An inter-generational approach to the public goods problem

Ananish Chaudhuri[1]
Liliana Kim
Susane Ko
Erin Rand-Giovannetti
Nina Varghese

Department of Economics
Wellesley College
106 Central Street
Wellesley, MA 02482

[1] Corresponding author. E-mail address: achaudhu@wellesley.edu

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Abstract

We adopt an inter-generational approach to the public goods game where at the end of each session subjects are allowed to leave advice for the succeeding generation via free form messages. We find that a process of social learning via passing advice from one generation to the next helps increase contributions over time and also mitigates problems of free riding.

JEL Classification: C71, C92

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 center around 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.

A typical public goods experiment looks like the following.[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 their 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

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[2] See Marwell and Ames (1981) Andreoni (1988, 1995), Isaac McCue and Plott (1985), Isaac, Walker and Thomas (1985) 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 each player then gets $0.50. The player who contributed 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 she is no worse off if no one else contributes, but she is actually better of if some others contribute. 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. This is because free riding is a dominant strategy in this game. As a result economists have usually called for government provision (via tax revenue) of non-excludable public goods such as public libraries, hospitals and schools. These questions are acquiring greater significance with increasing calls for smaller governments and greater reliance on community based activities and mobilizing the local community's resources to solve local problems with provision of public goods.[4]

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, subjects typically contribute about 40% to 60% of the optimal level (i.e. if maximum contribution is $20, then contributions in the first round of a

[4] Increasingly there is more emphasis, both at the federal as well as state levels, for community based solutions including George Bush's rather controversial call for greater involvement of faith-based charities in transforming welfare and providing a variety of local public goods. See www.whitehouse.gov/infocus/faith-based. Many states also are trying to enlist the help of local communities in reforming the welfare system. For a description of the state of Oregon's attempts see www.cascadepolicy.org/bgc/fong.htm.

typical game will be $8 - $12). Third, contributions decline steadily with repetition, i.e. if the players interact repeatedly over a number of periods 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. Thus free-riding, while definitely not pervasive, is not completely non-existent either.

In this paper 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,[5] and some communities do successfully solve the problems of providing non-excludable public goods without government assistance.[6]

Chaudhuri, Schotter and Sopher (2001) comment that there are two salient features of these 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 sequence of finitely lived agents. 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

[5] According to 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 Foundations Center's Report "Giving in the Aftermath of 9/11". See www.fdncenter.org for more details of charitable contributions after 9/11.

[6] 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.

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.

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 pioneered by Schotter and Sopher (2001, 2001a, 2001b) investigating the Battle of the Sexes, Ultimatum and Trust Games respectively.

In this experiment, groups of 5 subjects are recruited into the lab and play a public goods game for 10 periods (the exact experimental design and parameters are explained in Section 2). After their participation is over each player is replaced by another, her laboratory descendant, who then plays the game for another 10 periods with a fresh group of 5 subjects so the generations are non-overlapping. Advice from a member of one generation to his or 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 his or her lifetime plus 20% of what her children earn. Hence, incentives exist for subjects to pass on intelligent advice. The process continues for six generations of players.[7]

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 "talk

[7] Constraints of time and money necessitated stopping after six generations. It would be interesting to see what happens if the game continues for more generations because there is ample evidence that average contributions are increasing over the generations.

themselves to efficiency" in the sense that later generations would report much higher levels of contribution and would also be successful in mitigating the problem of decaying contributions over time. Hence, we expected that outcomes in our inter-generational game would be more efficient than those reported in previous experimental work.

What we find is that over six generations of play, while contributions do not quite reach the socially efficient level, still by the sixth generation average contributions are significantly higher than the first generation. More importantly while the first generation replicates the standard finding of contributions declining rapidly over time, by the sixth generation contributions do not decay as much over 10 periods of play. Thus we find the process of passing advice from one generation to the next does help in increasing levels of contribution and also prevents those contributions from declining over time.

