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Talking Ourselves to Efficiency : Coordination in Inter-Generational Minimum Games with Private, Almost Common and Common Knowledge of Advice

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1 Introduction

In a stimulating and often discussed paper, John Van Huyck, Raymond Battalio and Richard Beil (1990) (hereafter referred to as VBB) demonstrate the disturbing result that in a game with a set of Pareto-ranked equilibria subjects routinely select the Pareto-worst outcome.

While this result seems odd, it is consistent with a large number of game theoretic papers all of which demonstrate that Pareto inferior outcomes are likely in a setting where the Pareto dominant outcome is also the most risky. For example, Crawford demonstrates the VBB results are consistent with results in evolutionary game theory (see Crawford (1991)) since the Pareto-worst equilibrium of the VBB game is the unique evolutionarily stable outcome for the game. [1] He also demonstrates how such results could be the outcome of a learning process which converges to the Pareto-worst equilibrium. Carlsson and Van Damme (1993) study 2x2 global games in which risk dominant equilibria are

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[1] The intuition here is simple. If all subjects coordinate on the same number greater than 1, then a Nash equilibrium results. However, assume that one subject mutates or trembles and chooses an integer below the commonly chosen alternative. Then his or her payoff will be greater than those who did not deviate and by standard evolutionary arguments (perhaps imitation here) we would expect that type of behavior to reproduce in the population at a fatser rate than the original equilibrium behavior and eventually wipe it out. Such a Darwinian argument can be made for all but the all-1 equilibrium and hence the strategy 1 is the unique evolutionarily stable strategy.

the unique equilibrium expected to be selected despite the existence of another, Pareto dominant, equilibrium. Morris, Rob, and Shin (1995) generalize this result and give conditions under which we would expect it to occur. Finally, and most importantly for our purposes, Rubinstein (1989) shows that such results are possible when the players have "almost" but not "total" common knowledge of the payoffs of the game. Rubinstein adds, however, that while such an outcome is logically consistent, it is not intuitively appealing and hence we should search for the other heuristics that decision makers might use in such contexts that might lead them to the Pareto dominant outcome.

In this paper we concern ourselves with the external validity of results like those of VBB since if humans were subject to such perverse group irrationalities as those observed in the laboratory and supported by theory, we might expect to see a world trapped more tightly in the grip of inefficiency then perhaps we do. Hence, we suspect that such glaring irrationalities must be rectified over time by a process different than that defined by these analyses.[2]

Focusing our attention on the Minimum Game it is our claim in this paper that in the real world games like the Minimum Game are played in a manner that differs from that depicted in previous experimental studies. More precisely, the Minimum Game is one of a class of coordination problems that society faces. Most coordination problems are recurrent problems in which agents repeatedly face the same situation over and over again.[3] Two salient features of these situations are that while the games or problems they represent are infinitely (or at least long) lived, the people who interact in them 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 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 repeatedly solved each time a new agent or set of agents arrive.

The VBB design captures neither of these features of evolutionary coordination games: it has neither an inter-generational structure nor an opportunity for subjects to pass on advice to their successors. Furthermore, these features are not included in any of the game-theoretical papers mentioned (namely Carlsson and Van Damme(1993) and Morris, Rob, and Shin (1995)) since they are

[2]One should not conclude from this statement that we assume that the world around us is constantly in a Pareto Optimal state. On the contrary, we are willing to assume that there are substantial inefficiencies out there. However, we are assuming that if we humans were to prove ourselves so incapable of rectifying the most egregious violations of rationality, we would see a far more disfunctional world than we actually do.

[3]For example, deciding which side of the road to drive on was a recurrent problem faced by social agents as soon as roads were built and vehicles traveled on them. The problem of deciding how hard to work at the work place, "work norms", was one faced by modern industrial workers each day on assembly lines at the turn of the century as well as previously by primitve hunters each time they hunted in packs -a repeated stag-hunt game (see Bryant (1983)). Numerous other examples exist as well.

obviously static models of the phenomenon.

In the experiments discussed in this paper we present an inter-generational game version of the VBB experiment similar to that found in Schotter and Sopher (2001, 2001a, 2001b) that investigates the Battle of the Sexes, Trust Games, and Ultimatum, respectively. In this experiment groups of 8 subjects are recruited into the lab and play the same game payed by subjects in the VBB paper (the Minimum Game) for 10 periods. After their participation is over each one is replaced by another agent, their laboratory descendent, who then plays the game for another 10 periods with a fresh group of new 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 he or she has earned during his or her lifetime plus what their children earn. Hence, incentives exist for subjects to pass on intelligent advice.

It was our conjecture that if we played the Minimum Game using such an inter-generational design then, over time, generations would be able to "talk themselves to efficiency" in the sense that after playing the game, if any generation converged to a Pareto-worst equilibrium, they might advise the next generation to choose higher knowing that following their behavior was a first step on the path to mutually assured destruction. Wise subjects might say, "do as we are telling you to do not as we did", and such advice, if followed, might lead to a convention selecting the Pareto-superior outcome. Hence, we expected that outcomes in our inter-generational game would be more efficient than those found by VBB. (It is of course possible that subjects would have learned the exact opposite lesson, that people can not be trusted, and pass that on to their successors. Hence, advice could just as easily reinforce inefficiency as reduce it.)

What we find is that it was much harder for societies to "talk themselves to efficiency" than we expected. More precisely, we find that the Pareto dominant equilibrium emerges only in circumstances where advice is not only public (in the sense that all advice from a previous generation is offered to each successor in the next generation) but its publicness is common knowledge (in the sense that it is read aloud for all members of a generation to hear). Private advice between a predecessor and his or her successor or even public advice that is shared (i.e. all players in generation t are given a sheet specifying each piece of advice offered by the members of generation t-1 and all subjects know that all others have been given the same sheet) but not read aloud, what we call the equivalent of Rubinstein's "almost common knowledge" does a poor job of rasing the minimum.

In some sense then, our results demonstrate the same discontinuity in behavior predicted by Rubinstein (1989). When the advice offered by one generation to the next is only "almost-common knowledge" (i.e. each person in a generation can read all the advice offered by the previous generation and knows that all others are reading the same sheet who commonly know that everyone is reading it also) outcomes converge to the Pareto worst level. Introducing common knowledge of advice by reading the advice out loud, leads to Pareto efficiency.[4]

While private advice does not seem to change the behavior of the minimum choice of our subject groups in the Minimum Game, we conjectured that it might change the behavior of the group choices above the minimum, i.e. it might change the distribution of choices even if it left the minimum (the lowest order statistic) the same. For example, it might be that groups with advice are more trusting in that while there is always one person who makes a low choice, the rest of the group might show themselves to be more willing to cooperate and make higher choices for longer periods of time. By and large, except for groups with public advice (or in some instances where subjects could see both advice and history), we have to reject this conjecture also. In fact, just the opposite is true for groups with private advice only, i.e., where they were not able to look at the history of actions in the past but simply were given advice by their predecessors. Their actions were more uncooperative even than those groups without advice.

Finally, we find the interesting phenomenon that in private advice experiments advice tends to be pessimistic in that it tends to suggest to successors that they choose their Pareto-worst action and stick with it. Surprisingly, this advice is typically ignored in the first round of the subsequent generation, as subjects tend to take a chance and choose a number higher than they were advised. As time goes on, however, they quickly learn to choose the lowest so that by the end of the experiment (after 10 repetitions), they not only choose the worst action, 1, but suggest it to their successors. Hence, rather than experience teaching subjects the folly of their inefficient ways, it teaches them the wisdom of selfish choice which they pass on to their successors. Such advice is ignored, initially, and then its wisdom recognized in time to be passed on once again.

We will proceed as follows. In the next section we will present our experimental design. This will be followed by a presentation of our results where we analyze not only the actions chosen by our subjects but the advice they offer and the beliefs they hold given this advice. In the final section we will offer some concluding remarks.

2 Experimental Design

The game played by our subjects is identical to the Minimum Game performed by VBB except that we played it using 8 instead of 14 or 16 subjects as did VBB. More specifically, in this game each subject in a set of 8 subjects chose an integer, c_i, from the set {1,2,3,...,7}. Individual payoffs are determined for each subject by the payoff function

$$\pi_i = a[\min\{c_1, ..., c_n\}] - bc_i, \tag{1}$$

[4] VanHuyck (1992) found that under certain circumstances it is possible to coordinate behavior and select a Pareto optimal outcome when there is a common knowledge announcement suggesting that action profile. The games they study differ from ours and they find difficulties achieving Pareto Optimal outcomes when the Pareto dominant outcomes are risky.

$a, b > 0$. In other words, the payoff for any player is equal to a constant, a, times the minimum choice of any subject minus another constant, b, times i's choice. Choosing a = \$0.20 and b = \$0.10 defines the game depicted in Table 1 which is the identical payoff table used by VBB.

Table 1: Payoff Table in VBB's Minimum Game

		Minimum Choice of Others						
		7	6	5	4	3	2	1
Your Choice	7	1.30	1.10	0.90	0.70	0.50	0.30	0.10
	6	_	1.20	1.00	0.80	0.60	0.40	0.20
	5	_	_	1.10	0.90	0.70	0.50	0.30
	4	_	_	_	1.00	0.80	0.60	0.40
	3	_	_	_	_	0.90	0.70	0.50
	2	_	_	_	_	_	0.80	0.60
	1	_	_	_	_	_	_	0.70

In this payoff matrix the Nash equilibria are displayed along the diagonal and are Pareto-ranked. The best payoff occurs when all subjects choose 7 but since the cost of one's choice is subtracted from the common payoff to all, higher choices are more risky. In fact, the mini-max or secure strategy choice is to choose $c_i = 1$.

In the experiment discussed in this paper we present an inter-generational game version of the VBB experiment. In this experiment groups of eight subjects are recruited into the lab and play the VBB Minimum Game for 10 periods. After their participation is over each one is replaced by another agent, their laboratory descendent, who then plays the minimum game for 10 periods and are then replaced by eight successors who take their place and play on. When generations change, after 10 periods of repetition, outgoing agents are allowed to pass on advice in the form of free-form written messages to their successors. The successors, depending on the treatment, are able to view these messages and some subset of the history of play of previous generations before they make their choices. Payoffs are equal to the sum of what an agent earns during his lifetime plus what his successor earns in the next generation so there is complete inter-generational caring or zero one-period ahead discounting. Finally, before the first and last of the 10 periods of any agent's life, we ask them to state their beliefs (using a proper scoring rule) defining the frequency with which they expect each of the 7 strategies will be played in the eight person population. This gives us insight into the history of beliefs in the population.

