be private (advice left by one player in generation t is given only to her immediate successor in generation t+1) or public (advice left by players of generation t is made available to all members of generation t+1). We find that when advice is public it generates a process of social learning that helps increase contributions over time and also mitigates problems of free riding. Our results suggest that contrary to game theoretic predictions, socially connected communities may be able to achieve efficient or near efficient levels of public good provision on the basis of private contributions.

JEL Classification: C71, C91, C92

Keywords: Public Goods; Voluntary Contributions Mechanism; Inter-generational framework; Advice;

1. Introduction

Private provision of public goods has been the subject of much economic research.[2] As Ledyard (1995, p. 111-112) points out, some of the most fundamental questions about the organization of society focus on the issues raised by the presence of public goods. How well do current political institutions perform in the production and funding of public goods? How far can volunteerism take us in attempts to provide efficient levels of public goods? At a more basic level, contributions to public goods raise fundamental questions about whether people are generally selfish or cooperative.

Economists have attempted, via laboratory experiments, to capture the tension between contributing to a public good or free-riding on others' contribution. Ledyard (1995) provides a description of what a typical public goods experiment looks like.[3] A group of four subjects are gathered in a room. They are each given a sum of money (say $5) and they are told that they can keep any or all of this amount. Or if they want they can contribute some or all of this amount to a public pool. However any amount contributed to a public pool is multiplied by a factor greater than 1 (say 2) by the experimenter. This multiplied amount is then distributed equally between the four group members. The socially optimal outcome in this game is for every player to contribute the entire amount to the public pool. Total contributions to the public pool is $20 which is doubled to $40 by the experimenter and redistributed back to the group members netting each person $10. Each member then gets a 100% return on her initial investment. However individual rationality suggests a different course of action. Think about an individual player trying to decide how much to contribute. If this individual contributes $1 and no one else

[2] The literature in this area is voluminous. See Marwell and Ames (1981) Andreoni (1988), Isaac, McCue and Plott (1985), Isaac, Walker and Thomas (1984), Isaac and Walker (1988a, 1988b), Kim and Walker (1984) among others. Ledyard (1995) provides a comprehensive review of the existing literature.

[3] This description of a typical public goods experiment is taken from Ledyard (1995, p. 112).

contributes anything, then the $1 is doubled to $2. Distributed equally between the four players, gives each player $0.50. The player who contributed the $1 is worse off (incurs a 50% loss on the investment) while every other player is better off at the expense of the player who contributed. Thus if a player does not contribute, then she is no worse off if no one else contributes, but she is actually better of if some others contribute, while she herself does not.

Game theory suggests that faced with a situation like this, every rational self-interested player will engage in strong free riding behavior by not contributing any money to the public pool at all, since free riding is the dominant strategy. As a result economists have usually called for government provision (via tax revenue) of non-excludable public goods. These questions have acquired greater significance in recent times with increasing calls for smaller governments and greater reliance on a community's own activities and resources to solve local problems with provision of public goods.

Prior experimental work in the area has documented a number of empirical regularities. First, while groups of subjects do not manage to reach the socially optimal level of contributions, the strong free riding hypothesis of zero contribution is clearly refuted since subjects do contribute to the public good. Second, in a one-shot version of the public goods game, a group of subjects on average contribute between 40% and 60% of the optimal level (i.e. if maximum contribution is $20, then contributions in a typical game will be $8 - $12). There are, however, wide variations in individual contributions with some players contributing 100% with others contributing 0%. But most prior studies find that on average most groups contribute somewhere in the 40%-60% range. Third, contributions decline steadily with repetition, i.e. if the players interact repeatedly over a number of rounds then contributions decline steadily over time. In repeated plays of the game, contributions often start out at between 40% and 60% but then contributions decline steadily over time as more and more players choose to “free ride.” See Isaac, Walker and Thomas (1984), Isaac, McCue and Plott (1985), Isaac and Walker (1988a, 1988b) and Kim and Walker (1984) for studies describing this phenomenon. Ledyard (1995) provides a review of much of this literature.

This phenomenon of contributions starting at about halfway between the Pareto-efficient level and the free-riding level and then decaying towards the free-riding level has been the subject of voluminous research with Andreoni (1988) being one of the notable early studies. Andreoni (1988, p. 292) suggests that there are two possible explanations for this observed decay in contributions. First, the learning hypothesis holds that a single-shot play of the game is not sufficient for the subjects to learn the exact incentives and the dominant strategy. Repeated play allows such learning and so over time, with repeated trials, subjects learn to free ride. However, this test of learning as an explanation of decay is confounded by the fact that repetition allows subjects to signal future moves to each other as well as to infer each other’s strategies via contributions to the public account. This is the basis of the alternative - “strategies”- hypothesis. Andreoni (1988) examines the strategies and learning hypotheses but fails to come up with any definitive conclusions. Subsequently, this line of research has spawned a large number of papers but no general consensus has emerged. A review of this entire line of research is found in Andreoni and Croson (1998).

Rabin (1998) provides a different perspective on the problem by arguing that it is possible to view the public goods game as essentially a coordination problem. Rabin (1998, p. 21). writes “…reciprocal altruism essentially turns public goods situations into “coordination games” where high contributions are efficient equilibria and low contributions are inefficient equilibria”. But even if total contribution to the public good is the Pareto-efficient outcome, still subjects may engage in free riding because coordination at the social optimum (the efficient equilibrium) is inherently risky. Prior researchers have shown that Pareto inferior outcomes are likely in a setting where the Pareto dominant outcome is also the most risky. Van Huyck, Battalio and Beil (1990) demonstrate that in a coordination game (called the Minimum Game, which, while different from a public goods game, still captures some of the features of the latter) with a set of Pareto-ranked equilibria, subjects routinely select the Pareto-worst (but the risk dominant) outcome.

In this paper we are concerned with the real-world applicability of the findings such as those in Isaac, McCue and Plott (1985), Andreoni (1988) and the many other papers in public goods cited above. We propose to look at the public goods problem from a different perspective. We believe that in the real world such games are played in a manner that differs from that depicted in previous experimental studies. People do contribute large amounts of money to charities repeatedly over time[4], and some communities do successfully solve the problems of providing non-excludable public goods without government assistance.[5]

Chaudhuri, Schotter and Sopher (2001) is a study of a multi-player coordination game with multiple Pareto-ranked equilibria that extends the results reported by Van Huyck, Battalio and Beil (1990). Chaudhuri et al. in their study comment that there are two salient features of such situations. First, while the games or problems they represent are infinitely (or at least long) lived, the people who play the game change often. These are infinitely lived games played by a

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[4] According to the Internal Revenue Service, taxpayers claimed $125.8 billion in charitable deduction in 1999. This represents a 15.2% increase from the $109.2 billion claimed in 1998. These figures include strictly individual donations and do not include donations by corporations and foundations. Total charitable contributions in the U.S. reached $203.45 billion for 2000, an increase of 6.6% over 1999. Following the events of September 11, 2001, total private contributions amounted to $1.5 billion dollars of which 43% came from individuals and 57% came from foundations or corporations. See The Foundation Center's Report "Giving in the Aftermath of 9/11". See www.fdncenter.org for more details of charitable contributions after 9/11.

[5] The Family Helpline in Los Angeles is a good example. See "Family Helpline of Los Angeles: Community Based Solutions – One person at a time". Helpline meets needs for everything from food and housing to crisis intervention and counseling. www.capitalresearch.org/publications/cc/1999/9902.html.

sequence of finitely lived agents. When the transition between players takes place, the older generation informs their successors of all of the norms and conventions of behavior that have been created either during their lifetime or in the lifetimes of their predecessors.

Second, and more importantly, when anyone goes to play these games they have access to the wisdom of the past in the sense that those who have played before them (or at least immediately before them) are available to give them advice as to how to play. While the conventions passed from one generation of decision maker to the next may not be efficient solutions to the problem at hand, they at least avoid the need to have these problems solved repeatedly each time a new agent or set of agents arrive. For instance, as Schotter and Sopher (2001b) point out, if one thinks about the competition between large corporations, then while the CEOs of those corporation may change over time, the norms and conventions established during the tenure of one CEO often carry on and impact the nature of the competition during the term of later players of the game.[6]

In the experiments discussed in this paper we present an inter-generational version of the public goods game. The framework is similar to that found in Chaudhuri, Schotter and Sopher (2001) which analyses a coordination problem. The inter-generational approach was introduced by Schotter and Sopher (2001a, 2001b, 2003) investigating the Trust, Ultimatum and the Battle of the Sexes Games respectively. In our experiment, groups of 5 subjects are recruited into the lab and play the public goods game for 10 periods (the exact experimental design and parameters are explained in Section 2). After her participation is over each player is replaced by another

[6] Another good example of such conventions will be familiar to followers of international soccer. In many games (even highly competitive ones) when a player of one team is hurt, the opposing team will very often kick the ball out of play to stop the game so that the injured player can get medical attention. This however also turns the ball over to the opposing team. Even more surprisingly once the game resumes the latter team, which now has possession of the ball, will give the ball right back to the first team which stopped the play. Nothing in the rules of soccer dictates that the teams behave in this manner. However players of international soccer seem to have succeeded in establishing a stable convention which is not individually rational but is definitely a Pareto-improvement.

player, her laboratory descendant, who then plays the game for another 10 periods as a member of a fresh group of 5 subjects. Thus the generations are non-overlapping. Advice from a member of one generation to her successor can be passed along via free-form messages that generation t players leave for their generation t+1 successors. Finally, payoffs span generations in the sense that the payoff to a generation t player is equal to what she has earned during her lifetime plus 50% of what her laboratory descendant earns. This was done to provide an incentive to the subjects to pass on meaningful advice to their successors.

We incorporate two separate mechanisms for passing advice from one generation to the next. In our "private advice" treatment, advice from one subject in generation t is given to her immediate successor in period t+1. In the "public advice" treatment on the other hand advice from one generation of players is made public to the next generation in the sense that all the advice left by the former group is made available to all the members of the latter group. Moreover, this advice is *read aloud by the experimenter for all members of the group to hear.*

It should be noted that including advice in our experiments is different from either including cheap talk or allowing free communication amongst decision-makers, both of which have been known to increase efficiency. See for instance Cooper et. al.(1989, 1992) and Dawes et. al (1977). Cheap talk statements are public and non-binding statements made by players who are actually going to play the game and not their predecessors. In contrast, our advice statements are made by predecessors, and not by the people who are about to play the game. Our advice treatment is different from the communication treatments found in public goods experiments since we only permit one-sided statements to be made and not bilateral or multilateral non-binding discussions.

It was our conjecture that if we played a public goods game using such an inter-generational design then, over time, generations would be able to evolve norms of cooperation with later generations not only achieving higher levels of contribution but also managing to mitigate problems of free-riding. Norms or conventions of behavior – so-called "memes" (a term coined by Dawkins, 1976) - that arise during one generation may be passed on to the successors.[7] That is, even if one generation of players fail to arrive at the Pareto-efficient outcome, still they may exhort their successors to contribute higher. Or generations that do manage to keep contributions high may advice their successors to keep up the good work and such advice passed on through generations may lead over time to a convergence to the social optimum. Hence, we expected that outcomes in our inter-generational game would be more efficient than those reported in previous experimental work. Of course it is entirely possible that the presence of advice will have a detrimental effect in that the advice will reinforce negative and pessimistic beliefs among the subjects and reduce cooperation rather than enhance cooperative behavior.