Section 2 explains the experimental design and methodology. Section 3 presents our results and finally Section 4 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 either by word-of-mouth or via postings on an electronic bulletin board. A total of six sessions were held with five students in each session. Each session consisted of 10 periods and constituted one generation. At the beginning of each session, instructions were handed to the participants including the Record Sheet and Advice Sheet. The instructions were also read out loud. Each generation was told that part of their payoff relied on their performance during the experiment as well as the performance of the following generation. Before the start of the actual rounds the advice left by the 5 players of the preceding generation (except for the first generation) was also read out loud.[8]

The Public Goods Game was played in the following way. Each generation has five players. Each session consists of ten rounds. Each session of ten rounds comprises one generation. Each participant was told that she is given ten tokens for each round. At the beginning of each round, each participant must make a decision on how many of the ten tokens she wants to put into a public account and how many tokens she wants to keep for herself in her private account. After the decision was made for all participants, 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 four participants. The participants personal earning for each round is the sum of the tokens she decided to keep and the tokens she received from the public account. Total contributions to the public account and the number of token that each participant received from the public pool was 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. At the conclusion of each session, each participant wrote advice for the next generation.

[8] This design of making the advice from a previous generation available to all the members of the succeeding generation and then reading it out loud is based on the insight gained from the Chaudhuri, Schotter and Sopher (2001) study which studies a coordination problem. There it was found that making the advice from a previous generation public (i.e. available to all members of the succeeding generation) and also reading the same advice out loud constituted a "common knowledge of advice" situation which led to efficient outcomes. Simply making the advice available but not reading it out loud did not lead to efficient outcomes. See Chaudhuri, Schotter and Sopher (2001) for details. Another recent study by Antonopoulos, Chau, Chaudhuri, Hahn and Min (2002) replicates this discontinuity in behavior when the advice is read out loud and when it is not. These researchers also find that the frequency of the efficient outcome is greatly enhanced when the advice from a previous generation is read out loud as opposed to when it is not.

In order to ensure understanding of the game, every generation played five practice rounds after receiving the instructions and advice. This was done before the 10 money rounds. The results of the five practice rounds did not carry on to the ten money rounds, and the participants were not paid for the performance for the practice rounds. Each session lasted about 40 minutes and the subjects made $8.80 on average.[9]

1. Results

Observation 1: Average Contributions increase from generation 1 to generation 6.

We find that average contributions increase over the six generations with public and common knowledge of advice. Table 1 provides a summary of average first period and tenth period contributions to the public account.[10] The average investment in the public account for all 10 periods in generation 1 was 4.6 (46%) (standard deviation = 4.08) in the first generation, while the average investment increases to 7.66 (76%) (standard deviation = 3.59) in the sixth generation. A two-tailed t-test shows that this is a significant increase in investment between the first and last generation ($t = -2.77$, $p<.01$). The same conclusion is reinforced using a Wilcoxon test ($z = -2.805$, p-value < 0.01). Furthermore, when we combined the average investment of the first two generations and compared it to the average investment of the last two generations, we find a similar increase in average investment. The mean investment in the first two generations was 5.11 (51%) (standard deviation = 3.95). The mean investment in the last two generations

[9] Since average contributions increased over generations, later generations made more than earlier generations.

[10] A detailed breakdown of contributions for each individual in every generation over ten periods is available from the corresponding author by writing to achaudhu@wellesley.edu.

was 6.62 (66%) (standard deviation = 3.22). A two-tailed t-test once again showed this to be a significant increase in investment ($t = -2.04$, $p<.05$). This is borne out by a Wilcoxon test as well ($z = -2.391$, p-value = 0.01). Figure 1 demonstrates the patterns of contribution in generations 1 and 6.

There is another way of looking at contributions over generations. In each generation, 5 players decide how many tokens to contribute for each of 10 periods. Thus in each generation there are a total of 50 investment decisions (each decision being a number between 0 and 10). We decided to look at the number of times a subject decided to invest between 0 and 4 and the number of times a subject decided to invest between 5 and 10.[11] Figure 2 shows the distribution of low and high investments. The way to read the chart is this. For any generation the sum of low and high investments must add to 50, i.e. if one vertically sums the two numbers then they add to 50. So in generation 1, there are 27 low (between 0 and 4 tokens) investments and 23 high (between 5 and 10 tokens) investments. This changes to 19 low investments and 31 high investments in generation 2. By generation 6, there are 8 low investments and 42 high investments. As Figure 2 shows, over the course of the 6 generations the graphs for high and low investments diverge and there is a significant increase in the proportion of high investments and a corresponding decrease in the proportion of low investments.