In the first period of any generation, subjects are presented with a set of written instructions which are read to them out loud after they are finished reading them privately. After questions are answered, depending on the treatment, subjects are allowed to view the history of the previous generations and read the advice offered by their predecessor. In some treatments they are only allowed to read the advice offered by their predecessor in the previous generation but can not see the previous history of generations. After the last period, subjects write out advice to their successors and leave. (When they write advice they know whether it is to be made public to all eight subjects in the next generation or simply be read privately by their successor) They are paid upon completion of the next generation and are paid the sum of their payoffs in the 10 period game they played, plus the sum of what their successors earned in their play of the minimum game. They are also paid for their predictions according to a quadratic scoring rule. (See the Appendix for a description of the scoring rule used).

We performed a set of four different experiments which varied according to the information available to subjects. In Experiment 1, the Replicator (No-Advice) Experiment, we aimed to replicate the Van Huyck et al. design (albeit with only 8 rather than 14 or 16 subjects) running the Minimum Game as they did without either generations or advice. In short, we simply ran the VBB experiment with eight subjects for 10 periods.

In running our inter-generational experiments we started by running a "Garden of Eden" or Progenitor experiment in which eight subjects played the Minimum Game for the first time and hence with no advice. This generation was the progenitor of all generations in all treatments in the experiment in the sense that the first generations of all the treatments that followed all used the advice of this progenitor generation. For example, in Experiment 3 we had six generations of subjects play the Minimum Game in circumstances where each generation, upon arrival in the first period of their life, could view the history of all actions taken by all generations before them and also could receive advice from the generation before them. Here advice was private so that while each agent knew that the others were receiving advice, they did not know the content of any advice other than their own. This was the Advice- Plus- History treatment. Experiment 4 also had six generations of subjects playing the Minimum Game except here subjects could only receive advice from their successor but could not see any history of play. The first generation here received the same progenitor advice as did the subjects in Experiment 3. This experiment was called the Advice-Only experiment.

Finally, Experiment 5 was a Public Advice Experiment. This experiment was run differently for the first five and last four generations. During the first five generations before play started in the first period, subjects were given a sheet of paper upon which was written the advice offered by each of the subjects in the previous generation. (The first generation here received all the advice from the Progenitor Experiment). As a result, while each subject knew that all other subjects could read all of the advice offered by all subjects in the previous generation, they had no idea if they actually read the sheet or how carefully they actually read it. Hence, we call this the "Almost-Common-Knowledge Public-Advice" Treatment. Starting with Generation 6, however, we not only gave subjects the advice sheets listing all the advice given, but actually read these pieces of advice out loud so the content of the advice on theses sheets was common knowledge. This we call the "Common-Knowledge Public-Advice" Treatment. In none of these generations did subjects receive any history information.

Our exact experimental design is summarized by the following table:

Table 2: Experimental Design

Experiment	# of Gens	Periods Per Gen	Subjects Per Gen	Treatment	# of Subjects
1. Replicator No-Advice	4	10	8	No History or Advice	32
2. Progenitor	1	10	8	No history or advice but advice left	8
3. History & Advice	6	10	8	Private Advice and History	48
4. Advice Only	6	10	8	Private Advice Only	48
5. Public Advice	9	10	8	Public advice Public advice read aloud	40 32[5]
Total					208

The experiments were performed at Washington State University and the Center for Experimental Social Science (C.E.S.S) at New York University. Inexperienced subjects were recruited from undergraduate courses and participated for about one and on half hours. Average payoffs were approximately $19.00.

3 Results

We will present the discussion of our results by first describing the behavior of the minimum choices in our five experiments. When this is completed we will discuss the impact of common knowledge and almost common knowledge on our results. We will then discuss how the existence of advice affects the distribution of choices above the minimum. Next, we will look at the advice offered subjects in our experiments in an effort to explain under what circumstances such advice was followed and what explains its content. Finally, we will look at the reported beliefs of our subjects.

3.1 Minimum Choices

Table 3a shows the behavior of the minimum in the various different treatments in our experiment, while Table 3b does so for the VBB experiments.

[5] In the very last generation of or Public Advice treatment, we only had 7 subjects instead of the 8 that we used in every other session.

Table 3a: Observed Minimum Choices

Experiment 1: Progenitor	**Period**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
		1	1	1	1	1	1	1	1	1	1

Experiment 2: Replicator

Group	**Period**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1		2	1	1	1	1	1	1	1	1	1
2		2	1	1	1	1	1	1	1	1	1
3		1	1	1	1	1	1	1	1	1	1
4		1	1	1	1	1	1	1	1	1	1

Experiment 3: Adv + Hist	**Period**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
generation 1		1	1	1	1	1	1	1	1	1	1
generation 2		1	1	1	1	1	1	1	1	1	1
generation 3		4	4	4	4	4	4	4	4	4	4
generation 4		1	2	2	2	2	2	2	2	2	1
generation 5		1	1	1	1	1	1	1	1	1	1
generation 6		1	1	1	1	1	1	1	1	1	1

Experiment 4: Advice Only

	Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
generation 1		1	1	1	1	1	1	1	1	1	1
generation 2		1	1	1	1	1	1	1	1	1	1
generation 3		1	1	1	1	1	1	1	1	1	1
generation 4		1	1	1	1	1	1	1	1	1	1
generation 5		1	1	1	1	1	1	1	1	1	1
generation 6		1	1	1	1	1	1	1	1	1	1

Experiment 5: Public Advice

	Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
generation 1		1	1	1	1	1	1	1	1	1	1
generation 2		1	1	1	1	1	1	1	1	1	1
generation 3		6	5	5	4	1	1	1	1	1	1
generation 4		4	4	3	2	1	1	1	1	1	1
generation 5		4	3	1	1	1	1	1	1	1	1
generation 6		7	7	7	7	7	7	7	7	7	7
generation 7		6	6	6	6	6	6	6	6	6	5
generation 8		7	7	7	7	7	7	7	7	7	7
generation 9		7	7	7	7	7	7	7	7	7	7

Table 3b: Group Minima - VBB Experiment

Group \ Period	1	2	3	4	5	6	7	8	9	10
1	2	2	2	1	1	1	1	1	1	1
2	2	1	1	1	1	1	1	1	1	1
3	4	2	2	1	1	1	1	1	1	1
4	4	2	3	1	1	1	1	1	1	1
5	3	2	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1

In Figure 1 we present the period-by-period minimum choices of subjects for each of our five experiments along with those of the subjects in the seven experiments run by VBB. Here we show the pattern of choices made by each generation (in the various treatments) over all 10 periods. Each block in Figure 1 represents one generation and shows the choices that particular generation made over all 10 periods.

<<**Figure 1 about here**>>

As can be seen from Tables 3a and 3b and Figure 1, the behavior of group minima in the VBB and our Replicator (No-Advice) experiments (without advice) is dramatic. First note that in the VBB experiments in no period of any of the 7 experiments run was the minimum greater than 4 and in no experiment did the minimum remain above 1 for more than three periods. In two of the seven experiments we observe 1 chosen in each period. This behavior is even more dramatic in our four replicator experiments. Here in no period was the minimum greater than 2 and that only occurred in two experiments during the first period. Beyond that all minima were equal to 1.

It was exactly this behavior that we expected would disappear when we introduced advice into our design. To our surprise we found just the opposite to be true. For example, in the Advice-Only Experiment (Experiment 4) the behavior exhibited was more uncooperative that in either the VBB or our replicator experiments. In no period of any generation did we ever observe a minimum above 1. Hence, it appears as if a treatment where subjects can not observe previous history but can pass on advice is hostile to efficiency in a risky environment.

When advice and history are available as in Experiment 3, things change somewhat. Here, as in the Advice-Only Experiment, in four of the six generations (generations 1, 2, 5, and 6) we observed a minimum of 1 in each period. However, in generation 3, we observe the first instance of an interior equilibrium existing for all 10 periods. Here the minimum starts out in period 1 at 4 and stays at that level for the remainder of the experiment. In the next generation we also see an elevated minimum of 2 existing from period 2 to period 9. These two generations exhibit behavior different than any seen in the VBB or Replicator experiments since they exhibit the first instances of a minimum above 1 lasting past period 3. Still, these results can not be considered evidence of any strong impact of advice or behavior in our inter-generational game set up. Finally, in spite of the fact we see a minimum higher than 1 for 10 generations in this experiment, subjects in this treatment find it impossible to sustain that level of cooperation and by Generations 6 and 7, the minimum is again 1 for all 10 periods.

In order to find truly different minimum behavior one must look at the results of Experiment 5 where we have public advice. The pattern of behavior here is interesting. In generation 1 we see no increase in the minimum choice in any period. However, remember this generation received the advice of the progenitor generation which was written not knowing that it would be made public to all successors. Generation 2, however, behaved similarly by not succeeding in raising the minimum above 1 in any period. Generation 3 was significantly different in that the first period the minimum started out at 6, decreased to 5 for two periods, then dropped to 4 before crashing back to 1 for the remaining periods. This behavior was not so different than that observed in the VBB experiments except that the minimum of 6 reached in the first period was greater than any observed in VBB and this above-1 behavior lasted till period 4 which is one period longer than any VBB behavior. Generations 4 and 5 exhibited similar behavior starting out at 4 and quickly crashing to 1.

It was at this point that we read out loud the Generation 5 advice to all subjects in Generation 6. As you can see this had a dramatic impact raising the minimum to 7 in all ten periods. From this generation on in no period was the minimum choice below 5 (which occurred only once) and was 7 for 30 of the total 40 periods. (Of the remaining 10 periods it was 6 in nine of them and 5 in one.) In short, this treatment, public advice with common knowledge, was successful in breaking the strangle hold that the all-1 equilibrium had on behavior up until this point.

Hence, while these agents were finally capable of "talking themselves to efficiency", the process was much harder than we expected and occurred only when advice was public and common knowledge. [6]

3.1.1 A Connection to Rubinstein's Electronic Mail Game

Ariel Rubinstein (1989) in the "The Electronic Mail Game: Strategic Behavior Under 'Almost Common' Knowledge" investigates the discontinuity in behavior that results when subjects move from having "almost common knowledge" to common knowledge of the payoffs of the game. In that game, two players 1 and 2 are involved in a coordination problem. Each can take one of two actions, A or B, and there are two possible states of nature a and b. State a occurs with

[6] Note 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 Cooper et. al.(1989, 1992) and Dawes et. al (1977). Cheap talk statements are public non-binding and payoff irrelevant statements made by the players who are actually going to play the game and not their predecessors. In contrast, except for the public advice treatment, our advice statements are private and made by predecessors. Even when we made advice public and common knowledge, these statements are still not made by the people who are about to play the game.