What we find is that when the advice left by one group of subjects is "public" (in the sense that it is made available to all the members of the succeeding group and also read aloud for all to hear), then this advice has a significant positive impact. Contributions in the public advice treatment average 81% (aggregated over all generations and all rounds) which far exceeds the 51.7% average contribution level attained in the "private" advice (that is, advice from one subject is given only to her immediate successor) treatment. Moreover public advice leads to increasing contributions over generations and mitigates problems of free-riding. No such trend is apparent

[7] Dawkins (1976, p. 189-192) comments "Cultural transmission is analogous to genetic transmission in that, although basically conservative, it can give rise to a form of evolution. …Examples of memes are tunes, ideas, catch-phrases, clothes, fashions, ways of making pots or building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperms or eggs, so memes propagate themselves in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation."

when this advice is private. We also find that advice in general has some salutary effects, because while the private advice group fares worse than the public advice group, still it does better than an experimental control group which played the standard public goods game without generations or advice. However, the difference between the private and no-advice groups is attributable to the initial high contributions of the private advice groups and such differences in contribution levels disappear over time. Finally, we find that subjects write qualitatively different advice when they know that the advice would be made public as opposed to when it is private.

We proceed as follows. Section 2 explains the experimental design and methodology. Section 3 presents our results. Section 4 discusses possible implications of our research findings and Section 5 concludes.

2. Experimental Design

All the experiments for this project were carried out as non-computerized classroom experiments using students at Wellesley College. Students were recruited via postings on an electronic bulletin board. A total of seventeen sessions were held with five students in each session. The composition of the group remains unchanged during the course of a session. Each session constituted one generation and consisted of 5 players playing the public goods game for 10 periods. This group of 5 is then replaced by 5 successors who take their place and play on. When generations change, after 10 periods of repetition, outgoing agents are allowed to pass on advice through free-form written messages to their successors. The successors are able to view these messages.

In our “private advice” treatment, a message left by one player can be seen only by her immediate successor. In the “public advice” treatment, on the other hand, advice left by one group of players is “made public.” All 5 pieces of advice left by this group is given to all 5 players in the next generation, and in addition this advice is read aloud by the experimenter before the start of the actual game.[8] Payoffs to an agent is the sum of the amounts that an agent earns during her lifetime plus 50% of what her successor earns in the next generation so there is partial inter-generational caring. This second payment is designed to act as an incentive for subjects to leave meaningful advice. The subjects are paid their actual earnings from a session immediately upon completion of the session. They are told that they will be contacted via e-mail/phone at a later date and given a second payment (based on the earnings of their successors). This second payment was handed out to the subjects after we had finished running all the sessions. Every player involved in the study received both the first and the second payments.

Also, before the start of the actual rounds and before the advice is made available to the players, we ask them about their expectations regarding the other players. Specifically, we ask them how much they expect the other group members to contribute on average in round 1. This gives us insight into the subject's beliefs about her fellow players. See the experimental instructions in Appendix 1 for the actual question.

In the first period of any generation, subjects are presented with a set of written instructions that are read out loud to them after they are finished reading them privately. After questions are answered subjects are asked the question about their expectations regarding period 1 contributions by fellow group members. Then, depending on the treatment, they are allowed to read the advice offered by their immediate predecessor (in the private advice treatment) or by the

[8] We would like to point out that all the experiments for this paper were carried out by the second co-author who is an undergraduate student at Wellesley College. It was she who read out all the instructions and the advice. Thus any changes in behavior between the private and public advice sessions cannot be attributed to the fact that a professor, who is in a position of authority, is making the announcements and coming from a authoritative figure such pronouncements have a large impact on behavior. All announcements are made by a peer of the experimental subjects.

immediately preceding group of players (in the public advice). In the latter case the advice is also read aloud by the experimenter.

The public goods game was played in the following way. The group, consisting of 5 subjects, is told that each of them is given 10 tokens for each one of 10 rounds. At the beginning of each round, each participant j must make a decision on how many of the 10 tokens she wants to contribute to a public account ($0 \leq c_j \leq 10$) and how many tokens she wants to keep for herself in her private account. Contributions are in whole numbers only and are made simultaneously by all the subjects in a group. After all participants had made their decisions, the total tokens contributed to the public account are added up and then doubled by the experimenter. This doubled amount is then divided equally among all five participants. The participant's personal earning for each round is the sum of the tokens she decided to keep in her private account and the tokens she received back from the public account. Total contributions to the public account and the number of tokens that each participant received from the public pool were announced at the end of each round. Following this the participants made their decisions for the succeeding round. Each successive round proceeded in the same manner. Each token is worth $0.05. Balances are not carried over from one round to the next.

The payoff for each subject j in any round then is

(1) $$\Pi_j = 10 - c_j + 0.4\sum_{j=1}^{5} c_j$$

In our case the marginal per capita return from a contribution to the public good is 2/5 or 0.4 since all contributions are doubled and split 5-ways. The total payoff to a subject is the sum of the per period payoffs as given in (1) over all 10 rounds. Note that (1) implies that full free riding ($c_j = 0$) is a dominant strategy in the stage game. This is because

(2) $$\frac{\partial \Pi_j}{\partial c_j} = -1 + 0.4 < 0$$

However, the aggregate payoff $\sum_{j=1}^{5} \Pi_j$ is maximized if each group member fully cooperates (c_j = 10), because

$$\frac{\partial \sum_{j=1}^{5} \Pi_j}{\partial c_j} = -1 + 2 > 0$$

After the last period, subjects are asked to write advice to their successors and leave. The subjects were also asked separately to indicate a period 1 contribution to their successors by writing a specific number. We provided the next group of subjects with the free-from messages but not the actual number (though a vast majority of subjects included this number in their free-form advice as well). When they write advice they know whether it is to be made public to all five subjects in the next generation or simply be read privately by their successor. They are paid the sum of their payoffs in the 10 period game they played, plus 50% of what their successors earned as a second payment at a later date.

We performed a set of four different experiments that varied according to the information available to subjects. In Experiment 1, the Replicator (No-Advice) Experiment, we simply replicate the standard public goods experiments, five times with 5 subjects in each group, without either generations or advice. In short, we simply ran the public goods game five times with five subjects for 10 periods. This group serves as the control group against which we intend to compare the behavior of our two experimental groups – one that gets private advice from the immediate predecessor and the other that gets public advice from the immediately preceding group.

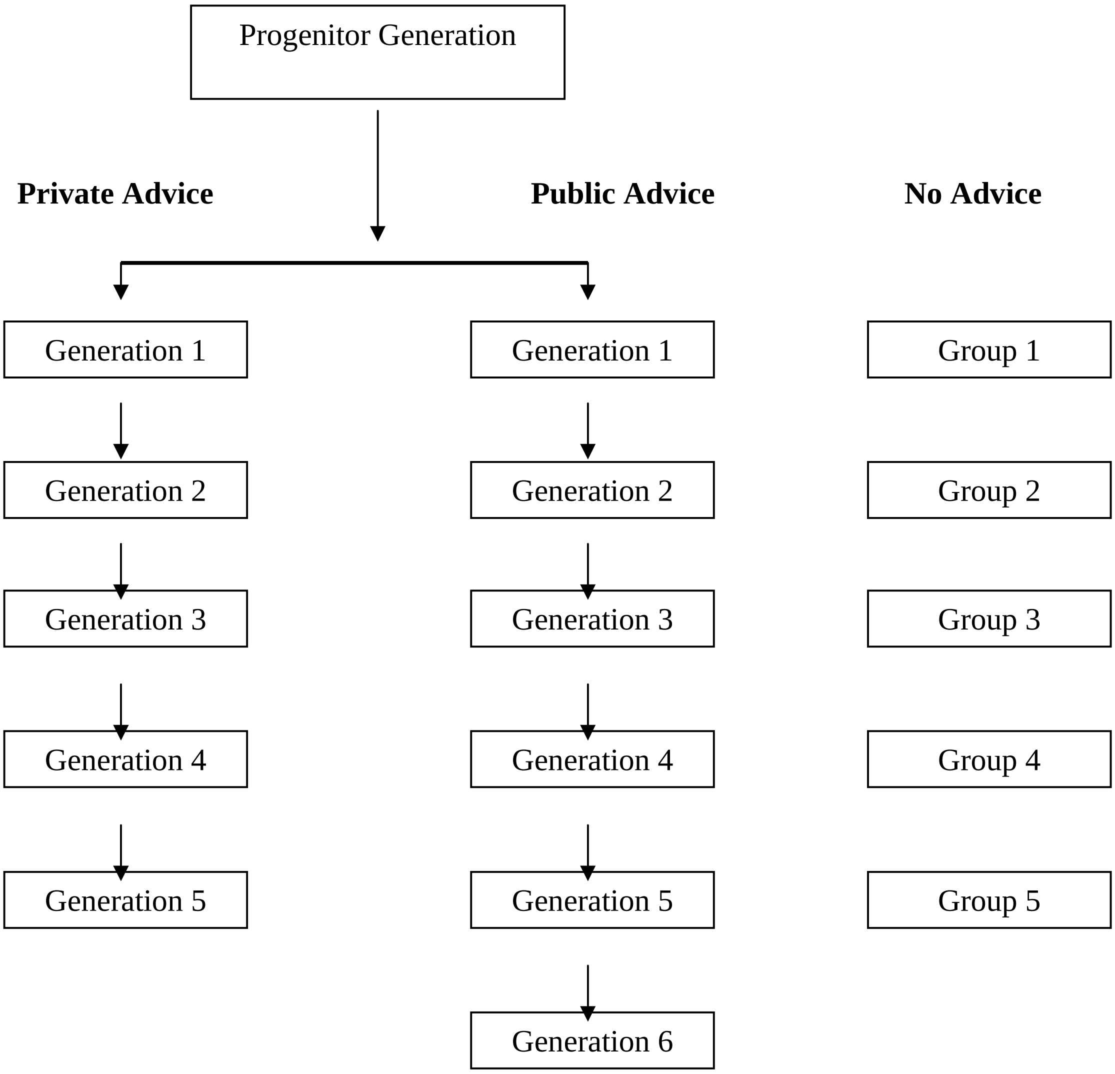
In running our inter-generational experiments we started (in Experiment 2) by running a "Progenitor" experiment in which 5 subjects played the public goods game for the first time and hence with no advice. This generation was the progenitor of all the generations in the two advice treatments – private and public - that followed in the sense that the first generations in each treatment used the advice of this progenitor generation. In Experiment 3 we had five generations of subjects play the public goods game with private advice, where each subject could receive advice from her immediate predecessor. So while each agent knew that the others were receiving advice, they did not know the content of any advice other than their own. Finally, Experiment 4 was a public advice experiment, which consisted of six generations. The first generation here received a sheet with all the advice from the progenitor experiment. However, this advice was also read aloud for all the subjects to hear, so the content of the advice on these sheets was common knowledge. Our exact experimental set-up is described in Table 1.

Table 1: Experimental Design

No.	**Design of Experiment**	**Number of Generations**	**Periods Per Generation**	**Subjects Per Generation**	**Treatment**	**Number of Subjects**
1	Replicator No-Advice	5	10	5	No History or Advice	25
2	Progenitor	1	10	5	No History or Advice but Advice Left	5
3	Private Advice	5	10	5	Private Advice only	25
4	Public Advice	6	10	5	Public Advice Read Aloud	30
	TOTAL					85

Table 2 outlines the structure of the experiments. Each session lasted about 40 minutes (the advice sessions took a little longer than the ones without advice) and the average payoff to the subjects was $12.30.