Observation 2: Generation 6 does not exhibit the usual pattern of decaying contributions.

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

[11] The cut-off point of 4 (40%) was chosen because in prior studies this is the lower limit of first period contributions.

for generation 1 were significantly different from those in generation 6. In other words, we wish to find out if by generation 6, a process of social learning via passing on advice manages to mitigate the problem of decaying contributions as compared to generation 6. We find that while generation 1 displays the usual pattern of decaying contributions over 10 periods (average contributions decline from 8.4 tokens (84%) to 0.6 token (6%)), the pattern of contribution is very different in generation 6. In generation 6 contributions start out close to the socially optimal level at 9.2 tokens (92%) and even though they decline, still even in period 10, they are at a robust 5.8 tokens (58%). This is still at the high end of the usual contributions in public goods games of 40% to 60%. 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 generation 6 is indeed different from that in generation 1. 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 generations against a set of independent variables which includes period (1 through 10), a dummy for generation (0 for generation 1 and 1 for generation 6) and finally an interactive term gen*period where gen*period is the product of generation and period. The regression results are presented in Table 2. As one can see, the coefficient for gen*period is significant with a t-stat of 4.35 (p-value < 0.01) showing that the slopes are different and that contributions decline faster in generation 1 than they do in generation 6.

Observation 3: Advice plays a role in increasing investments.

Are the increased contributions of later generations caused by the act of passing advice? Intuition suggests so since the behavior of subjects in the later generations is dramatically different from those in generation 1. Since every group plays the identical public goods game, and the only thing that is different is that later generations are receiving the accumulated advice of previous generations, then accordingly it would stand to reason that differences in behavior may be attributed to a process of social learning via advice. One striking feature of human decision making is how willing people are to take advice from their peers. For example, people choose doctors by the word-of-mouth suggestions of their friends, buy stocks after getting a "tip" from their barber even though he or she is typically no expert, choose schools for their children, car dealerships from which to buy a car, and accountants to do their tax returns, all on the merest suggestion of a friend.[12] The question then is why are people so willing to follow advice? It could be because they underestimate their own abilities in solving the problem at hand and simply assume that others are better at it than they are. Or it could be that they think that others, while not better analytically, have better information.

In order to rigorously examine the role of advice we needed to quantify or code the advice given in some form. Many of the advice are dynamic rules such as the following. “Start investing really high to make the group invest high and then start to invest a little less each time so you keep more. If everyone else invests and you don’t, you double your profit.” Since most of the advice did not recommend the investment of a specific amount we categorized the advice into various categories. The first category is those that advised investing the full amount (10 tokens) in each period. This advice was given the value of 10. The second category, advised investing only some of the tokens or investing heavily at first and then dropping back. This advice was given the value of 7.8.

[12] We thank Barry Sopher for pointing out this fact about our willingness to follow the advice of others, even non-experts.

If the advise suggested something like being in the middle or finding a "happy medium: then it was coded as 5. If the advice could not be coded because it was not specific enough the this advice was given the value 0. Finally if the advise suggested more than one level of investment such as 7 or 8 tokens then it was given a value equal to the mean of those numbers – in this case 7.5. (See Appendix B for coded advice)

Figure 3 shows the relation between average amounts invested by a player and the advice left by her. We looked at the average amount invested by each individual and the advice that individual left to the next generation and found a significant positive correlation between the two (see Figure 3). The Spearman's rank correlation coefficient was 0.52 (p-value < .01). Individuals who invested highly left advice to invest high and individuals who invested low, left advice to invest low. Thus it seems that over time as the level of investment by players increased, the quality of the advice left also increased and this is turn enhances contributions in the later generations.