Our advice treatments are 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.

probability (1- p) and b with probability p with $p < 1/2$. In the state of nature a(b) the players get a positive payoff M if both choose the action A(B). If they choose the same action but the "wrong" one, they get 0 while if they choose different actions the one choosing B gets a negative payoff and the other gets zero. Strategy A is therefore the secure strategy since it never yields a negative payoff. Rubinstein describes the informational aspects of the game as follows:

> The information about the state of nature is known initially only to player 1. Without transferring the information, the players can not achieve an expected payoff higher than (1-p)M. If the information could be common knowledge they could achieve a payoff of M. However, imagine that the two players are located at two different sites and they communicate only by electronic mail. Due to technical difficulties there is a small probability, ε, that the message does not arrive at its destination. ......it is assumed that, when player 1 gets the information that the state of nature is b, his computer automatically sends a message (a blip) to player 2 and then player 2's computer confirms the message and then player 1's computer confirms the message and so on. If the message does not arrive the communication stops. No message is sent if the state of nature is a. At the end of the communication stage the screen displays the number of messages his machine has sent. (Rubinstein (1989, p. 386))

If the machines exchanged messages infinitely then there would be common knowledge of the state and coordination would be easy. Rubinstein demonstrates, however, that for any finite number of exchanges, the only equilibrium is for both players to choose A in each period. Hence, even for a large number of exchanges, where we might think that players have "almost common knowledge" of the information, we see that the players can not obtain an expected payoff, in equilibrium, higher than that they could achieve without any information exchange. There is a discontinuity when common knowledge is achieved.

If one is willing to accept the notion that having it be common knowledge that all players are reading the same advice sheet is similar to Rubinstein's notion of "almost common knowledge" while reading that advice out loud is equivalent to the advice being "common knowledge" (using some metric not specified here) then this experiment has replicated a result in the spirit of Rubinstein's theorem since behavior in the almost common knowledge treatment differs dramatically from that of the common knowledge experiment and in the direction predicted, i.e. they choose the safer and Pareto inferior outcome.

It is important to note that there is one major difference between our situation and that described by Rubinstein (1989) which prevents us from claiming any formal correspondence between the two. It is that while Rubinstein and others are dealing with games of incomplete information where players must determine whether there is common knowledge of the payoffs, our situation is one where people are perfectly informed about the payoffs of the game but do not know whether everyone has interpreted the commonly read or announced announcements as indicating that they should all choose seven. In our experiment the distinction is between having common and almost-common knowledge of public advice and perhaps its meaning. (For example, if public advice is not read out loud a subject might wonder if a player really read the statements all the way to the bottom and noticed the strong urging to choose 7, etc. When the statements are read out loud, then at least one can have faith that they were heard).

Our result, however, is only valid if the advice given subjects in the almost-common knowledge treatment is basically equivalent to what they receive in the common- knowledge treatment since if the advice in the former were more uncooperative, then obviously it might lead to more uncooperative behavior whether or not it was common or almost commonly known.

To demonstrate that this is in fact the case, we have placed the exact advice offered to all generations of the public advice treatment in the appendix. Note that the while the advice offered to the first two generations was rather pessimistic, there is little to distinguish the advice given to generations 3-5 (the last three periods of the almost-common knowledge treatment) from generations 6-9 (the common-knowledge treatment). While some statements raise the possibility of choosing low numbers, especially once someone else has started the ball rolling, almost all of the statements suggest choosing 7 initially and then following any trends that develop. Many are emphatic, however, about sticking with 7 always.

To give some quantitative content to these texts, we coded them, as we will explain later, with reference to what advice they suggest for the first round of play if any was offered. In other words, we gave a 7 to advice which clearly suggested choosing 7 in the first round a 6 to those pieces of advice that suggested 6 etc. While much of the advice was in terms of dynamic rules, most of the rules started with suggesting an action in period 1 followed by a way to respond to what happens there. (If it made no suggestion about a first round action, we coded it with a zero. If it suggested starting out "high" we coded it 5.5 while if it suggested starting out "low" we coded it 2.2).

Table 4: Coded Advice in the Public Advice Experiment

Subject Generation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Information**
1	1	1	0	7	1	0	0	0	Almost Common
2	1	1	1	1	1	1	7	7	Almost Common
3	7	7	0	7	7	7	7	7	Almost Common
4	6	7	7	7	7	0	7	7	Almost Common
5	4 or 5	1	7	7	0	5.5	7	7	Almost Common
6	7	7	7	7	7	7	7	7	Common
7	7	7	7	7	7	7	7	7	Common
8	7	7	7	7	7	7	7	7	Common
9	7	7	7	7	7	7	7	7	Common

Table 4 presents the coded advice data for all the public advice experiments. As you can see, after Generation 2 the advice received by the Almost-Aommon and Common Knowledge treatments is very much the same. From this we can conclude that the difference in behavior between the common knowledge and almost-common knowledge treatments was the result of the different informational conditions and not the actual content of the advice.

3.1.2 Non-Minimum Behavior

Cooperativeness Index While the impact of private advice on group minima was not strong that does not mean that advice might not have had an impact on subject behavior. For example, the observed minium of a group is merely the lowest order statistic of the distribution of their choices. The distribution of choices generating these minima could differ greatly yet these differences would not be noticed in an environment where only the minimum was reported. Just reporting the minimum of the groups then could disguise a willingness to cooperate that may very well differ from one treatment to the next. For example, take two groups both of which have a reported minimum of 1 but one has seven people choosing 1 and one choosing 7 while the other has just the opposite, seven choosing 7 and only one choosing 1. Clearly, the first group is more uncooperative than the second yet we would not know it from the minima.

To provide a quick scalar measure of this cooperativeness of a group of subjects period by period, we calculate a cooperation index as follows. Since the cooperativeness of a group of subjects in any period is maximized when all subjects choose 7 and since we have 8 people, if each choose 7 the sum of their choices would be 56. If we take the actual sum of the choices made by our eight subjects and divide it into 56, (and multiply it by 100) we get a percentage measure of how cooperative the behavior in the group was. If all choose 7 we get an index of 100% while if all choose 1 we get an index of 14.28% $(= \frac{8}{56} \cdot 100)$.For each of our treatments we can calculate the mean cooperative index by calculating this percentage period by period for each generation and averaging. These averages are portrayed in Table 5 .

What we find here is that subjects in the treatment with private advice and no history fare the worst. In fact subjects in this treatment show less cooperation than subjects in the treatment with no advice or history. Making history of past plays available improves cooperation somewhat. Public advice leads to even more cooperative choices. But while the almost common knowledge for the first five generations of the public advice leads to increased level of cooperation, it is only in the common knowledge scenario of the last four generations of the public advice treatment do we see sustained and total cooperation leading to the Pareto-dominant outcome on a consistent basis.

Table 5:Cooperation Index

Treatment	Index Value
Public Advice	67%
Public Advice (First five generations)	48%
Public Advice (Last Four generations	98%
Advice Plus History	35.4%
Advice-Only	27.5%
No Advice	30.3%

At a more disaggregated level, a Wilcoxon sign-rank test (see Table 6 below) demonstrates that while the mean of the cooperativeness indices in the Advice Only and No Advice treatment are not significantly different from one another, the mean of the Advice-Plus-History treatment is significantly higher than either of them, while the mean of the Public-Advice experiment is significantly different from all of the other treatments. Moreover within the Public Advice treatment the mean cooperativeness index (98%) of the common knowledge treatment (Generations 6 through 9) is significantly higher than the mean cooperativeness index of the almost-common-knowledge treatment (48%) (Generations 1 through 5).

Figure 2 provides a comparison of the Cooperativeness Index across our four different treatments as well as the level of cooperation in the Common Progenitor generation. As one can see from Figure 2, the mean cooperation in the public advice treatment is much higher than those in the other three. In Figure 3, we present the behavior of the cooperativeness index across the 9 generations of the public advice treatment. As one can see from the figure, in the first five generations (the almost-common knowledge scenario), while the groups start out with a high level of cooperation in the beginning, this cooperation degenerates over time. For the last four generations (the common-knowledge scenario), however, high cooperation is sustained over time. These four generations start at total cooperation and except for one group (Generation #7, which chooses a minimum of 6 in periods 1 through 9 and 5 in period 10), they maintain total cooperation over the 10 periods of the session.

<<Figures 2 and 3 about here>>

Table 6: Cooperation Index

	PA-AO	PA-NA	PA-AH	AH-AO	AH-NA	NA-AO	PACK PAACK
Difference in Mean Cooperativeness (%)	40.5	36.7	31.6	7.9	4.1	2.8	50
Value of Test Statistic (z)	6.048	4.423	4.922	2.253	1.869	1.024	5.445
p-value	0.00	0.00	0.00	0.02	0.06	0.30	0.00

PA = Private Advice, AO = Advice Only
AH = Advice Plus History, NA = No Advice
PACK = Public Advice Common Knowledge
PAACK) = Public Advice Almost-Common Knowledge

Overall, then the Public Advice treatment achieves 40.5% more cooperation than the Advice Only treatment, 36.7% more than the Replicator treatment, and 31.6% more than the Advice-Plus-History treatment. The Advice-Plus-History treatment also exhibits significantly higher levels of cooperation than either the Advice-Only or the Replicator (No-Advice, No-History) treatments.

3.1.3 Robustness

Another index that could be used to see if advice has any impact on behavior is to look at order statistics above the smallest. As stated above, looking only at the minimum choice made by a group may mask differences in other order statistics of the distribution of choices. For example, if we compare the third lowest choice made by our groups it may be that advice has the effect of increasing that order statistic. Hence, advice, while not affecting the lowest order statistic might actually effect behavior above it. To investigate this point we present Tables 7 and 8.

Table 7: Comparison of the Mean Values of the Order Statistics (Aggregated Over All Generations in a Treatment)

Order Statistic	Advice Only	No Advice	Advice+History	Public Advice
Minimum	1	1.04	1.54	3.35
Minimum-1	1.3	1.3	1.74	3.57
Minimum-2	1.37	1.56	1.94	3.87
Minimum-3	1.53	1.72	2.04	4.03
Minimum-4	1.78	2	2.31	4.37
Minimum-5	2.14	2.38	2.67	4.71
Minimum-6	2.80	3	3.1	5.29
Maximum	4.03	4.32	4.28	6

Table 7 presents the mean order statistic of the choices made by subjects in each treatment aggregated over each generation. As we can see, when compared to the No-Advice treatment there appears to be no difference between any of the order statistics for experiments using private advice.[7] So, for example, in the Advice-Only treatment, 1 is the mean of the minimum of all 6 groups who did that experiment taken over all periods. Looking across row 1 of Table 7 we see that this minimum is not significantly different from those in any of the private advice treatments yet there does appear to be a significant difference between it and the observed minimum of the public advice treatments. Looking across all of the other rows we see the same phenomenon. An equality of order statistics between no-advice and private-advice treatments but a difference between all of them and the public advice treatments.