Table 2: The Structure of the Experiments



3. Results

We will begin in Section 3.1 by providing a broad overview of what we find in the three different treatments. In section 3.2 we will focus exclusively on the two advice treatments – public and private - and explore differences in the two. In Section 3.3 we take up the role of expectations and advice received and their impact on contribution levels.

3.1 Broad Overview of the Data

In table 3 we show the levels of contribution over 10 rounds aggregated over all generations (or groups) in the three treatments. As can be seen from the table, contributions in the public advice treatment are much higher than that in either the private advice or no advice treatment. Average contribution in the public advice treatment starts at 9.53 tokens out of 10 (95.3%) in round 1, which is close to the efficient contribution level of 10 tokens. While average contributions do decline over the 10 rounds still by the 10th round contribution in the public advice treatment is at a very robust 61%. Contributions in the private advice treatment start at 74.4% in round 1 and fall to 27.6% in round 10. In our replicator (no-advice) treatment, contributions start at 48.4% and drop to 38% by round 10. Aggregating over generations and advice we find that the public advice groups manage to achieve 81% contribution on average. This is significantly higher than the average of 51.7% achieved by the private advice groups ($z = 5.416$, $p\text{-value} < 0.01$ using the non-parametric Wilcoxon test). Contributions in the public advice treatment are also significantly higher than those in the no-advice treatment, which averaged 44.88% ($z = 5.937$, $p\text{-value} < 0.01$). Finally overall contribution in the private advice treatment at 51.7% is higher than the average of 44.88% in the no advice treatment ($z = 2.303$, $p\text{-value} = 0.02$).

Table 3: Round by round contributions in the three treatments

Treatment	Rounds									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Progenitor	8.8	9.2	9.4	8.8	8.8	8.6	8.8	8.2	7	7.8
Public Advice										
Generation 1	8.8	8.2	7.8	7.6	6.2	5.4	2.8	2	2.6	0.2
Generation 2	9.4	9.2	9	8.8	7.2	6.2	3.8	7.6	7	2.4
Generation 3	9.2	9.6	9.2	9.4	9.2	9.2	8.6	8.2	6.4	6.2
Generation 4	9.8	9.8	10	10	10	10	10	10	10	10
Generation 5	10	10	10	8	10	8	9	8	6.8	10
Generation 6	10	9.8	9.2	8.6	8.2	9.4	9.4	9	8	7.8
AVERAGE	**9.53**	**9.43**	**9.2**	**8.73**	**8.47**	**8.03**	**7.27**	**7.47**	**6.8**	**6.1**
Private Advice										
Generation 1	7.6	6.8	5.6	5.2	4.6	5	4.6	4.2	3.8	5
Generation 2	7.8	7.6	7	5.8	4.2	2.8	2.6	3	1.8	0.8
Generation 3	7	7.2	7.6	6.4	6	4.8	5.8	6.4	5	2.2
Generation 4	8	8.6	8	7.8	7.2	4.8	4.2	2.8	3.6	4.2
Generation 5	6.8	6.8	5.2	5.2	4.8	5	3.2	3.6	3	1.6
AVERAGE	**7.44**	**7.4**	**6.68**	**6.08**	**5.36**	**4.48**	**4.08**	**4**	**3.44**	**2.76**
No Advice										
Group 1	3.2	4.2	4	1.8	2	2.8	3	2.2	2.6	2
Group 2	5.8	4.8	4.4	5.4	3.2	4.6	4.8	3.6	4	3.4
Group 3	4.2	7.2	4.4	3.4	2.8	4.2	3	2.8	2.2	1.8
Group 4	6.4	8.6	7.4	8	6.8	7	7.2	7	4.6	7
Group 5	4.6	5.8	5.4	5.6	4.6	4.2	3.6	1.4	2.6	4.6
AVERAGE	**4.84**	**6.1**	**5.1**	**4.8**	**3.9**	**4.6**	**4.3**	**3.4**	**3.2**	**3.8**

Figure 1 depicts contributions over the 10 rounds for the three different treatments. Notice that the contribution level in the public advice treatment is always higher than that under the private advice and no-advice treatment for all 10 rounds. Also notice that contributions in the private advice treatment start out higher than that under the no-advice treatment. We find that contributions in round 1 of the private advice treatment at 74.4% is significantly higher than that in the first round of the no-advice treatment which starts at 48.4% ($z = 3.171$, p-value < 0.01 using the non-parametric Wilcoxon test), nevertheless by round 6 any such difference disappears. In fact by round 10 contributions in the private advice treatment are lower than the no-advice treatment, but the difference is not significant.

<<Figure 1 about here>>

Figure 2 provides a more disaggregated view of contributions. Here we show the pattern of choices made by each generation (in the three different treatments) over all 10 rounds. Each block in Figure 2 represents one generation and shows the average choices that particular generation made over all 10 rounds. What stands out from Figure 2 is the fact the contributions in the public advice treatment are much higher than the other two treatments. Generation 4 in the public advice treatment actually manages to sustain full cooperation for the last 8 of 10 rounds of the game. Generations 5 and 6, while faltering a little, also maintain contribution levels of 80% or more for all but 2 out of 20 rounds.

<<Figure 2 about here>>

Figure 3 isolates the evolution of contributions in the public advice generations and shows how the level of contributions increases steadily over generations reaching efficient or near efficient levels by generation 4. The first generation in the public advice treatment looks very similar to a typical group in public goods experiments. This group starts out at 88% contribution in round 1 but by round 10 contributions have declined to 20%. The next generation does not do that much better either, going from 94% in round 1 to 24% to round 10. The third generation however looks very different; even in round 10 this group contributes a robust 62%. Generation 4 starts out at 98% in the first two rounds and then manages to sustain total cooperation for the last 8 of 10 rounds. Generations 5 and 6 also maintain close to efficient levels of contribution falling below 80% in only 2 out of 20 rounds. Average contributions in the last three generations are 99.6%, 89.8% and 89.4% respectively for an overall average in the last three generations of 92.9%. Needless to say, these levels of contribution are far in excess of any recorded in any previous studies of the public goods problem.

No such increasing trend is apparent in the contributions made in the private advice treatment. We discuss these differences in greater detail in the next section.

<<Figure 3 about here>>

Section 3.2 Free riding in the public and private advice treatments

The discussion in Section 3.1 should have convinced the reader that contributions in the public advice treatment are significantly higher than that in the private advice and no-advice treatments. The presence of advice does seem to matter in that the private advice groups do better on average than groups in the no advice treatment. Thus, we find that the presence of advice in our inter-generational set-up does have a significant impact on contributions, but the impact of advice is far more pronounced when such advice is public than when it is private.

Having shown that the public advice subjects do far better than the private advice and the no advice treatments and that the private-advice subjects do marginally better than the no-advice subjects, in this section we are going to focus only on the differences between the two advice treatments – public and private.

We find that the behavior of the subjects in the public and private advice treatments is very different on a number of dimensions. First, as shown in Figure 3, in the public advice treatment there is a steady upward trend in contributions over generations. No such trend is apparent in the private advice treatment. Table 4 compares the average contributions over generations in the two treatments.

Table 4: Comparison of Public and Private Advice Generations

Generation	Public Advice Treatment	Private Advice Treatment	Wilcoxon z-statistic (p-value)	T-test t-statistic (p-value)
1	5.16	5.24	0.24 (0.8085)	0.147 (0.8824)
2	7.06	4.34	4.595 (0.0000)	5.740 (0.0000)
3	8.52	5.84	4.993 (0.0000)	5.552 (0.0000)
4	9.96	5.92	5.929 (0.0000)	9.016 (0.0000)
5	8.98	4.52	5.380 (0.0000)	8.906 (0.0000)
6	8.94			

As you can see from Table 4, contributions in the public advice treatment increase steadily over generations from 51.6% in generation 1 to 89.4% in generation 6. No such trend is apparent in the private advice treatment, where contributions actually decline from 52.4% in generation 1 to 45.2% in generation 5. In fact, in the first generation of the two treatments, contributions are not significantly different from one another. However, from the second generation onwards contributions in the public advice treatment are significantly higher than that under private advice. Needless to mention, if we compare the contribution between generation 1 and generation 5 in the public advice treatment, then we get a significant difference ($z = 5.258$, p-value < 0.01) as we do if we compare generation 1 and generation 6 ($z = 5.305$, p-value < 0.01).

Moreover if we compare the first three generations in the public advice treatment with the last three generations then we find that the first three generations manage an average contribution of 69.1% while the last three generations average 92.9%. This again is a significant difference ($z = -4.054$, $p\text{-value} < 0.01$). But if we compare the first and last generations of the private advice treatment, then we find that the first generation contributed 52.4% on average while the fifth generation contributed 45.2% on average. These contributions are not significantly different from one another ($z = 0.849$, $p\text{-value} = 0.396$). Similarly, if we combine the first two and the last two generations in the private-advice treatment, then we find that the first two generations contributed 47.9% on average while the last two generations averaged 52.2%. Once again this difference between the first two and last two generations is not significant ($z = 1.207$, $p\text{-value} = 0.23$).

Figure 4 depicts the information presented in Table 4 and shows what happens to average contributions across generations in the two advice treatments – public and private. This figure clearly illustrates the clear upward trend in contributions across generations in the public advice treatment.

<<Figure 4 about here>>

There is another way to show that the incidence of free-riding is significantly lower in the public advice treatment and such free-riding decreases over generations. In each generation, 5 players decide how many tokens (out of 10) to contribute for each of 10 periods. Thus in each generation there are a total of 50 investment decisions (5 players making 10 decisions each, with each decision being a number between 0 and 10). We will define a “high investment” as any contribution between 6 and 10 tokens while a “low investment” is any contribution between 0 and 5 tokens. Since the total number of contributions is constant at 50, the number of low investments is always equal to 50 minus the number of high investments. We focus only on the number of high investments in the public and private treatments. In figure 5 we compare the number of times a subject decided to invest high by choosing a contribution between 6 and 10 in the two treatments. So in generation 1 of the public advice treatment there are 27 high investments (between 6 and 10). This means that there were 23 low investments (between 0 and 5 tokens). In generation 1 of the private advice treatment there are 21 high investments (between 6 and 10) and 29 low investments (between 0 and 5). By generation 2 the number of high investments in the public advice treatment has increased to 39 while that in the private advice treatment has fallen to 17. In the last four generations of the public advice treatment, the numbers for high contributions (out of a maximum of 50) are 46, 50 (the maximum possible), 46 and 47 respectively. As Figure 5 shows, over the course of the 6 generations the graphs for high investments for the two treatments diverge and there is a significant increase in the proportion of high investments in the public advice treatment while no such increase is seen in the private advice treatment.[9, 10]

<<Figure 5 about here>>

As is well documented in the literature, contributions to the public good decline with repetition. We are interested in finding out whether the rates of decay in contribution (over the 10 rounds) in the public advice treatment were significantly different from those in the public advice treatment. In other words, we wish to find out if public advice and the concomitant process of

[9] This approach of categorizing investments in any given period as "high" or "low" is merely another way of exploring the amount of free riding in the data as done in Andreoni (1988, Table 2, p. 297). Except we take a more expansive definition of free riding as any contribution of less than or equal to 5 tokens. The subjects who contribute 6 tokens or more in any period are considered to be not free riding.