Overall we were able to find a significant increase in amount invested over six generations when players received and passed on advice that was public and common knowledge. Not only were average investments higher by the sixth generation, but also the rate of investment did not decline as rapidly as compared with the first generation. There is a strong positive correlation between amounts invested and the advice left. Individuals, who invested high, left advice for players in the next round to do the same, and vice versa for low investors. Finally, we found that over the six generations there is a steady increase in the number of high investments and a steady decrease in the number of low investments.

4. Conclusion

We have found that playing the public goods game using an inter-generational design leads, over time towards greater contributions by later generations. A process of social learning via advice giving proves successful in not only encouraging future generations to contribute more, but to contribute at a more consistent rate. This demonstrates that our conjecture, that over time, generations would be able to "talk themselves to efficiency," is in fact true. Although the Pareto optimal outcome was not reached in any of the generations, the average contributions for later generations were reported at much higher levels. In addition, these later generations were also successful in mitigating the problem of decaying contribution over time. Thus, one can expect more efficient outcomes in an inter-generational game than those reported in previous experimental works.

The implications of these results are quite promising. If people invest high, they will leave advice to future generations to do the same. The end result is that as a collective group, members of later generations will contribute at a higher and more consistent rate. One can, therefore, expect members of future generations to reach a socially efficient level of contribution (or close to it) and resolve the problem of contribution decay, if and when, we, at the present time, contribute at a high level and teach them to do the same. Only when the lessons of our experience are common knowledge to our children will one be able to witness a more cooperative society in the future.

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Table 1: Average Contributions to the Public Account by Generation

Generation	**Period 1 Contributions**	**Period 10 Contributions**	**Average Contribution**
1	8.4	0.6	4.6
2	7.2	5	5.62
3	7.2	3.8	5.8
4	7	1.4	5.66
5	5.2	5.6	5.58
6	9.2	5.8	7.66

Table 2: OLS Regression to test for difference in the slopes

Independent Variables	Coefficient	Standard Error	T-statistic	p-value
Period	-0.994	0.083	-12.03	0.000
Generation	0.267	0.725	0.37	0.718
Gen*period	0.508	0.117	4.35	0.000
Constant	10.067	0.513	19.64	0.000