Finally, note that the No-Advice treatment exhibits order statistics all of which are greater than those of the Advice-Only treatment. In other words, having no advice leads to more cooperative behavior than having advice only without access to history. If your informational landscape is so barren as to only have the jaundiced advice of a subject with a bad experience, then you'd be better off not having that advice at all.

Since these means are taken over periods where all choices eventually converged to 1, we might ask what these order statistics look like in the first versus the last five periods of these treatments. Table 8 does this.

[7] Wilcoxon Tests for Order Statistics

Order Statistic	PA-AO	PA-NA	PA-AH	AH-AO	AH-NA	NA-AO
Minimum	2.34***	2.30***	1.80*	0.54	0.50	0.04
Minimum-1	2.27***	2.34**	1.83**	0.51	0.44	0.07
Minimum-2	2.50***	2.31**	1.93**	0.57	0.38	0.19
Minimum-3	2.51***	2.31**	1.99**	0.51	0.32	0.19
Minimum-4	2.58***	2.36**	2.05**	0.53	0.31	0.22
Minimum-5	2.57***	2.33**	2.04**	0.53	0.29	0.24
Minimum-6	2.51***	2.29**	2.19**	0.30	0.10	0.20
Maximum	1.97***	1.68**	1.72**	0.26	-0.04	0.30

***: Significant at 1%
**: Significant at 5%
*: Significant at 7%

TABLE 8: Comparison of the Mean Values of Order Statistics (Aggregated Over Generations):First Five and Last Five Periods

Order Statistic	Periods	Advice Only	No Advice	Advice& History	Public Advice
Minimum	First Five	1	1.08	1.542	3.822
	Last Five	1	1	1.542	2.868
Minimum-1	First Five	1.458	1.6	1.914	4.246
	Last Five	1	1	1.57	2.89
Minimum-2	First Five	1.742	2.12	2.312	4.754
	Last Five	1	1	1.57	2.978
Minimum-3	First Five	2.054	2.44	2.514	4.978
	Last Five	1	1	1.57	3.09
Minimum-4	First Five	2.514	2.92	3	5.268
	Last Five	1.056	1.08	1.626	3.444
Minimum-5	First Five	3.112	3.52	3.6	5.646
	Last Five	1.17	1.24	1.742	3.778
Minimum-6	First Five	4.084	4.36	4.17	6.178
	Last Five	1.51	1.64	2.028	4.4
Maximum	First Five	5.084	5.64	5.228	6.55
	Last Five	2.97	3	3.34	5.45

As we can see, over the first five rounds the mean of all order statistics was higher in the No-Advice treatment than in the Advice-Only treatment and virtually identical to the order statistics of the Advice-Plus History treatment. One thing of interest is how uncooperative these order statistics are. For example, over the first five rounds of any treatment, the mean of the third-highest order statistic (minimum-5) is only 4.084, 4.36, and 4.17 in the Advice-Only, No-Advice, and Advice Plus History treatment. (It was 6.178 for the Public Advice Experiments). This means, that on average, even those who chose high numbers did not choose very high ones. Hence, you have to go almost to those people who chose the highest number in any period before you get to see numbers approaching 7 and even then for the Private and No-Advice treatments we only see choices of about 5.

3.2 Advice

There are two things that interest us about advice. First we would like to know whether it is followed and second, what determines its content? If the introduction of advice into our experiment is going to have an impact on behavior then we would expect that it would be followed. If it is going to increase cooperation, we would expect that it would suggest a cooperative course of behavior.

To investigate these questions we took the advice messages written by our subjects and coded them according to what we think they implied about what action suggested for the first period of any generation's life. For example, if a subject said, "Choose 7 in period 1 and then choose the period t-1 minimum in period t" , we coded this with a 7 since it indicated that in the first period 7 should be chosen and then the subject should look around and see what happened and then follow the minimum thereafter. Such advice was fairly typical in that most advice messages suggested dynamic rules for subjects to follow. The problem is that in certain cases they did not specify what action to take in period 1. For example, a subject may write, "Choose the minimum of last period". This rule is well specified for all rounds but the first. In other cases a subject may write, "Choose pretty high in round 1 and then follow the minimum of last period". To consistently code this data we took all statements that offered no advice for the first period and coded it with a zero and imputed a 5.5 (2.2) to all advice suggesting a "high" ("low") action in round 1, i.e. advice that did not specify a number but implied a range of numbers. Pieces of advice that were nonsense, gibberish, were also coded with a zero. In all, there were only 24 pieces of advice that fell into this category. (In two cases the subject suggested choosing either 4 or 5 or 1 or 2 which we indicated).

In Table 9 we provide a summary of the advice received by the subjects in different treatments. In this part of our analysis we exclude all advice coded "0", i.e. advice that was considered nonsensical. In Table 10 we provide some summary information about advice received by a generation, their first period action, last period actions taken by those same generations and the advice they left for the succeeding generation.

Table 9: Summary of Coded Advice Received

Coded Advice	Advice Only	Advice+History	Public Advice
1	28	20	10
1 or 2	1	0	0
2.2	4	1	0
4	0	4	0
4 or 5	0	0	1
5.5	0	2	1
6	0	0	1
6 or 7	0	1	0
7	5	5	43
Total	38	33	56

Table 10: Advice Received, Offered and Action Taken

	Mean Advice Received	Mean Per #1 Action	Mean Per #10 Action Taken	Mean Advice Left
Only Advice	1.93	4.0625	1.25	1.75
Advice& History	2.75	4.6875	1.98	3.05
Public Advice	5.41	6.46	3.52	5.375
Public Advice (Gens 1-5)	5.02	6.2	1.775	5.2975
Public Advice (Gens 6-9)	7	6.95	6.69	7

Looking at Table 9 first, note the preponderance of subjects advising their successors to chose "7" in the Public-Advice treatment. 43 subjects did so in the public advice treatment as opposed to 5 in the advice only treatment and 5 in the Advice Plus History treatment. Note also that advice in both the Advice-Only experiment as well as the Advice-Plus-History experiment is considerably below that of the Public-Advice experiment. The mean advice received in the Advice Only treatment is 1.93, while that in the Advice Plus History treatment is 2.75 and in the Public-Advice treatment it is 5.41. Using a set of pair-wise Wilcoxon sign-rank tests we see that when we test the null hypothesis that the samples of non-zero coded advice coming from any two experiments came from the same population, we see that we can reject this hypothesis for the Advice-Only Public-Advice comparison(z= 4.76, p = .00) and the Public-Advice Advice-Plus-History comparison (z = 3.403, p-value = 0.00). However there is no significant difference between the quality of advice left in the Advice-Only and Advice-Plus-History treatments at the 5% level (z = -1.627, p = 0.10).

It appears as if knowing that advice will be made public leads people to write different types of advice since in generations 3-5 of the Almost-Common Knowledge treatment, while actions converged to 1 in the last half of each of those generations, the advice they left was extremely cooperative and quite different from the advice left by private advice groups with similar histories. For example, the mean advice left for generations 3, 4, and 5 were 6.12, 6, and 4.86, respectively (the 4.86 was caused by one piece of advice to choose 1 and one coded 0 that was eliminated. All others were coded as 7). More importantly, the advice left by generation 2 and given to generation 3 was extremely high (mean 6.12) and this followed a generation 2 experience which was very uncooperative. Hence, it may well be that people tend to write different type of advice when they know they will be addressing the entire community as opposed to only their own successor.

Our discussion of advice to this point only looks at what advice was offered. However, as stated above, we are also interested in whether this advice was followed. Looking at the Advice- Only and Advice-Plus-History treatments first, we notice that by and large, subjects tend to choose actions in the first period of their experimental life which are far greater than those they are advised to do. For example, taking all of the non-zero coded advice, i.e. all the advice that gave a definitive suggestion for behavior in the first round, we see from Table 10 that the mean advice offered in the Advice-Only Experiment was 1.93 while the mean action taken was 4.062. A Wilcoxon test establishes the fact that the distribution of actions and advice are not samples taken from the same population at the 0.00% level (z = -3.27). Hence it appears as if subjects reject the advice to choose low and, at least in the first round, make choices that are considerably higher than those they are advised to. A similar result holds for the Advice-Plus-History Experiment where the mean advice offered to subjects was 2.75 while the mean first period action taken was 4.679. This difference was also significant using a Wilcoxon test at the 0.0% level (z=-3.369).

What is ironic in the private advice experiments, however, is that while subjects seem willing to take a chance in the first period of their life and ignore the advice given to them by their predecessors and choose high, their experience with the minimum game during their lifetimes teaches them that their predecessors were correct so that when they retire from the game they too tend to give advice which is almost identical to what they initially received and ignored. In terms of explaining the content of advice, it seems obvious from the data that subjects in our Private-Advice experiments offer advice that is approximately equal to the actions they take in the last period of their laboratory life. To use a metaphor, it is as if we are born willing to trust others, reject the advice of our cynical parents, learn life's lessons in the school of hard knocks, and then die leaving our children the same cynical advice we received from our parents but rejected.

To illustrate these patterns graphically, consider Figures 4 -7 which portray the advice received and first-period actions taken by generations in the two Private-Advice experiments, Figures 4 and 5, as well as the advice left by subjects and their tenth-period actions in these two experiments, Figures 6 and

7.

<<Figures 4 -7 about here>>

Looking first at the Advice-Only and Advice-Plus-History Experiment (Experiments 3 and 4) there is a huge difference between the first period actions of subjects and the advice they receive. Quite the opposite appears to be true for the relationship between tenth period actions and advice left since they tend to be quite similar. To summarize these pictures consider the following facts. First in period 1 of the Advice-Only treatment, 16 of the 28 subjects who were asked to choose 1 by their predecessors chose to ignore that information and chose a number 4 or higher. By period 10, however, 26 of these 28 people are choosing "1" and leaving advice to do so. In the Advice-Plus-History treatment, 10 out of 20 who received advice asking them to choose 1, actually chose 7. By period 10, 13 of them choose 1.