[10] There is a reason why we have looked at average contributions and high (or low) contributions over generations separately. Consider a group of 4 players who contribute {10, 10, 2, 2} tokens respectively in a given period. The average for this group is 6 tokens. Consider another group which contributes {6, 6, 6, 6} tokens during a period. The average for this group is 6 tokens as well. However the former group has two high contributors and two free-riders according to our definition. The latter group has no free-riders. As a result the second group will possibly be more successful in sustaining cooperation than the former group. Simply focusing on the average contribution in a group will lose sight of the fact that there may be free-riders in the group whose free-riding is obscured by the high contribution of other, more cooperative, players. What we find here is that the high contribution in the public advice treatment is sustained by both high contributions in general as well as the absence of free-riders.

social learning it generates manage to mitigate the problem of decaying contributions (as the rounds progressed) as compared to the private advice treatment. As reported above if we aggregate over all generations in the private advice treatment then we find that contributions start at 74.4% in round 1 and decline to 27.6% in round 10. The pattern of contribution is very different in the public advice treatment where contributions start out close to the socially optimal level at 9.53 tokens (95.3%) and even though they decline, still even in period 10 they are at a robust 6.1 tokens (61%). This is still at the high end of the usual contributions in public goods games of 40% to 60%.[11] See Figure 1 for a comparison of the patterns of decay in contribution for these two generations.

We want to know if the pattern of decay in the public advice treatment is indeed different from that in the private advice treatment. That is if we look at the slopes of the two graphs in Figure 1, then are the two slopes significantly different from one another? In order to do this we regressed average contributions for these two treatments against a set of independent variables which includes round (1 through 10), a dummy for treatment (0 for private advice and 1 for public advice) and finally an interactive term "treatment*round" where "treatment*round" is the product of treatment and round. The regression results are presented in Table 5. As expected the coefficient for round is negative and significant showing that contributions do decline as the rounds progress. The coefficient for the treatment dummy is positive and significant showing that when treatment changes from "0" (private advice) to "1" (public advice) average contributions increase. Finally the coefficient of the interaction term is positive and significant showing that that the slopes are different and that contributions decline faster in the private advice treatment than they do in the public advice treatment.

[11] In Andreoni (1988) average round 1 contribution 1 is 48.2% for partners and 50.8% for strangers while average round 10 contribution is 11.6% for partners and 24.4% for strangers. In Isaac, McCue and Plott (1985) contributions decline from 50% in round 1 to 9% in round 5.

Table 5: OLS Regression to test for difference in the slopes between public and private advice treatments

Independent Variables	Coefficient	Standard Error	t-statistic	p-value
Round	-0.546	0.026	-20.95	0.000
Treatment	2.022	0.229	8.84	0.000
Treatment *round	0.165	0.037	4.49	0.000
Constant	8.176	0.162	50.54	0.000
Adjusted R^2	0.98			

Section 3.3 Advice and Expectations

Schotter (2003) points out that one striking feature of human decision making is how willing people are to take advice from their peers, even if those peers are not necessarily experts in the task at hand and even when the advice that they provide is naïve in nature. For example, people make a large number of decisions such as buying a car, choosing a doctor, or investing in stocks or mutual funds on the suggestion of a friend even though he or she may have no expertise in these areas. In the context of voluntary contributions to public goods also such received wisdom may play a large role. In fact we have already shown in Sections 3.1 and 3.2 that such advice, from predecessors, who are not experts by any means, has a large impact on contributions.

We are interested in a thorough understanding of the impact of advice on contributions. To that end we first need to quantify the advice left by the subjects. Most of the advice left specified some kind of a dynamic rule such as “Start off by giving 10 tokens to the public account. From here, you can see what other people are doing. By the end you should put most of your tokens in your private account.” In the later generations of the public advice treatment though, the advice gets very strong with literally every subject exhorting their successors to choose “all 10 all the time!” Or they advised their successor to “Contribute 10 for the first round - establish trust right away, and keep it up. Contribute 10 every time and everyone wins. Once one person starts cheating, it all breaks down. Don't let it! Give 10 regardless”. (See Appendix 2)

In coding this advice what helps us is the fact that we asked each subject to leave not only free-form advice but also specify (separately) a token amount that they recommended to her successor as a suggested round 1 contribution. So in coding the advice we simply use this suggested contribution number.[12] Advice that suggested choosing more than one number such as “Contribute 7 or 8 tokens” was simply assigned the average of the two numbers.

Croson (1996) and Chaudhuri et al. (2002) have found that expectations are a crucial factor in determining an individual’s contribution levels in a public goods game. Chaudhuri et al. (2002) found that, in the public goods game, expectations are a significant predictor of both first round contributions and average contributions. These researchers comment that the “Spearman rank correlation coefficient between average expectations and round 1 contributions is 0.668 with a p-value of 0.000 and that between average expectations and average contributions is 0.597 with a corresponding p-value of 0.000.”

In our study, we wanted to examine which factor was more important in determining contributions, expectations or advice. To that end, after the instructions were read but before subjects received advice, we asked subjects to indicate the average contribution they expected from the other members of their group (excluding them). See appendix 1 for the instructions and the specific question on expected contribution from group members.

Table 6 shows the average advice received, expectations and period 1 contributions for the two advice treatments.

[12] However while we did provide the entire free form advice to the subjects we did not include the answers the questions about a specific contribution level. Though a vast number of subjects included this information in their free form advice in any case.

Table 6: Advice and Expectations in the two treatments

	Public Advice	Private Advice
Average Expectations	6.42	5.48
Average Advice	9.597	7.98
Average Period 1 Contributions (Out of 10 tokens)	9.53	7.4

As can be seen from Table 6, period 1 contributions in the public and private advice treatments closely follow the advice received rather than expectations. In the no-advice treatment, (not shown in Table 6) however, as you will see shortly, period 1 contributions are close to subjects' expectations. In order to focus more clearly on the role of advice and expectations we regress period 1 contributions against expectations and advice.

Table 7 shows the results of three OLS regressions looking at factors determining round 1 contributions in the three treatments. As the table shows, for both the public and private advice treatments, advice received is a significant predictor of round 1 contributions, while expectations are not significant. The coefficient for the advice variable is positive and highly significant in both the public and private advice treatments (p-value = 0.0198 in the public advice treatment and p-value = 0.0008 in the private advice treatment) while the coefficient for the expectations variable is not significant. However, in the absence of advice (in the no advice treatment), subjects rely on their expectations to select a contribution level. In the latter case the coefficient of the expectations variable is positive and highly significant.

Table 7: OLS Regression; Y-variable is 1st Round Contributions

Treatment	Independent Variables	Coefficient	Standard Error	T-statistic	p-value
Public Advice	Advice	1.3688	0.5526	2.4772	0.0198
	Expectations	0.1014	0.0743	1.3639	0.1839
	Constant	-4.2659	5.3735	-0.7939	0.4342
	Adjusted R^2	0.1595			
Private Advice	Advice	0.6285	0.1610	3.9037	0.0008
	Expectations	0.0798	0.1566	0.5096	0.6154
	Constant	1.9874	1.7546	1.1327	0.2695
	Adjusted R^2	0.3609			
No Advice	Expectations	1.1623	0.2518	4.6163	0.0001
	Constant	-0.6927	1.2650	-0.5476	0.5892
	Adjusted R^2	0.4584			

If we examine the roles of advice and expectations in the public and private advice treatments further then we find the following. Mean expectations were not different between the two treatments; the mean of expectations for the private advice treatment was 5.48, while in the public advice treatment the mean was 6.42. This difference is not significant. (z = - 1.64, p = 0.101 using a Wilcoxon test and t = -1.352, p = 0.189 using a t-test). Advice, however, was significantly higher in the public advice treatment than in the private advice treatment (z = -3.042, p = 0.00 using the non-parametric Wilcoxon test). The mean advice received in the public advice treatment was 9.597, while the mean advice received in the private advice treatment was 7.98. Figure 6 shows a histogram comparing advice in the public and private advice treatments. Notice from Figure 6 that the advice in the private advice treatment is much more scattered ranging from 2 at the lowest to 10 at the highest. In the public advice treatment however all but one person advised their successor to choose 8.5 or higher.

<<<Figure 6 about here>>>

Since contributions are shaped by advice received and advice received is clearly higher in the public advice treatment than in the private advice treatment, we can understand the reason for higher contributions in the public advice treatment. There is another trend relating to public and private advice; over time, mean advice passed from one private advice generation to the next decreases, while advice passed from one public advice generation to the next increases (see Figure 7).[13] In the first round after the progenitor, the private advice group advised their successors to choose an average of 8.7, while the public advice group advised their successors to choose an average of 9.4. This is not a significant difference (z = -0.948, p = 0.343). But from that point on the advice keeps getting stronger in the public advice treatment and more pessimistic in the private advice treatment. The last three generations of the public advice treatment unanimously advised their successors to choose 10, while the last three generations of the private advice treatment left an average advice of 7.1. This difference is highly significant (z = -3.26, p = 0.00).

<<Figure 7 about here>>

It should be noted that subjects in both the private and public advice treatments, at the end of their play, left advice that was significantly higher than their last period contributions. In the private advice treatment, average round 10 contribution is 2.76 while the average advice left is 7.64. In the public advice treatment the corresponding numbers are 6.10 and 9.72 for round 10 contributions and advice left respectively. See Table 8. However as we have noted before the advice left in the public advice treatment is significantly higher than the private advice treatment. Moreover even though first round contributions are strongly correlated with advice received, in the private advice treatment the subjects fail to sustain this initial level of cooperation. This can

[13] We have included the advice from the progenitor generation in Figure 7. The first generation in this figure is the progenitor generation. This is why the two advice lines start from the same point. The first generation in each treatment – public and private advice – corresponds to generation 2 in Figure 7.

be attributed to how subjects were advised to behave after the first round. Many subjects in the private advice treatment gave their successors conditional advice, such as “I would pick a high number for the first round like 9, but when you see the average start to drop, pick a small number so you don’t lose money.” On the other hand, subjects in the later generations of the public advice treatment tended to advise their successors to contribute all their tokens to the public account throughout the game, not considering what others did. Here is one example. “I advise all of you to contribute all 10 of your tokens in Round 1, and in all the other rounds. This will bring the maximum of ☺ $$ to each and every one of you. KEEP FAITH! NO ONE SHOULD MESS IT UP FOR THE OTHERS. 10 TOKENS FOR EVERY 10 ROUNDS!”

Table 8: Round 10 Contributions and Advice Left

	Public Advice	**Private Advice**
Average Round 10 Contribution	6.10	2.76
Average Advice Left	9.72	7.64

Section 4: Discussion of the results

This paper was motivated by the idea that if we played the public goods game with subjects who have experience in playing the game leaving advice to successive generations of players, then over time these groups of players will be able to achieve efficient of near-efficient levels of contribution. In some sense we wanted to see if by talking to successive generations players could evolve norms or conventions of giving – the so-called “memes” – whereby contributions would increase over generations and mitigate problems of free-riding. What we find is that advice matters – when advice is present subjects do contribute more. This is borne out by the fact that in the private advice treatment we get average contributions of roughly 51.7%, which is higher than what the no-advice replicator groups did. However our major finding is that for us to observe truly different behavior, such advice needs to be made public – that is each subject must be convinced that every other subject is getting the same message and such advice must be common knowledge. In the public advice treatment we get average first round contributions of 95.3%. Moreover there is a steady upward trend in contributions with the last three groups in this treatment averaging 92.9% overall, as opposed to the first three groups which averaged 69.1%. In the fourth generation of the public advice we see 100% contributions in the last 8 of 10 rounds. In generations 5 and 6 of the public advice treatment the contribution is close to the efficient level as well dipping below 80% in only 2 out of 20 rounds.