Figure 1: Average Contributions for First and Sixth Generations

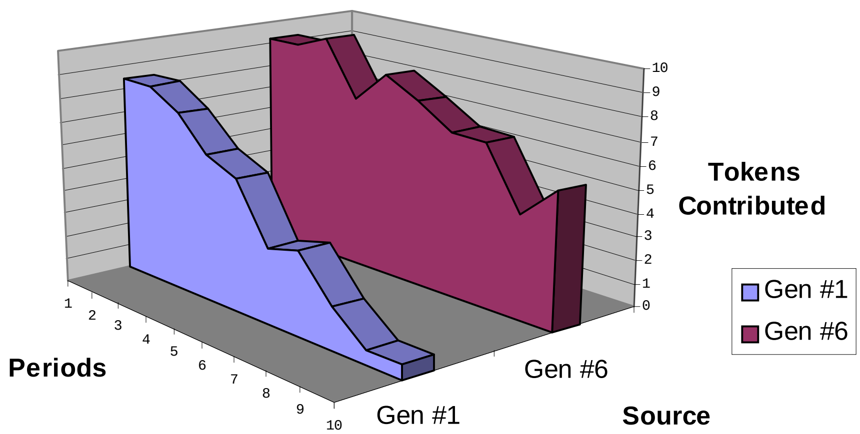


Figure 2: Comparison of High and Low Contributions

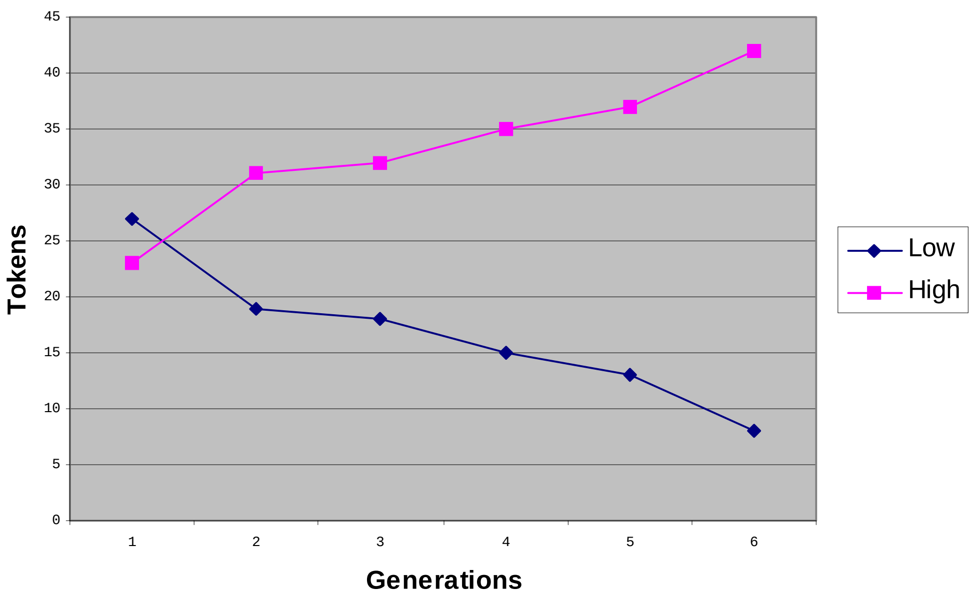
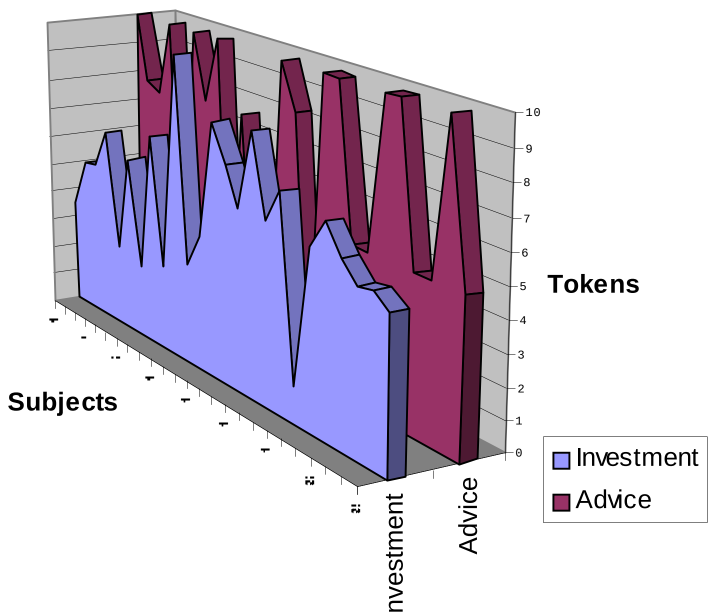


Figure 3: Relation Between Investment and Advice



Appendix A: Instructions

This is an experiment in investment decision behavior. The instructions are simple. If you follow them closely and make appropriate decisions, you may make an appreciable amount of money. These earnings will be paid to you in cash at the end of the experiment.

You will be in a market with 4 other people. In this experiment there will be 5 practice rounds and 10 decision rounds. Every participant will receive a total of 10 tokens per round. In each round, every participant will choose a number of tokens to invest in a pool, ranging from 0 to 10. The total number of tokens invested in the pool will be doubled and divided equally amongst all participants. Your personal earnings for each period will equal the amount you keep plus the amount that will be returned to you from the pool.

At the end of the experiment, your total token earnings will be converted in dollars and cents, at the rate of 1 token: $.05.

Unless you are in the first group to participate in this experiment, when you start the experiment you will receive advice on how to make your decisions from a 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 20% of the earnings of the subject you give advice to. Please write your advice on the sheet provided. Please write or print legibly. You will be notified by email or telephone when your second payment is ready.