On the other hand, the period 10 action-advice relationship is quite different. In the Advice-Only treatment out of 39 people for whom we have substantive advice, 36 chose 1 in period 10. Of these 28 (78%) asked their successors to choose 1 as well. Overall 30 out of 39 (76%) subjects advised their successors to choose 1. In the Advice-Plus-History treatment, of the 36 people for whom we have salient advice, 23 chose 1 in period 10 and out of them 16 subjects (70%) advised their successors to choose 1. Overall, 19 out of 36 (53%) advised their successors to choose 1. The mean advice in the Advice-Only treatment is slightly higher, 1.75, than the mean period 10 action, which is 1.25. The difference in the mean advice left and mean period 10 action is bigger in the Advice-Plus-History, 3.05 and 1.98 respectively. Most of this difference is accounted for the advice left by the subjects in Generation 3 who managed to sustain the interior equilibrium of all-4.

Hence it appears as if subjects, when leaving advice, basically tend to suggest a first round action for their successor that is very close to how they behaved in the last round of their generational life. Such advice, in the private advice experiments, does not help facilitate cooperation.

Advice giving and receiving behavior was quite different in the Public-Advice experiments. Here, especially in the later generations (generations 3 and above) advice tended to be high and on average this is what subjects tended to choose. For example, the mean advice received by subjects in the Public-Advice Almost-Common Knowledge (Common- Knowledge) experiment was 5.02 (7) while the mean action taken was 6.2 (6.95). Neither of these mean actions were different from the advice they received at the 10% level. Using a Wilcoxon signrank test, we get a z-value of -1.575 and a corresponding p-value of 0.11 for the almost common knowledge treatment. For the common knowledge treatment the value of the test statistic is 1.00 with a corresponding p-value of 0.32.

Thus both these groups received high advice and chose high in period 1. But interestingly enough, for the Public-Advice Almost Common Knowledge treatment, the subjects found it impossible to sustain this cooperation and the mean last-period action fell to a dismal 1.775. Still this group advised their successors to choose high numbers and mean advice offered was a much higher 5.295, a difference which was significant at the 0.00% level using a Wilcoxon test (z=-5.075, p = 0.00). For the Common-Knowledge experiments (see Figures 8 and 9), advice and actions are tied closely together. Every subjects received advice asking them to choose 7, and they did so almost without exception. In period 1, 22 out of 23 subjects who received advice to choose 7, chose 7. In period 10, 17 out of 23 did so. As we have mentioned there was only generation (Generation 7) which faltered a little, and failed to achieve total cooperation in all 10 periods.

Overall in the Public-Advice experiments the vast majority of subjects exhorted their successors to choose 7. These relationships are presented in Figures 8 and 9.

<<Figures 8 and 9 about here>>

3.3 Beliefs:

Another avenue through which advice may have an impact on behavior is through its influence on beliefs. Here we are interested in comparing the beliefs of subjects in our replicator (No-Advice) experiments to those of subjects in our private and public advice experiments. We are interested in answering two questions: First does the existence of advice change the distribution of beliefs of subjects from what it would be if no advice existed? Second, does advice increase the minimum action upon which there is positive probability placed. The second question is important since if subjects best respond then the best response rule is trivial: Choose that action which you think is the minimum to be chosen by your cohorts. Hence, if any subject believes that there will be even one other who will choose 1, then 1 is their best response. If advice can raise this expected minimum, it can succeed in rasing subjects choices.

The answer to both of these questions can be seen in Figures 10a-10f which present the results treatment by treatment. These diagrams place the various actions 1,2,....,7 along the horizontal axis and along the vertical they display the mean number of subjects (aggregated over all generations) predicted to choose that action. For example, in Figure 10a we see that on average in the No-Advice treatment subjects expected 3.6 people in their group of eight to choose 7, 1 to choose 6, etc.(If you multiply each number by 8 you would get the total number of choices in each category.)

<<Figures 10a-10f here>>

Looking across these treatments we see some interesting results. First when comparing the beliefs of subjects in our No-Advice treatment (Figure 10a) to those in our Private- Advice treatments we see that while there appears to be no significant difference between these distributions (a χ^2 test fails to detect any difference in the distributions of the No-Advice and either the Advice-Only (Figure 10b) or Advice-Plus-History (Figure 10c) treatments at the 5% level ($\chi^2_{7\text{dof}} = 8.88$ and $\chi^2_{7\text{dof}} = 14.32$ respectively)), private advice does seem to lower expectations in the sense that subjects expect more people to choose 7 in the No-Advice treatment (mean = 3.6) than in either the Advice-Only treatment (mean = 2.5) or the Advice-Plus-History treatment (mean = 2.6). In addition, subjects in the private advice treatments predict at least one person will choose 1 (mean = 1.2 for the Advice-Only treatment and 1.4 for the Advice-Plus-History treatment) while in the No-Advice treatment subjects expect an average of only 0.80 subjects will choose 1. Obviously, the advice offered damaged beliefs in these experiments and led them to think that fewer people are likely to choose 7 and more are likely to choose 1.

When we move to the Public-Advice treatments the results are more dramatic. As can be seen by comparing Figure 10e to all the other figures, public advice with common knowledge changes the beliefs of the subjects dramatically. For example, in the Public Advice with Common Knowledge treatment, we see that on average subjects expected 5.2 people to choose 7 in round 1 and no one to choose either 1, 2, or 3. The firm belief that no one will choose a low number seems to give subjects the confidence which allows them to choose 7 and maintain efficiency. In addition, the distribution of beliefs for this treatment is significantly different from the distribution of beliefs in all other treatments at the 1% level. (See Table 11below which reports the results of a χ^2 tests run to test these hypotheses). When we compare the distribution of beliefs in the Public-Advice Common and Almost-Common- Knowledge treatments, we see that common knowledge has an impact on beliefs. For example, while Figure 10d presents the results of all five generations of the Almost-Common Knowledge treatment, and Figure 10e presents the beliefs of subjects in the Common-Knowledge treatment, Figure 10f presents the beliefs of subjects in the last three rounds only of the Almost Common Knowledge treatment. The first two rounds were eliminated because the advice offered here came initially from the progenitor experiment and was particularly pessimistic leading the minimum to quickly converged to 1. Comparing Figures 10e and 10f we see that while the Almost Common Knowledge fostered beliefs that were more like the Common Knowledge treatment than either of the private advice treatments, it did not succeed as completely in eliminating the possibility that some subject might choose allow number. As can be seen by the actions taken, it may be that even this small suspicion was enough to ruin cooperation. A χ^2 test comparing the distributions of beliefs in the Common Knowledge and Almost Common knowledge treatments indicates

The lesson to be learned from these belief distributions is simple. Common Knowledge plus Public Advice seems to be a necessary condition for beliefs to be sufficiently positive so as to lead to efficient outcomes. All other settings hold the prospect of someone choosing 1 which leads to a spiral of actions toward 1.

Table 11: χ^2 Tests on Belief Distributions

treatment	AO1	A+H	PAACK	PAACK (3-5)*	PACK
AO	-	3.84	31.2	62.45	64.16
A+H	-	-	31.84	63.12	103.92
PAACK	-	-	-	NA	37.92
PAACK (3-5)					31.19
NO	8.88	14.32	11.84	26.91	34.24

AO = Advice Only, A+H = Advice-Plus History, NA = No Advice
PACK = Public-Advice Common-Knowledge,
PAACK= Public-Advice Almost-Common Knowledge
PAACK (3-5) Public-Advice Almost-Common Knowledge (Gen 3-5)

4 Conclusions:

This paper was motivated by the conjecture that if we played a coordination game with Pareto ranked equilibria in a manner that allowed players who had experience with the game to advise thier successors, then this process of advice-giving would, over time, allow all subjects to achieve an efficient outcome. In this sense we thought people could "talk themselves to efficiency" through advice.

What we found is that this conjecture is basically false. If the advice offered by one generational agent to his or her descendent is private, in the sense that no other agent can hear it although it is common knowledge that all agents are receiving advice from their predecessors, then just the opposite occurs. Efficieny is harder to achieve. It is only when advice is both public (in the sense that all agents in generation t are allowed to see the advice of **all** predecessors in generation t-1) and common knowledge among the players (in the sense that the advice is read out loud) that we are capable of attaining Pareto optimal outcomes.

We found the difficulty of achieving efficiency under these circumstances surprising but instructive since it indicates that if we expect to teach our children the lessons of our experience, we will need to assure them that others in their generation are being taught the same lessons and that fact must be common knowledge.

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Figure 1: Behavior of the Minimum Across All Treatments