In section 4.1, we are going to talk about why we think subjects in the public advice treatment achieve results that are so startlingly different from those achieved by subjects in the private advice treatment. Then in section 4.2 we are going to address the implications of our results.

Section 4.1 Why are the results so dramatically different in the public advice treatment?

What explains the very high levels of cooperation that we observe in the case of the public advice treatment? One explanation is that the public advice treatment creates a situation of common knowledge about advice and thereby helps to reinforce positive beliefs about other subjects. As Rabin (1998) has pointed out, if one assumes the existence of reciprocal altruism then it is possible to think about the public goods game as a coordination problem where high contributions are efficient equilibria and low contributions are inefficient equilibria. Michael Chwe in his book “Rational Ritual: Culture, Coordination and Common Knowledge” talks at length about the role of common knowledge in fostering coordination. Chwe (2001, p. 3), in talking about a variety of situations where coordinated action is called for, comments

> “Because each individual wants to participate only if others do, each person must also know that others received a message. For that matter, because each person knows that other people need to be confident that others will participate, each person must know that other people know that other people have received a message, and so forth. In other words, knowledge of the message is not enough; what is also required is knowledge of others’ knowledge, knowledge of others’ knowledge of others’ knowledge and so on – that is “common knowledge. To understand how people solve coordination problems, we should thus look at social processes that generate common knowledge.”

Crawford (2001), reviewing Chwe’s book in the Journal of Economic Literature, writes

> “…coordination is often influenced not only by what people know about each other, but by what they know about what the others know, and so on. In game-theoretic language, coordination may require common knowledge of factors that influence people's intended decisions, not just mutual knowledge. (Common knowledge requires that something be known, that everyone knows that everyone knows it, and so on ad infinitum.)”

We believe that when we make the advice from a previous generation public and read it aloud, it is only then that we succeed in creating a common knowledge situation where subjects feel emboldened enough to choose higher contribution levels.

Moreover it can be argued that the outcome in this game (as in many others) depends on the beliefs that players possess about one another. Geanakoplos, Pearce and Stacchetti (1989) introduce the paradigm of psychological games where the payoff to each player depends not only on what every player does but also on what she thinks every player believes, and on what she thinks they believe others believe and so on. By explicitly introducing players’ beliefs, the authors argue that in many cases the psychological payoffs associated with a terminal node are endogenous and so are the equilibrium strategies. Geanakoplos et al. (1989, p. 61) suggest that along the same lines players’ utilities may depend

> “not only on the physical outcome of the game but also on their beliefs before and during play…. Consequently, the traditional theory of games is not well suited to the analysis of such belief dependent psychological considerations as surprise, confidence, gratitude, disappointment, embarrassment and so on.”

What this implies in terms of the present study is that if we allow for different distributions of beliefs on the part of players, free riding is not the only possible equilibrium outcome. However in order to contribute to the public good players need to possess appropriately optimistic beliefs about each other's actions and their beliefs about others' beliefs and so on. When advice is private with each subject getting advice from only her immediate predecessor, players' beliefs about each others' beliefs are not sufficiently optimistic to increase contributions significantly. But when the advice is public each subject reads and hears the same information and knows that every one else is also reading and hearing the same message. This finally succeeds in creating an atmosphere where players feel sufficiently bold to start with high contributions and then go onto establish a norm of high contribution based on that auspicious start.[14]

Chaudhuri, Schotter and Sopher (2001) study an inter-generational version of the the Minimum Game introduced by Van Huyck, Battalio and Beil (1990). This is a coordination game with multiple Pareto-ranked equlibria. In Van Huyck et al.'s original study groups of subjects routinely, and rather quickly, converged to the risk-dominant equilibrium that yields the lowest payoff. Chaudhuri et al. (2001), also use an inter-generational set-up similar to our present study. They find that when advice from a previous generation is public (made available to all the members of the succeeding generation) and also read aloud (therefore creating a situation of common knowledge of advice) subjects manage to attain the (payoff dominant) Pareto-efficient outcome. The Chaudhuri et al. results of public advice facilitating coordination have been replicated by Antonopoulos et al. (2002). The results of this current study contrast sharply with the findings of the Chaudhuri, Schotter and Sopher (2001) and the Antonopoulos et al. (2002)

[14] In future studies it would be worthwhile to ask subjects about their expectations about others' contributions once before the reading of advice and once after. It seems clear that receiving the advice changes subjects' expectations in a significant way.

studies because in both those studies the Pareto-efficient outcome is still *a Nash equilibrium of the game*. In the current study the social optimum of contributing all tokens to the public good is not a Nash-equilibrium since free-riding is the dominant strategy. Thus we have obtained a result that is stronger than the result obtained by Chaudhuri et al. (2001) namely *that public and common knowledge of advice can sustain a socially efficient outcome even when such an outcome is not a Nash equilibrium.*

Section 4.2 Implications of our results for real-life economic phenomena

What we find here then is that given the right institutional setting (namely the public advice treatment) a group of subjects do seem to be able to overcome the incentives to free-ride in achieving efficient or near-efficient levels of contributions.

Fishbacher, Gächter and Fehr (2001) show that a large number of subjects in these experimental games are conditional cooperators, i.e. they will cooperate as long as they expect other subjects to cooperate.[15] Keser and van Winden (2000) also show the presence of conditional cooperators in public goods experiments. Moreover Fehr and Gächter (2000, 2002) show that conditional cooperators are willing to punish non-cooperators for their non-cooperation even if such punishment has pecuniary costs for the cooperators. Conditional cooperation coupled with the opportunity to punish non-cooperators results in subjects being able to sustain high levels of cooperation over time. In fact Fehr and Gächter (2002) and Bowles and Gintis (2002) suggest that such "altruistic punishment" by *homo reciprocans* – humans who are willing to punish free-riders even when such punishment is costly to the punishers - may be the primary driving force behind sustaining cooperation in a variety of social dilemmas. This is similar to Axelrod's (1984) idea of Tit-for-Tat cooperators. That is, subjects are not altruists but rather conditional

[15] Ernst Fehr and his associates have done extensive research along these lines. See for instance Fehr and Gächter (2000, 2002), Fehr and Fischbacher (2002) and Fisbacher, Gächter and Fehr (2001).

cooperators who start out by cooperating at the beginning of the interaction and from the next period on mimic what others did in the previous period – they cooperate if others did so. But they are also willing to punish defection from the cooperative norm.

However our results suggest that if the population consists of a large number of conditional cooperators then, even in the absence of explicit punishment mechanisms, communities may be able to create inherent social norms that lead to efficient levels of contribution to the public good. All that is needed is the creation of conducive conditions that lead to the generation of optimistic beliefs about other subjects. Once subjects have adequately optimistic beliefs about one another then a group of conditional cooperators may be able to sustain cooperation even without the explicit threat of punishments. Punishments (or the threat thereof) will keep contributions high but we have shown that while punishments may be sufficient to sustain cooperation they may not be necessary.[16] Groups may be able to generate social norms that serve the same purpose of sustaining cooperation.

This in turn questions the traditional emphasis on the provision of public goods by governments. It seems that socially connected communities may be able to do quite well for themselves in terms of providing public goods even in the absence of government interventions.[17] One implication of this is that religious groups, which are more socially connected, should do better in terms of providing public goods. In fact Ruffle and Sosis (2002) finds in a study of religious and secular kibbutzim in Israel that religious males (the primary practitioners of collective religious ritual in Orthodox Judaism) contribute significantly more to an experimental public good.

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[16] See Fehr and Gächter (2000) for examples of social situations where cooperators can actually punish non-cooperators for their lack of cooperation.

[17] See Putnam (2000) for an excellent discussion about the role of social capital and social connectedness in fostering community development.

4 Conclusion:

In this paper we find that if we adopt an inter-generational approach to the public goods game where a group of subjects with experience playing the game can leave advice to successive generations of players then over time subjects manage to achieve efficient or near-efficient levels of contribution. While the presence of advice matters in the sense that groups with advice exhibit greater cooperation than a control group which plays the standard public goods game with no advice, for us to observe sustained cooperation and efficient levels of public goods provision, advice needs to be public (made available to all the members of a group).

We find that when advice is made public and read aloud then over time contributions to the public good increase and remain close to the efficient level. Before ending we want to point out that advice in our treatment works differently than communication in the sense of Cooper et al. (1989, 1992) or Dawes, McTavish and Shackley (1977) where the players themselves are allowed to talk to one another. Such communication usually increases efficiency. In our experiments subjects cannot talk to one another but only to their successors. Moreover not all forms of advice increase efficiency. Private advice from one player to her own successor does not result in lasting cooperation. It is only when the advice is public that we observe high levels of cooperation.

References:

Andreoni, J. and R. Croson (1998), "Partners versus Strangers: Random Rematching in Public Goods Experiments", forthcoming in C. Plott and V. Smith (eds.) Handbook of Experimental Economics Results.

Andreoni, J., (1988), "Why Free Ride? Strategies and Learning in Public Goods Experiments", *Journal of Public Economics*, 37, p. 291-304.

Antonopoulos, C., L, Chau, A. Chaudhuri, E. Hahn and S. Min (2002), "Efficiency Breakthrough: Conversion from Almost Common Knowledge to Common Knowledge of

Advice in an Inter-generational Minimum Game", Working Paper, Wellesley College, Spring 2002.

Axelrod, R. (1984), "The Evolution of Cooperation", Basic Books.

Bowles, S. and H. Gintis (2002), "Homo Reciprocans", *Nature*, 415, January 10, 2002, p. 125-128.

Chaudhuri, A., A. Schotter and B. Sopher (2001), "Talking Ourselves to Efficiency: Coordination Conventions in an Inter-Generational Minimum Game with Private, Almost Common and Common Knowledge of Advice, Economics Research Report #2001-11, C.V. Starr Center for Applied Economics, New York University, December 2001.

Chaudhuri, A., D. Chen, S. Graziano, F. McIntire and D. Winkler (2002), "To Free Ride or not to Free Ride? The Role of Patterning and Feedback in a Public Goods Game", Working Paper, Department of Economics, Wellesley College, Spring 2002.

Chwe, M.S. (2001), Rational Ritual: Culture, Coordination and Common Knowledge, Princeton University Press, Princeton, NJ, 2001.

Cooper, R., D.V. DeJong, R. Forsythe, and T. W. Ross (1989) "Communication in the Battle of the Sexes Game: Some Experimental Results," *Rand Journal of Economics*, 20, p. 568-587

Cooper, R., D.V. DeJong, R. Forsythe, and T.W. Ross (1992) "Communication in Coordination Games", *Quarterly Journal of Economics,* 107, p. 739-771.

Crawford, V. (2001), Review of "Rational Ritual: Culture, Coordination, and Common Knowledge" by Michael Suk-Young Chwe, *Journal of Economic Literature*, 40, p. 577-578.