Please write your participant number on top of every page. If there are any mistakes on any question sheet the experimenter will go over the instructions again. IF YOU HAVE ANY QUESTIONS PLEASE ASK THEM AT THIS TIME.

Appendix B: Advice Left by Each Generation

Generation One

ID	Advice	
11	You should always give 10 tokens, so everyone gets the most.	10
12	Start investing really high to make the group invest high and then start to invest a little less each time so you keep more. If everyone else invests and you don't you double your profit.	7.8
13	Invest around 7 or 8 tokens and feel out the group. If investment stays high keep investing high, if it goes down, go down as well.	7.5
14	Have faith in the other people in the group. If you start off giving all you can, everyone else will too and you will get the most you can.	10
15	Don't let one person ruin the whole game. If it's going really well and one person stops putting in as much, don't stop putting in money. It just starts a really bad spiral downwards.	0

Generation Two

ID	Advice	
21	Give it all up... don't keep anything because you'll earn the most money if you invest it all.	10
22	Use the practice rounds to see how others "vote" Invest high, but watch your back too. Think of what others might invest due to the previous round and "vote" accordingly	7.8
23	Invest like mad! If everyone gives, everyone gains.... competition drives your earnings down.	10
24	If everyone else thinks everyone would invest $10 every round and you invest none, then you'll receive the most. However, once people start to realize people aren't investing everything, they begin to change their behavior, however, slowly. The invested amount wouldn't drop to zero right away but over time it will, and if you invest nothing right from the beginning, you should receive the most. Though, if everyone thinks like this, the strategy wouldn't work either.	0
25	Generally invest high so that the pool amount is large. Take a couple of rounds where you invest really little though - just to add some variety to your life.	7.8

Generation Three

ID	Advice	
31	The most advantageous situation is if everyone puts in ten. But people are selfish and will put in less. This is particularly effective if they do it when no one is expecting it and everyone is putting in a large amount.	0
32	If everyone invests everything, everyone will do well, but then if you invest a little less than everything, you can earn more without compromising everyone else's earnings too drastically.	0
33	If you start off low, so will everyone else. Invest all 10 tokens! If everyone invests everything we all end up getting more.	10
34	At the beginning, you think everyone's voting high to maximize profits. If you give only 8 or 9, you can always add at least 1 or 2 extra points to your total. But if you lower your investment too much, it will bring the average down. In the last few rounds, I think people started giving less to see how it would turn out. This brought all the averages down collectively. Best bet: aim for 8 or 9 tokens to invest each time.	8.5
35	If everyone puts 10 in, everyone will get 20 back if everyone else puts in 10 and you put in nothing you will get back 16+10=26. But if 2 people put in nothing, you will get back 12+10=22. So you have to try to figure out your "opponents' will they put 10 in or nothing in or any number in between.	0

Generation Four

ID	Advice	
41	“Don’t try to be a conniving stockbroker. Just be generous and win out.”	10
42	“You should really really put in 10 tokens. BE HONEST! Don’t try to think or figure out what the others do-Just put in 10 tokens!!! Trust me….But if you realize that you’re the only one putting in a lot, just put in 5.”	10
43	“Use the practice round to figure out a good medium between giving too much or too little. If everyone gives more-the average will go up and all will get more in the end. Don’t be selfish!”	5
44	“Find a “happy medium” amount during practice rounds and just use that as a tester to see how the group goes up and down. Usually things go down for 2 or 3 consecutive rounds before people get desperate and put lots in.”	5
45	“If you put in 10 tokens you’ll get the most returns. (Not everyone does that though, so be careful!)”	10

Generation Five

ID	Advice	
51	It’s definitely good to pool more money. Stay constant with your decision, don’t experiment too much. If you think the pooled money is going down (towards the end) keep more money for yourself.	10
52	Mix it up! Keep them all and give them all and see what happens.	5
53	Find out the medium of the group during the practice round. If they’re generous, be generous also. It’s better not to be stingy.	5
54	Everyone should give all 10 tokens. That way people will make $10 in the game. If anyone puts in anything less than 10 tokens, everyone will earn less.	10
55	Don’t put all your money down, hang around 4-6.	5