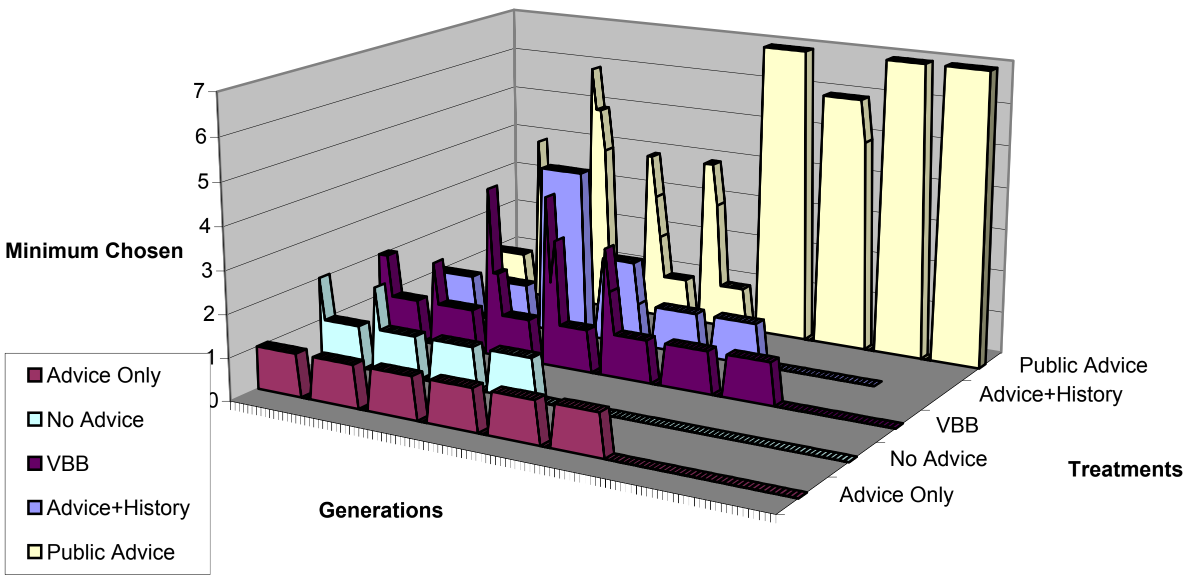


Figure 2: Comparison of The Cooperation Metric for All Treatments

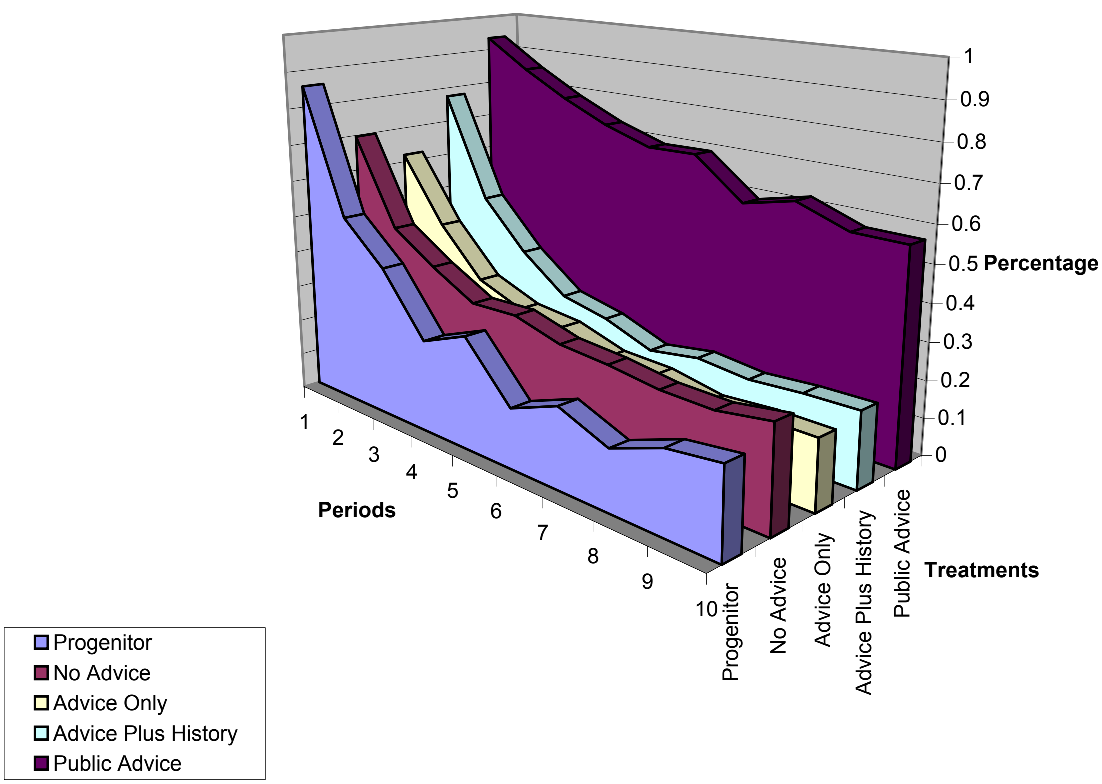


Figure 3: Cooperation Metric for Public Advice Treatment

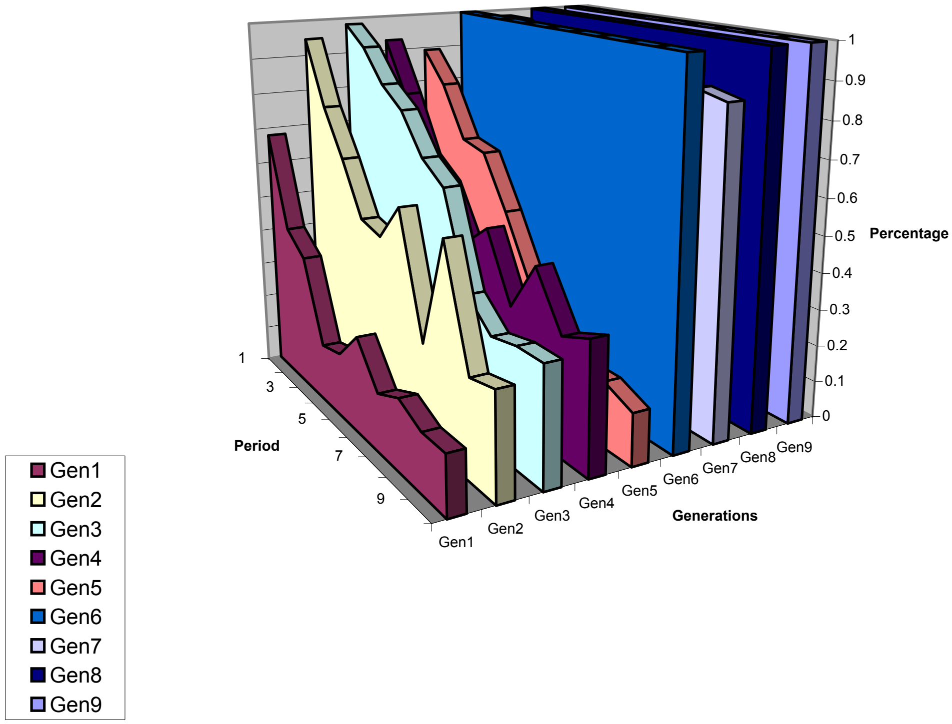


Figure 4: Comparison of Advice Received and Period 1 Actions in the Advice Only Treatment

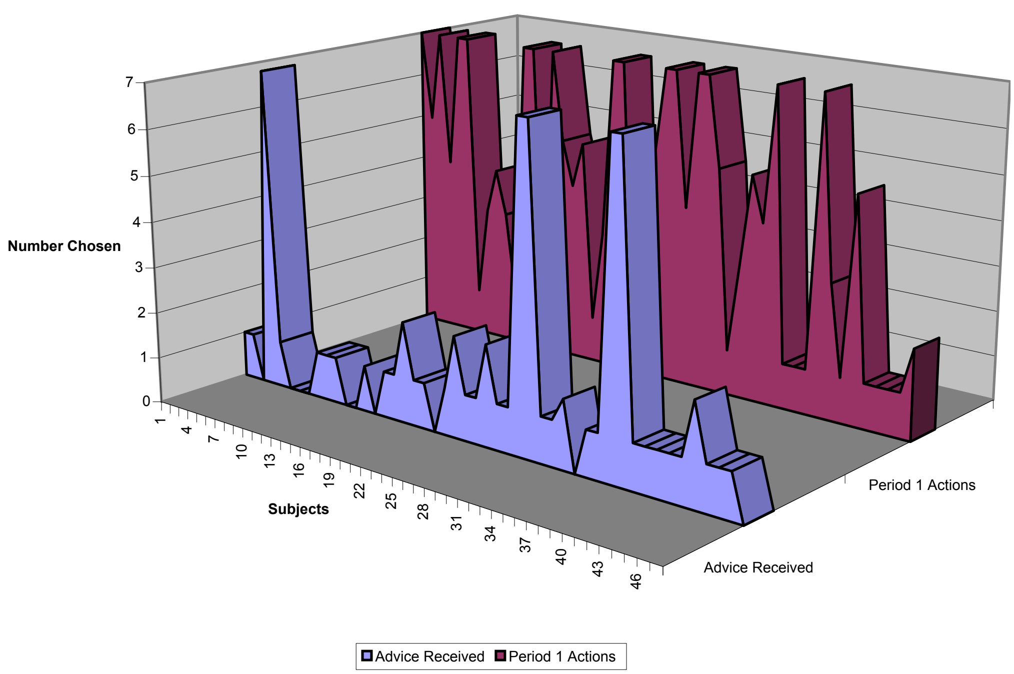


Figure 5: Comparison of Advice Received and Period 1 for the Advice + History treatment

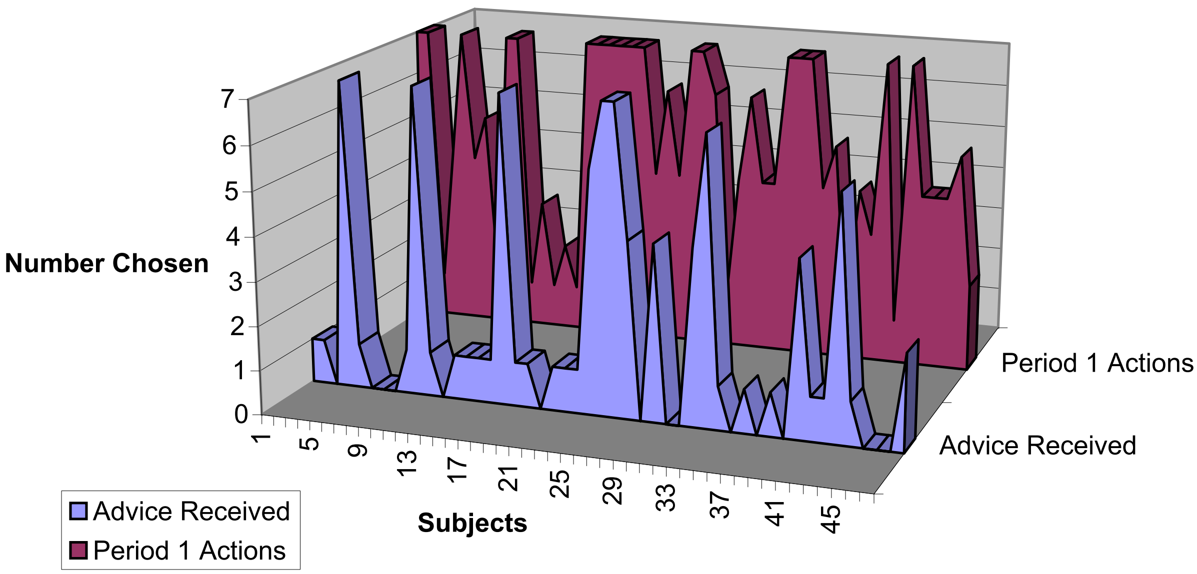


Figure 6: Comparison of Period 10 Action and Advice Left for Advice Ony Treatment