Croson, R. (1996), "Partners and Strangers Revisited" *Economics Letters*, 53, p. 25-32.

Croson, R. (1995), "Expectations in a Voluntary Contribution Mechanism", Working Paper No. 95-03-02, Department of Operations and Information Management, Wharton School, University of Pennsylvania.

Dawkins, R. (1976), The Selfish Gene, First Edition, Oxford University Press.

Dawes, R., J. McTavish, and H. Shaklee (1977), "Behavior, Communication, and Assumptions About others People's Behavior in a Commons Dilemma Situation", *Journal of Personality and Social Psychology*, 35, p. 1-11.

Fehr, E. and S. Gächter (2002), "Altruistic Punishment in Humans" *Nature*, 415, January 10, 2002, p. 137-140.

Fehr, E. and S. Gächter (2000), “Cooperation and Punishment in Public Goods Experiments”, *American Economic Review*, 90(4) p. 980-94.

Fehr, E. and U. Fischbacher (2002), “Why Social Preferences Matter--The Impact of Non-selfish Motives on Competition, Cooperation and Incentives”, *Economic Journal*, 112 (478), p. C1-33

Fischbacher, U., S. Gächter and E. Fehr (2001), “Are People Conditionally Cooperative? Evidence from a Public Goods Experiment”, Economics Letters, 71(3), p. 397-404.

Geanakoplos, J., D. Pearce and E. Stacchetti (1989), “Psychological Games and Sequential Rationality”, *Games and Economic Behavior*, 1, p. 60-79.

Issac, R. M. and J. Walker, (1988a), “Communication and Free Riding Behavior: The Voluntary Contributions Mechanism”, *Economic Inquiry*, 26(2), p. 585-608.

Issac, R. M. and J. Walker, (1988b), “Group Size Effects in Public Goods Provision: The Voluntary Contributions Mechanism”, *Quarterly Journal of Economics*, 103, p. 179-99.

Isaac, R. M., K. F. McCue, and C. Plott (1985), “Public Goods Provision in an Experimental Environment,” *Journal of Public Economics*, 26, p. 51-74.

Isaac, R. M., J. M. Walker, and S.H. Thomas (1984), “Divergent Evidence on Free Riding: An Experimental Examination of Possible Explanations,” *Public Choice*, 43, p. 113-149.

Keser, C. & F. van Winden (2000), “Conditional Cooperation and Voluntary Contributions to Public Goods”, *Scandinavian Journal of Economics*, 102(1), p. 23-39.

Kim, O. and J. Walker, (1984), “The Free Rider Problem: Experimental Evidence”, *Public Choice*, 43, p. 2- 34.

Ledyard, O., (1995), “Public Goods: Some Experimental Results”, Ch. 2 in John Kagel and Alvin Roth (eds) “Handbook of Experimental Economics” , Princeton University Press, Princeton, NJ.

Marwell, G. and R. Ames (1981), “Economists Free Ride, Does Anyone Else?” *Journal of Public Economics*, 15, p. 295-310.

Putnam, R.D. (2000), “Bowling Alone: The Collapse and Revival of American Community”, Touchstone, New York, NY, 2000.

Rabin, M. (1998), “Psychology and Economics”, *Journal of Economic Literature*, XXXVI, p. 11 – 46.

Ruffle B. & R. Sosis (2002), “Do Religious Rituals Promote Cooperation”, Working Paper, Department of Economics, Ben Gurion University, Beer Sheva, Israel

Schotter, A. (2003), “Decision Making with Naïve Advice”, Paper presented at the American Economic Association Annual Meetings, Washington D.C. January 2003.

Schotter, A. and B. Sopher (2003), ““Social Learning and Coordination Conventions in Intergenerational Games: An Experimental Study”, *Journal of Political Economy*, forthcoming.

Schotter, A. and B. Sopher, (2001), “Social Learning and Coordination Conventions in Intergenerational Games: An Experimental Study”, Mimeo, Center for Experimental Social Science, New York University, October 2001.

Schotter, A. and B. Sopher, (2001a), “Advice and Behavior in an Inter-generational Trust Game”, Mimeo, Center for Experimental Social Science, New York University, September 2001a.

Schotter, A. and B. Sopher, (2001b), “Advice and Behavior in Intergenerational Ultimatum Games: An Experimental Approach”, Mimeo, Center for Experimental Social Science, New York University, September 2001b.

Van Huyck, J., R. Battalio, and R. Beil, (1990), “Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure”, *American Economic Review*, 80, p. 234-248.

Appendix 1: Experimental Instructions

Subject ID ____________________

Instructions for the Private Advice Treatment

This is an experiment in economic decision-making. Wellesley College has provided the funds to conduct this research. The instructions are simple. If you follow them closely and make appropriate decisions, you may make an appreciable amount of money. This money will be paid to you in cash at the end of the experiment.

You are in a market with 4 other people. The experiment will consist of 10 decision rounds. At the beginning of each round each participant will have an endowment of 10 tokens. In each round, each participant will choose how many tokens (ranging from 0 to 10) to allocate to a private account and how many tokens (ranging from 0 to 10) to allocate to a public account. For each round, these two numbers should add to 10, the total number of tokens you have for that round. At the beginning of each round you will write the number of tokens you wish to contribute to the public account on a slip of paper and hand it to the experimenter. The experimenter will then add up the total contributions to the public account and announce it publicly. The total number of tokens invested in the public account will be **doubled** and divided equally among all 5 participants. Your personal earnings for this round will equal the number of tokens you invested in your private account plus the number of tokens you get back from the public account (the latter may be a fractional amount). You will keep track of your contributions to each account and your earnings on the Record Sheet on the next page. Please take a look at the Record Sheet now.

Each new round will proceed in the same way. Tokens invested in the private account in any round do not carry over to the next round. Every round you start with a fresh endowment of 10 tokens. At the end of the experiment your total earnings from the 10 decision rounds will be added up and converted into cash at the rate of 5 cents per token.

Unless you are in the first group to participate in this experiment, when you start the experiment you will receive written advice on how to make your decisions from a single subject who participated in the experiment immediately prior to you. At the end of your 10 decision rounds you will leave advice to a new subject on how to make decisions. On top of what you make in this session of the experiment, you will receive an additional payment equal to 50% of the earnings of the subject to whom you give advice. Please write your advice on the sheet provided, and write or print legibly. You will be notified by email or telephone when your second payment is ready.

If you have any questions, please ask them now.

Subject ID ____________________________

Please answer the following question after the instructions have been read and before the first round begins.

What is the average contribution to the public account that you expect from the other subjects in your group? Do not include yourself, and round to the nearest integer if necessary. Please choose one:

____ 0	____ 3	____ 6	____ 9
____ 1	____ 4	____ 7	____ 10
____ 2	____ 5	____ 8	

Record Sheet

Round	**Tokens in Private Acct (Column 2)**	**Tokens in Public Acct (Column 3)**	**Returns from Public Acct (Column 4)**	**Total Tokens (Add Cols. 2 and 4)**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
			TOTAL	

ADVICE:

Please write your advice to the next player here. Continue on reverse if necessary.

Appendix 2: ADVICE

Progenitor Group

I would start off giving everything. That seemed to work well for me – giving all 10 tokens to the public account. At the 1st sign the payoff decreases, in the next round you should start giving less. Not much less, but down by a token or so. If the public account payoff keeps decreasing, keep giving less and less to it in the subsequent rounds. I never had to decrease what I gave the public account to under 7 tokens. Bottom line: it makes sense for you to give a lot to the public account. It starts to not make sense when you find everyone else isn't giving. Good luck! Go make money!

In the beginning, everybody will contribute the full 10 points to the public fund, but don't do that, keep your contribution at 7 or 8 tokens because you will make more than 20 (which is what everyone would make if everyone's contribution was 10 tokens). Later on, the contributions by everyone will decrease so that people are not giving everything, but you will still have made more than anybody else.

Put a lot of money in the public account at first so the pot gets really big and it builds people's confidence, then around round 3 or 4 contribute significantly less (like 4 or 5 tokens). By then people will start contributing less as well. 4 private 6 public is fairly advantageous.

I would suggest giving 10 tokens to the public sector and hoping that all will be able to benefit from giving 10 + multiplying total by 2. if there are too many free riders, i.e. column 3 is 10 but 4 is a lot less than 20, you may want to save more to help your total.

Don't be too conservative, especially in the beginning, but if you see everyone else pulling back, don't be the only dope giving your money away. I'd suggest putting in 9-10 tokens in the first round.

Private Advice, Generation 1

Give everything in the first round, like 10. It would seem risky but definitely the return would be bigger. You might want to put less when there is a sign that people are putting less, but not less. It would be best to put a lot of money in the account (public one).

Bet a lot at the beginning, 8 or 9. In order to make the most money, everyone should give 10 each time. However, people get selfish as the game went on. I gave 9 consistently, which helped the average, but probably hurt me.

I would suggest giving a large number of tokens in the first round, as many others will be doing the same, and the most money can be made in the first round. As the game progresses, put more tokens in your private account, and less in the public account. (Round 3 or 4). I found the most advantageous combination to be 6 in private and 4 in public account.

If everyone contributes generously to the public account, then everyone will profit. Try to see how generous your particular group is. I would recommend starting with 7 tokens in the public sector and then see the relative generosity of the group.

Don’t be too conservative in the beginning. I would pick a high number for the first round like 9. But when you see the average start to drop, pick a small number so you don’t lose money.

Private Advice, Generation 2

In the first round, I suggest giving 5. This way you play it safe and feel out what the other players do without losing out. As the game continues, if you find that the # of tokens in the public account rises, then add more of your own to it. Starting at round 6, consider giving less to the public account because the group's trust will probably begin to break down. By round 7 or 8, choose to put all 10 tokens into the private account.

Invest/vote highly in first three rounds for public account.
Vote zero in public accounts for 4-5.
Round 6, Round 7, Round 8, slowly begin to decrease contributions to public.
Rounds 9-10 → vote zero in public accounts.
Try to spark "hope" in select rounds (hence 1-3) to encourage investment or (4-6).

Round 1, put all your tokens into the public account – everyone else puts them in as well. Put in a decreasing # of tokens as the rounds progresses. The return will likely get lower, but try to keep the faith! Hopefully others will as well – putting money in the public account is best for everybody. 6 in your private account and 4 in the public is a good number to level off at.

First round start off with 5 to see what everyone else's response is. Try to increase your amount and see if everyone else does too. But if after a few rounds, the returns from public account is still low, then decrease the contribution to the public account.

Stay high (7 or above) as long as you can, 4 or 5 rounds. Then get out quick (pick a small contribution) if the average is dropping.

Private Advice, Generation 3

In the 1st round, people are going to give about 5 tokens to test the waters. Give 10 to encourage the group. After that give about 8 each round until the returns drop below 12. Confidence will waver and returns will plummet at the end. By rounds 8, 9, 10, give no more than 2 tokens.

Vote medium to high during 1st 3-4 rounds.
Vote zero for the next 2-3 rounds.
Vote 5 for the next 1-2 rounds.
Vote 0 for final 1-2 rounds.
First round vote 6.

I found that a good amount for most of the rounds to put into the public account was eight. In round one don't put less than 7 in the public account. In the last round, it is good to conserve more in your private account because people tend to pull out of the public account.

Start with a 7 or an 8. See how the trend goes. Put the same number for the first two or three rounds. If the response is increasing, slowly increase your numbers too.