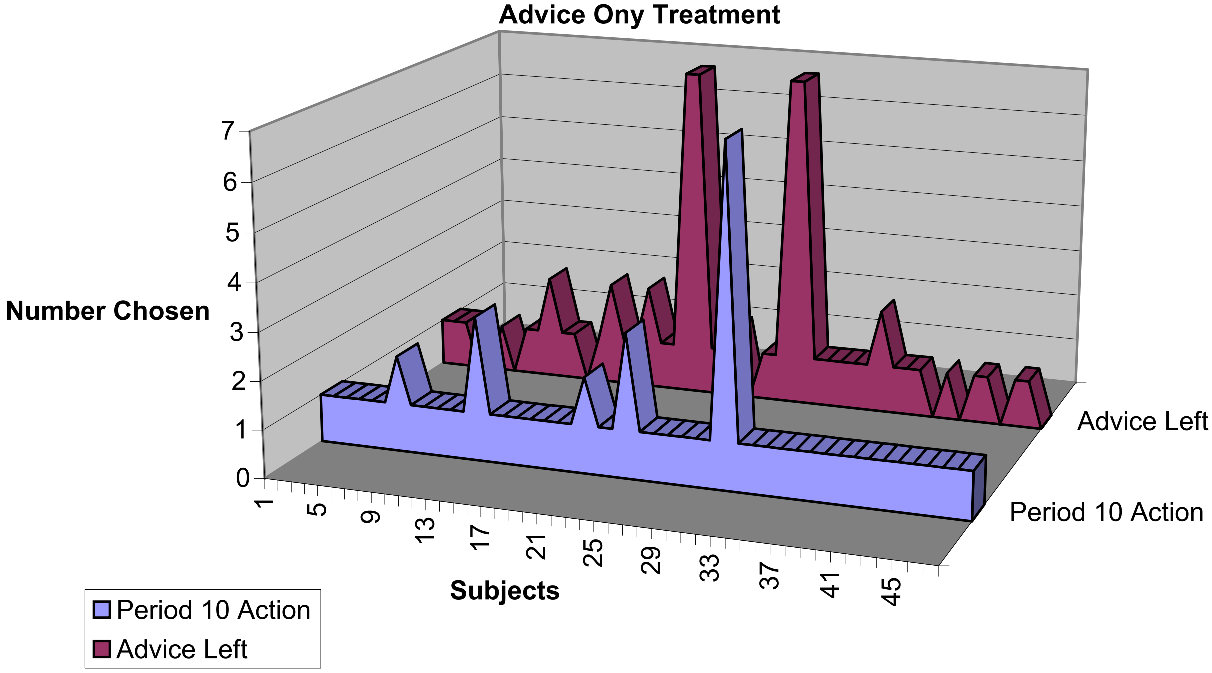


Figure 7: Comparison of Period 10 Actions and Advice Left for the Advice + History Treatment

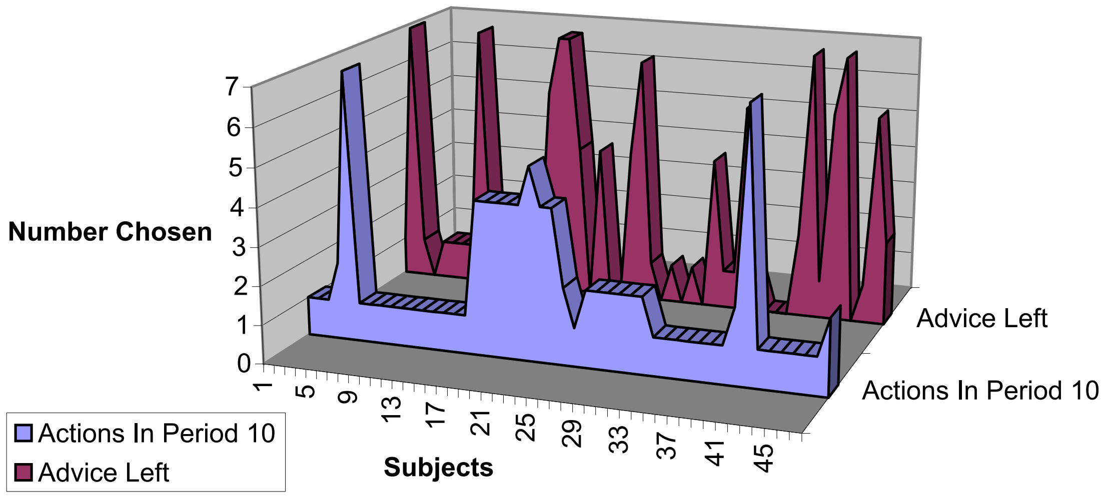


Figure 8: Comparison of Advice Received and Period #1 Actions for the Last Four Generations in the Public Advice Treatment

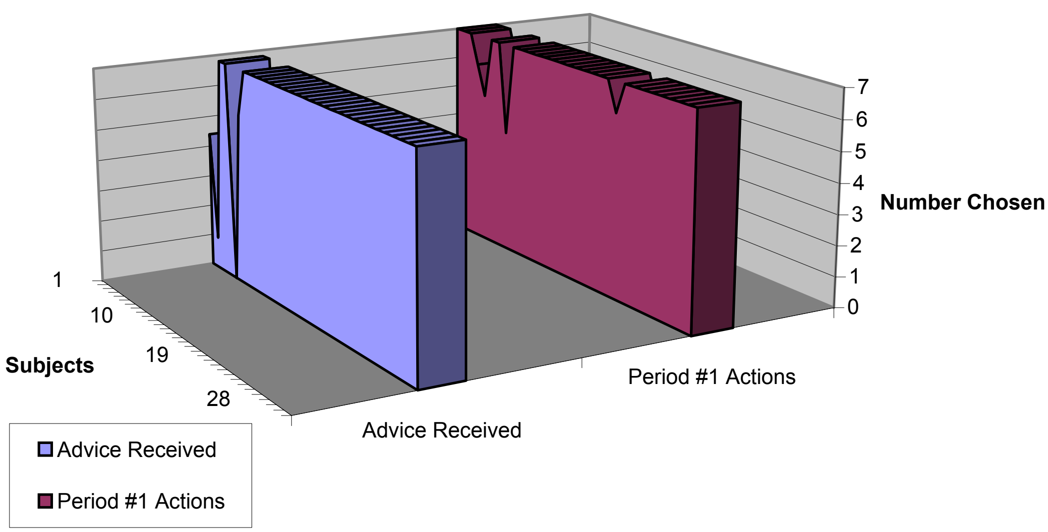


Figure 9: Comparison of Advice Received and Period #10 Actions for the Last Four Generations in the Public Advice Treatment