Start with a relatively high contribution (~7), but don't be too concerned to drop down to a lower public donation/account.

<u>Private Advice, Generation 4</u>

In the first round, contribute 10 tokens to see what others do. Then see how things go in the next few rounds.

1st round – 8 (contribution to public)
Next 2-3 rounds – medium to high
Next 2-3 rounds – low to medium
Last 1-2 rounds – low
Final round – zero

For the first 3-4 rounds don't hesitate putting 9 tokens in the public account. For the 5th round, be careful and check how much other people is putting into the public account. If it's getting low you're better off keeping 5 or 4 for private and put the rest into the public account.

Choose a high number first, 7 or 8. Stick with the same number for the next round or 2. don't invest all to the public account too early, but follow the trend. If the return is increasing, there's trust building among the people. Then invest more. But if the trend continues to fall, invest around 5-7. don't invest too little (0-3) because the trust amongst the people will drastically fall. It pays off for everyone to invest more in the public account <u>BUT</u> everyone must do so at the same time. Only invest a smaller amount when the return has drastically (and continues) to drop.

If you really want to make money at the start, begin with a low number ~2, because people bid high at the start.

Private Advice, Generation 5

Start off by giving 10 tokens to the public account. From here, you can see what other people are doing. By the end you should put most of your tokens in your private account.

1st round - 8
2nd round - 5-7
3rd-4th round - 0
5th-6th - 2-3
7th-10th – 0

Put more (8 or 9) into the public account the first couple rounds; confidence drops by Round 5, so keep more (<5) in your private account for the last couple rounds.

It is important that you start your initial investment with an investment of 6-8 tokens in order to develop a trust with the rest of your opponents. If you see a trend that the majority of returns are decreasing, then leave more for your personal account.

People tend to bid high (for the public account) in the first round, so bid a low # (around 2) and keep more for your private account. Also, as the bidding goes on, people tend to bid less (the amount in the public account goes down).

Public Advice, Generation 1

If everyone starts off with a strong donation to the public, about 8 or 9, and keep going at around that amount, everyone benefits and makes the most money. Yet if it seems like others are not contributing, put in less.

It would be best if you give 9 or no less than 7 in every round. Be consistent. If people sense that they make more by giving more to the public, you would all give more to the public and get more in return. Don’t play selfish games unless other people do, but you will benefit the most by doing what is best for the group!

Start out big. Contribute all you have to public account. Slowly decrease this amount i.e. round 3 – 8 tokens, 4 – 8 tokens. Make a drastical jump at around 8 and 9 like 2 tokens or 1 to public account. Have fun with it!

It is profitable (very profitable) if everyone adds all their money to the public account. If you want to be greedy, fine, but be greedy and make money. In the public account your profits double. Don’t be shy, put your money out there and get more in return.

Our group got too stingy too quickly, and we all got stuck in the end. My advice – it’s better if you all put $ in the public account, and keep going. Putting in 7 and keeping out 3 was the best for me. For the first round, definitely put 9 or 10 in public account – the key, I think, is to keep group confidence in the public account high for as long as possible. If you must, be selfish once or twice, but not to the extent that confidence will suffer.

<u>Public Advice, Generation 2</u>

Unless you are in a group where people can't do math, don't be selfish because people will realize it. So if you want to make a good amount of money and you want others around you as well (hey why not?) then invest a good amount of your money into the public account. 9 is a good number. My challenge is for you <u>not</u> to be selfish.

Give all your tokens all the time to the public account. This goes for everyone. Don't be greedy, everyone wins.

The most certain way for everyone to maximize their profits is for everyone to contribute all 10 tokens to the public account all 10 times. If people play games to try to guess what other people are going to do and cheat them, everyone just ends up losing out. Trust each other and put in all 10 tokens. It will pay off.

Always contribute at least 5 to the public account. It's ok to experiment between 10 and 7, but give a lot to keep the group's morale high. If others start to give less don't let it discourage you!

If you want to make money, put money into the public!!! The more everyone puts into the public, the bigger your profit. So, if everyone puts 8-9 tokens in the public account for all of the rounds, everyone benefits. You can do the math yourself. It works. So for the first round put 9 tokens in the public. In our group, people started putting less into the pot in rounds 2 and 3 (and so on), so we all lost confidence in each other and we didn't make as much as we could have made. So, have confidence and trust that everyone will put $ in the public account.

Public Advice, Generation 3

I am a die-hard idealist… So I put all 10 in, if everyone does the SAME, everyone will get the maximum! Please do not lose faith in win-win situations! If the world was fair, then this would be it – make the world a better place – PUT ALL 10 IN ☺ !

Give **LOTS** of tokens!!! Keep in mind that if everyone gives a lot, everyone wins – if one person puts in very little, other people get discouraged & put in less, and then everyone loses – you shouldn't put in less than 7 tokens per round, try putting in 9 or 10. Do trust other people – believe it or not, they'll put in a lot more than you'd expect. And if you all put in 10 each round, EVERYONE WINS!!! Good luck. ☺

Unless everybody puts all their $ into the public account, someone's going to feel ripped off. So EVERYONE should put in all their $ into the public account. And you should do this from the beginning, because once someone doesn't, no one will contribute $ and no one will get that much $. That way everyone maximizes their profits and everyone's happy.

Give around 7 or 8. Giving is great, so contribute! And it really sucks when people don't contribute, so the more you contribute, the more money you'll get and your group won't hate you. ☺ Experimenting is ok, but don't go under 6. You won't get as much if everyone only contributes 6.

ALL 10 ALL THE TIME! DON'T BE A CREEP.

Public Advice, Generation 4

If you want to do the best for yourself (and for others – funny how it turns out that way) you MUST put 10 in public account. That's the way you will make the most money. Don't try to fool people – you'll only fool yourself because when trust is gone, maximum money about possible is gone to. Have Fun and Bet 10!

Give 10!! From the beginning! Trust me, if everyone gives 10, then everyone wins big! 10! 10! 10! 10! (DON'T be a creep and be a free rider)

Everyone should contribute $10 to the public account for every single round. If you put more into your private account you will make less money for sure! The way to make the most profit is to always contribute the maximum amount to the public account since this total is multiplied by 2. Think about it, it's the game theory.

In the first round contribute 10. You will see how your group will turn out sort of based on how much it contributes. To benefit everyone, contribute 10 each time. Our group was successful in doing this. If you don't, success will not be satisfactory if 10 is not contributed.

I advise all of you to contribute all 10 of your tokens in Round 1, and in all the other rounds. This will bring the maximum of ☺ $$ to each and every one of you. KEEP FAITH! NO ONE SHOULD MESS IT UP FOR THE OTHERS. 10 TOKENS FOR EVERY 10 ROUNDS!

Public Advice, Generation 5

If it feels good do it. Think of the public masses (contribute 10 each time every time). Just do it, peeps. If one person withholds, then you all will lose some – but maybe your curiosity will get to you – don't let it!

All 10 tokens to the public account in Round 1. You <u>must</u> establish trust in the beginning for people to benefit.

Ok guys, think about it. You will be maximizing everyone's profit (and good will) if you give 10 every time! You will double your investment. For goodness' sake don't be that morally vacant girl who prioritizes her own profit & takes advantage of everyone else!

Contribute 10 in round 1. Continue to contribute 10 throughout the game. I tried to cheat the other players, but we all ended up losing something. It's better to contribute 10 and everyone goes away happy.

Please allocate all ten tokens in each round to the public account. You may make a few extra tokens by "cheating" the rest of the group. However, once one player cheats, all confidence is lost and profits will continue to fall. Place all tokens in the public account consecutively and things work out fine.

Public Advice, Generation 6

Contribute 10 for the first round - establish trust right away, and keep it up. Contribute 10 every time and everyone wins. Once one person starts cheating, it all breaks down. Don't let it! Give 10 regardless.

DON'T GET GREEDY! You will maximize your profits if <u>everyone</u> contributes 10 to the public account: the first round and every round.

You <u>have</u> to contribute 10 tokens first round! It benefits everyone! The best thing for everyone is to contribute all 10 every round, you'll all make the most money. Once someone skimps out it all goes downhill. All time, every time! Dead serious!!

The best way to go is to contribute 10 in Round 1. Once you've done that, you've established trust among your group members. There will come to a point when someone in the group will start becoming selfish and that's when you too could put some amount into your private account and see how things go. Most likely, you will lose rather than gain but since it is human nature to be selfish, you should try your best to avoid doing that!! Trust me!!!

Contribute 10 at least in the first round. Don't try to be selfish because it works out better if you contribute 10, everyone wins.

Figure 1: Round by round contributions in the three treatments

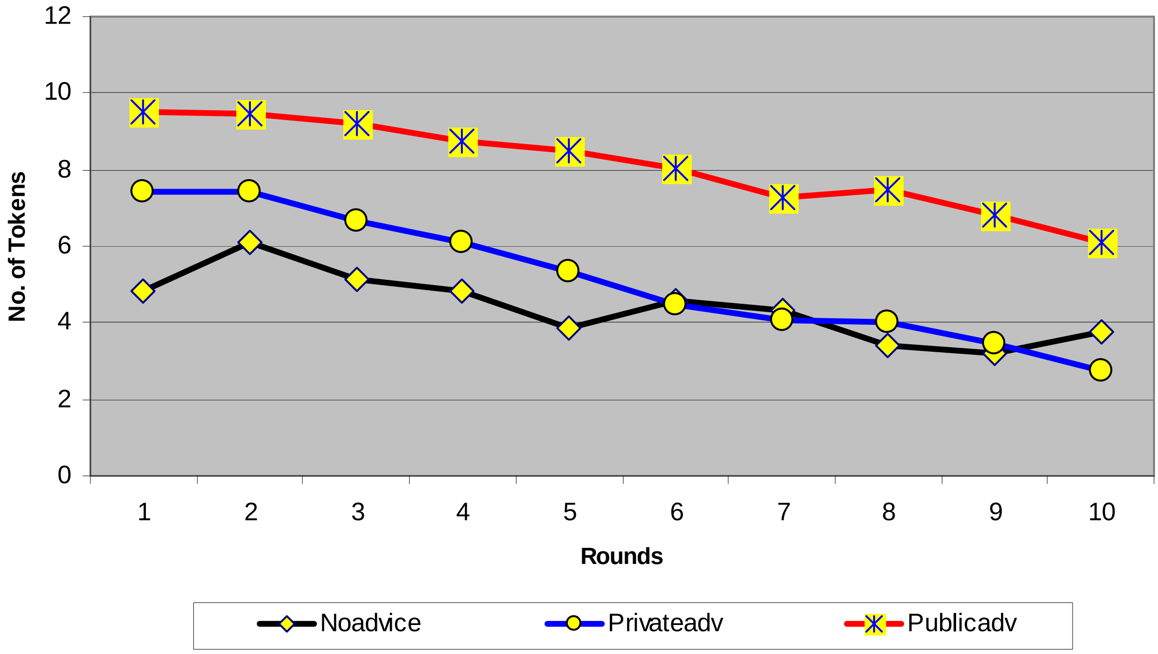

Figure 2: Contributions over generations

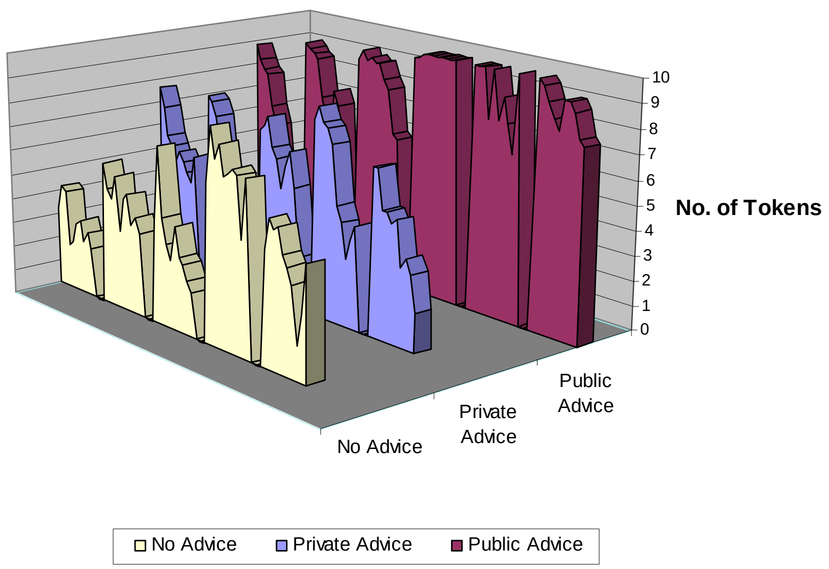

Figure 3: Contributions across generations in the public Advice treatmment

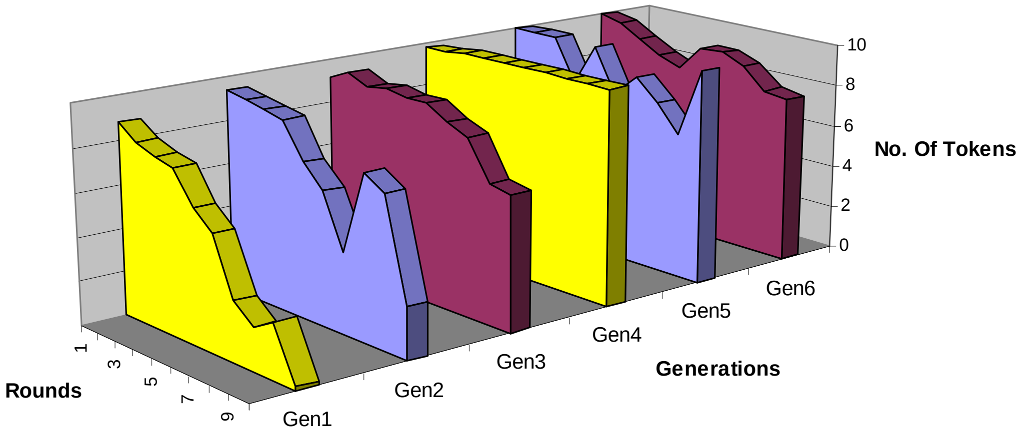

Figure 4: Evolution of average contributions over generations

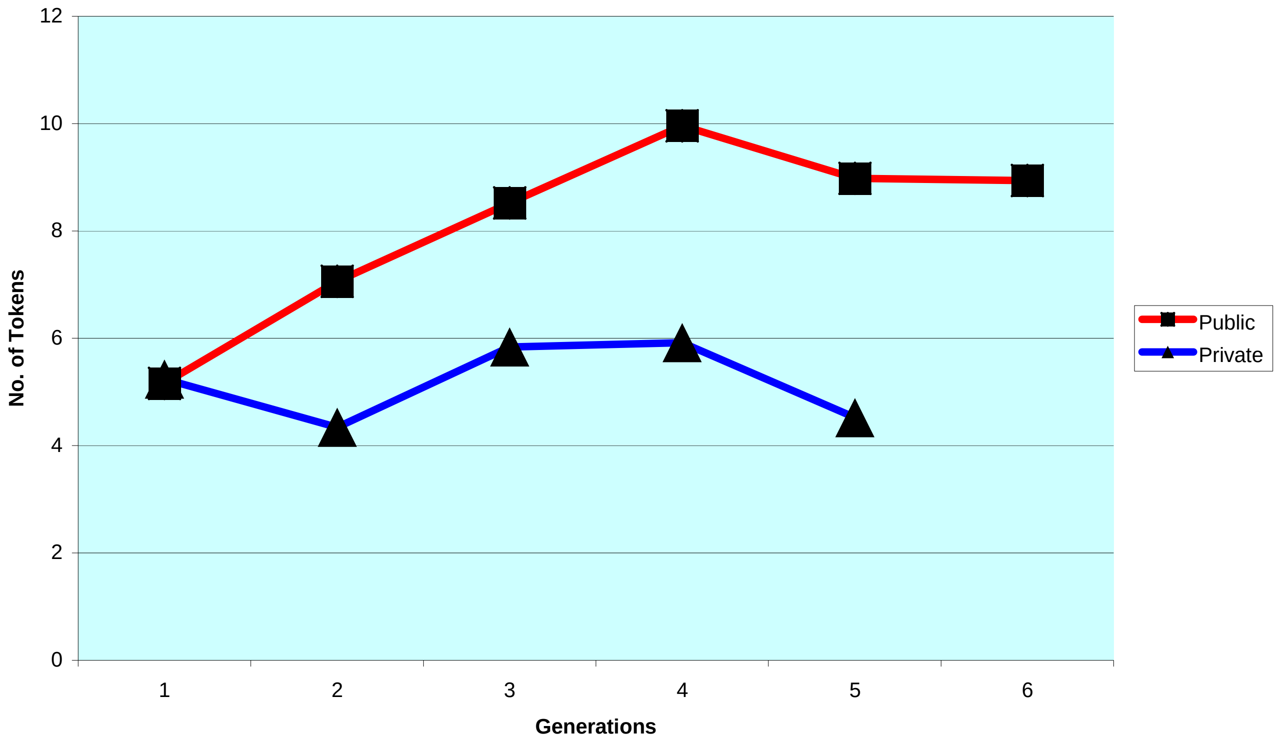

Figure 5: Evolution of high contributions over generations

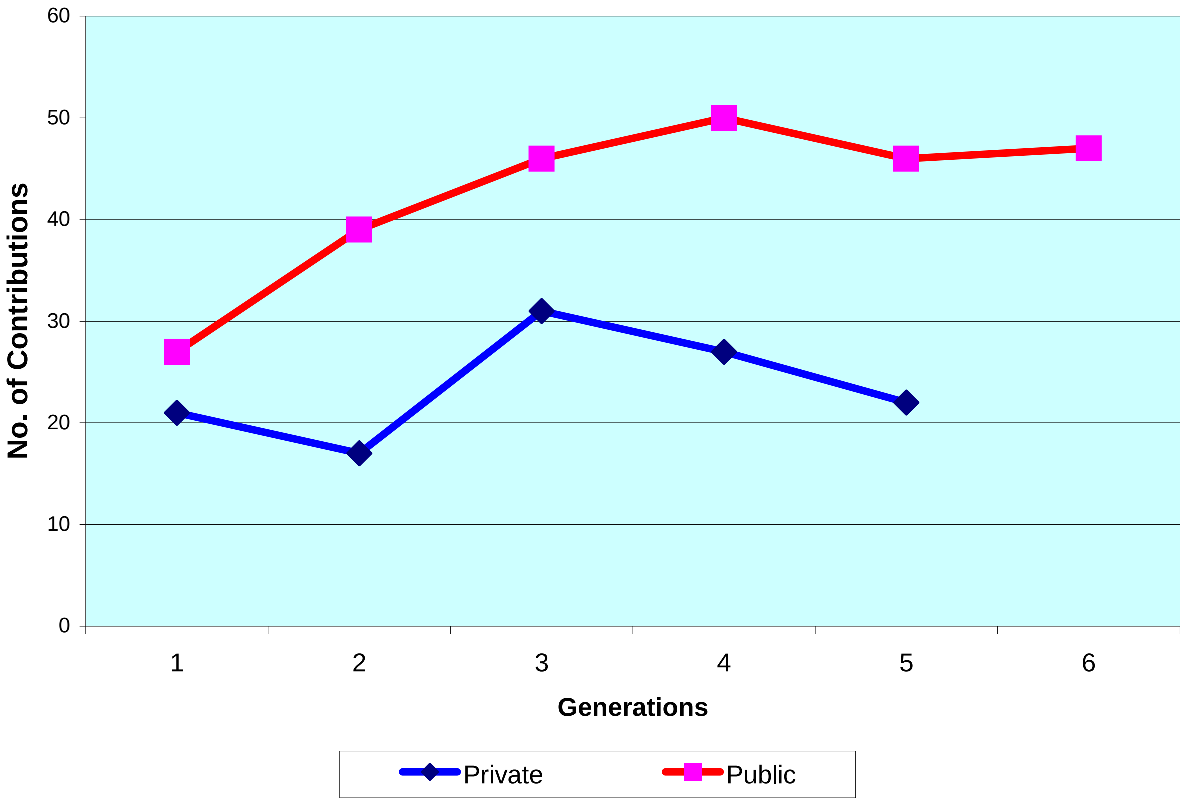

Figure 6: Frequency distribution of advice

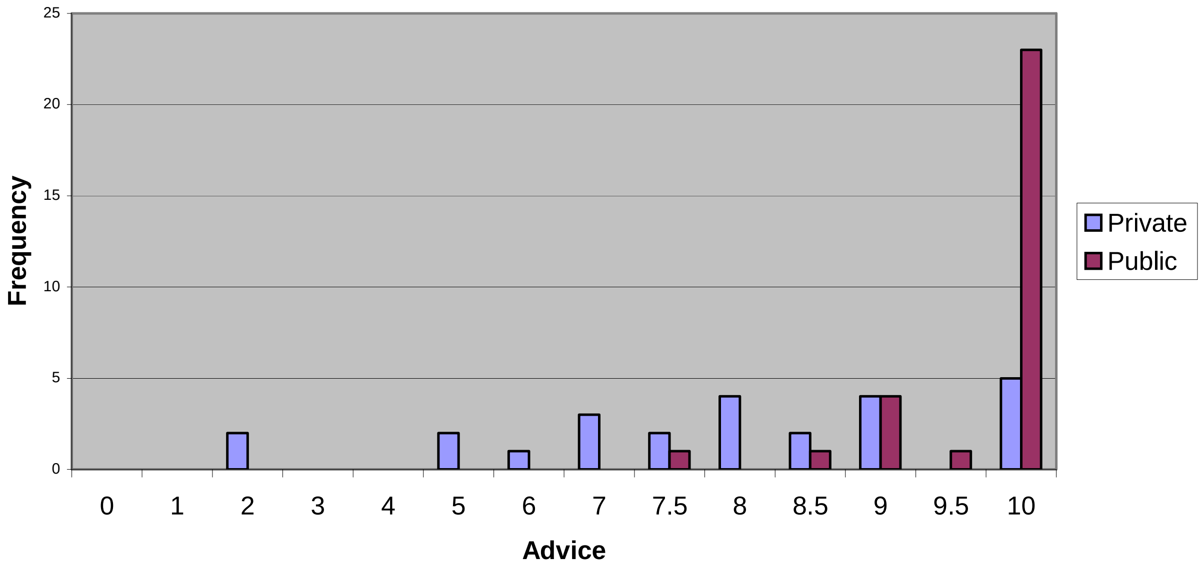

Figure 7: Evolution of Advice over Generations