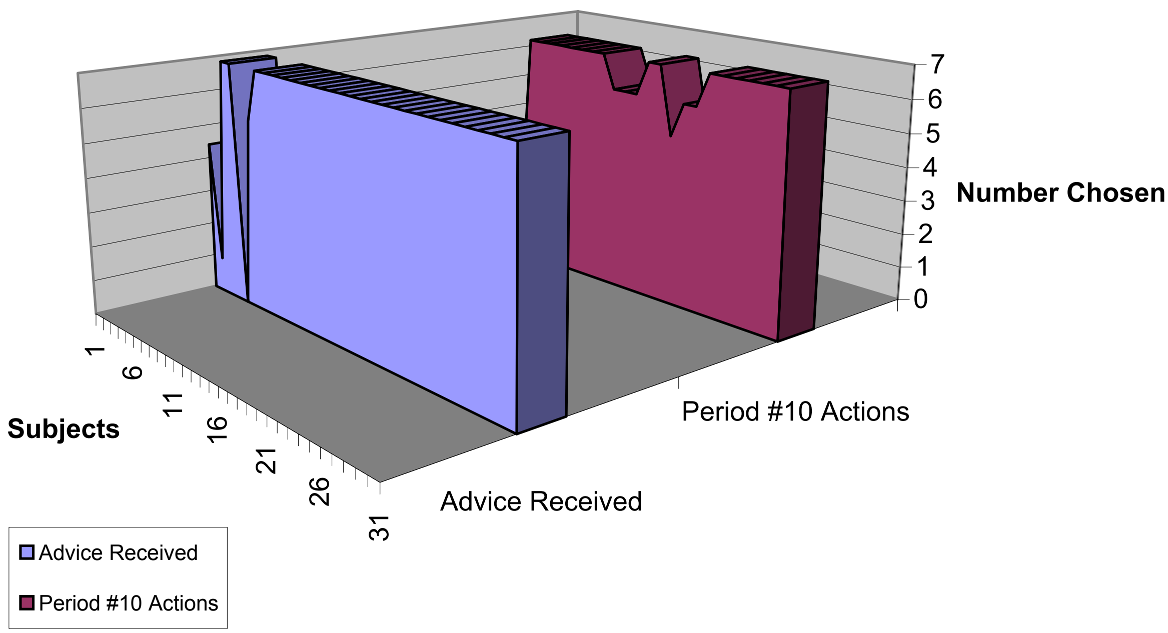


Figure 10a: Beliefs in the No-Advice Treatment

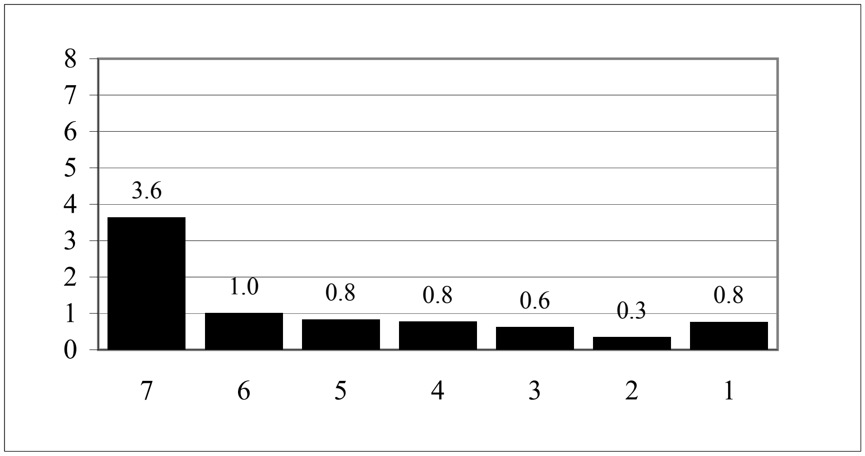


Figure 10b: Beliefs in the Advice-Only Treatment

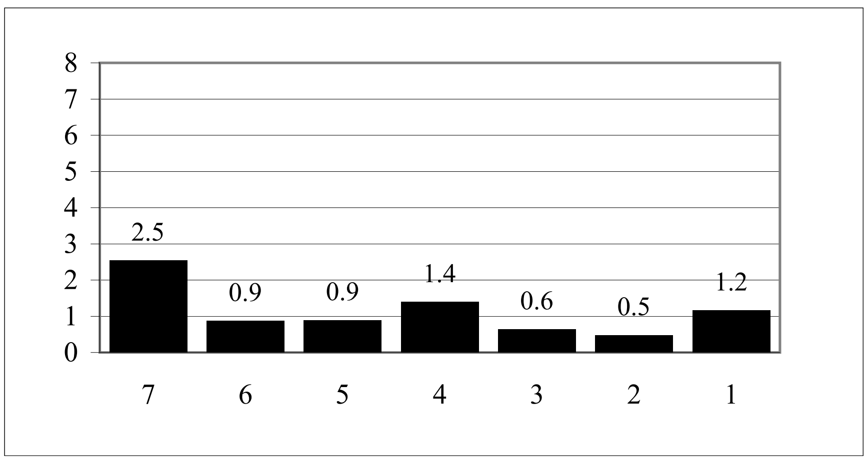


Figure 10c: Beliefs in the Advice-Plus History Treatment

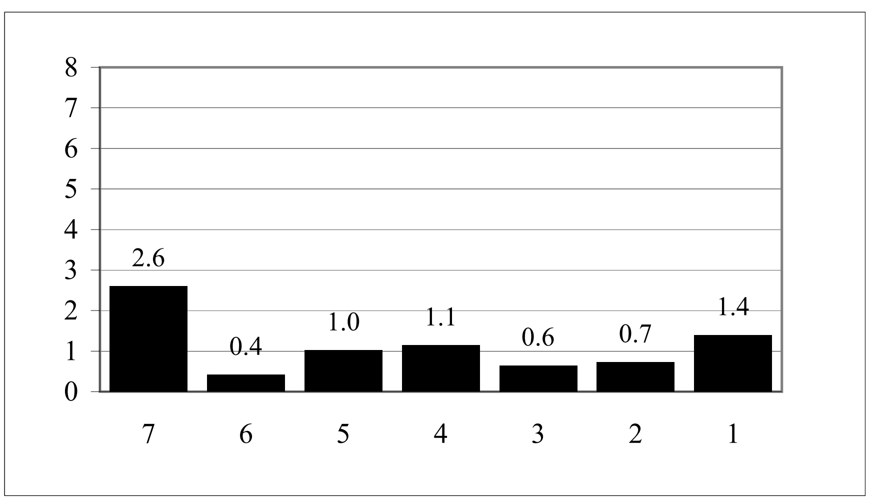


Figure 10d: Beliefs in the Public-Advice Almost-Common-Knowledge Treatment

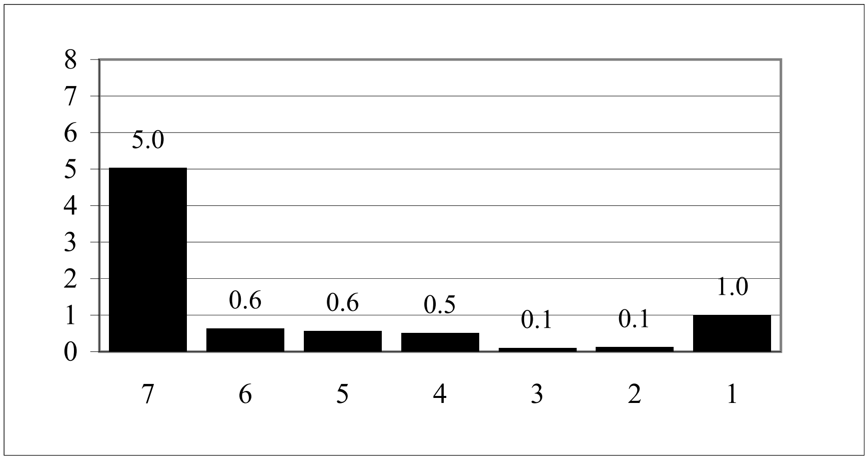


Figure 10e: Beliefs in the Public-Advice Common-Knowledge Treatment

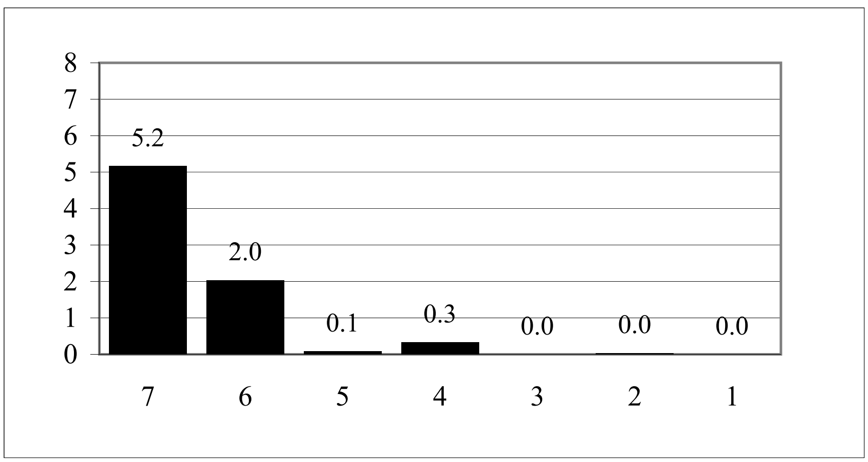
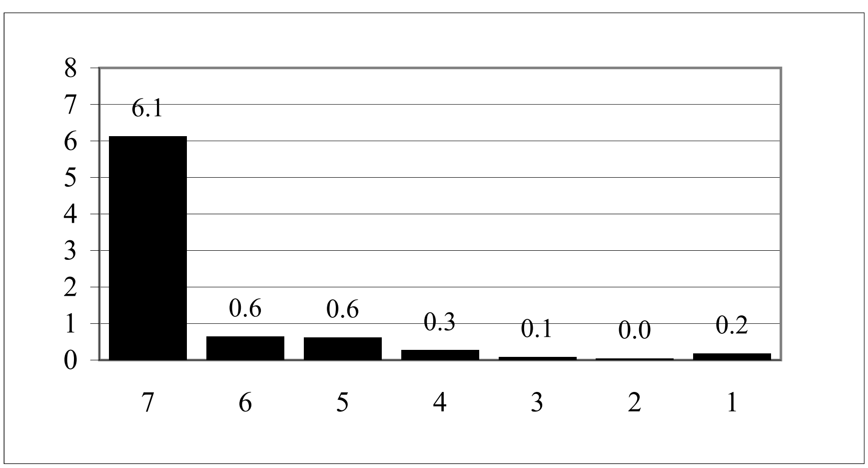


Figure 10f: Advice in the Public-Advice Almost-Common Knowledge Treatment (Generations 3-5)



Appendix: Advice

Advice left by the Progenitor Generation

My advice is that you should choose the minimum number because you will still get a better pay-off. Though higher number is good, it is safer to go to the minimum number which is likely the lowest number in the chart. You may lose some pay-off by going higher (there is a risk of also getting higher pay-off).

If you choose 1 you are guaranteed a pay-off of 70 cents. Where if you choose anything else you are not guaranteed such a large pay-off.

Always choose “1” for the most profit.

Have fun, watch, observe, relax. Don’t get money hungry. There’s a saying in Spanish it translates into “ a dove in your hands is better than 1000 doves in the air”. I hope you enjoyed that. And don’t worry about what everyone else is doing.

If everyone chooses 7, everyone wins. I hoped that everyone would also see that, however someone chose 1 to ensure that they would get 70 cents. This hurt my earnings and everyone who chose a number higher than 1. It forced me, and I assume others, to choose one as well, just so they could maximize profit while 1 person or all people were choosing 1. I began to choose 2 to see if everyone else had gained enlightenment, unfortunately someone was still choosing 1. I recommend you try choosing 7, in hopes that people in your experiment have a brain. If the “1 syndrome” appears stick with 1, if they haven’t figured it out by now the never will. Good luck.

In a perfect world everyone would pick 7 always, unfortunately someone is inevitably going to choose 1. Therefore, it is best to pick 1 and make a max of $7.00 in the first round section. Otherwise you will get less than that no matter what.

My advice would be to use the payoff table, use the examples and read carefully the extra instructions.

There is a definite strategy to these choices. To me it seems that the smaller number your choice of X, the greater your likelihood of making the most money. This is the result of the smallest value of X chosen by someone else in this experiment.

Private Advice-Plus-History Treatment (Subjects get to see the history of all previous plays and receive advice from their immediate predecessors)

Generation #1:

My advice is that you should choose 1 all the time because it never failed that someone chose 1. Therefore making that the smallest number chosen. You would think that everyone would pick 7, so you could get the highest pay-off but they didn't. So if you pick 1 then you'll make the most amount possible.

I don't understand why everyone would not choose 7. If you choose 1 you are guaranteed a pay-off of 70 cents. Where if you chose anything else you are not guaranteed such a large pay-off.

I chose 1 all the time because in any round if one other person chose 1 and I chose higher number my pay-of would be lower. So I played it safe with a straight 70 cent pay-off.

If you choose what ends up being the actual lowest then you will end up better off. Watch for what is usually picked as the lowest number and choose it too.

If everyone chooses 7, everyone wins. I hoped everyone would see that, however someone will always pick 1 to ensure 70 cents. Pick 1 for all rounds to ensure maximization of profit. Round Prediction is where you really make the money. Round 1 prediction is scattered so pick mainly high a few middle range and the rest low. For the second prediction it will be all at the bottom except pick 7 as you r pick and don't forget to predict that # you chose. The rest will make it for #1.

Best advice; someone, at least one person will choose 1 every time. If you choose 1 every time, you are guaranteed $7.00. If you choose 7 every time and someone chooses 1 you are guaranteed $1.00.

My advice will be to use a strategy to maximize your money based on not knowing what others will choose – which path would earn the most regardless of what others chose? What "guarantees" the highest pay-off? You'll only get $1.00 if you choose 7 every time. You'll get $7.00 choosing 1 every time.

If you always choose 1 you will be guaranteed a pay-off of 70 cents. What I observed from the previous experiment and the one I participated in was that the minimum was always 1. I picked a few higher numbers just to make sure and the minimum was always 1.

Generation #2

My advice is to do round #1 with 7 to get a feel for how the others are choosing and if everyone chooses 7 continue choosing 7 until someone chooses 1 – then begin choosing 1 for maximum payout. The first round is somewhat of a “trusts” round to determine if everyone figures out that if everyone chooses 7 that everyone gets the maximum 4

Pick 1 in all the rounds. You could bet that everyone may pick 7 but they will not. Always pick 1.

I chose one all of the time in order to secure a $0.70 pay-off per round. The history showed that the minimum was always one.

You should choose the lowest number and you will be best off. Whatever the lowest number is of the previous round, choose that number.

You should pick 1 always to maximize your payout. Someone will always pick 1 even thought you should pick number 7 to maximize your payout. When it comes to the prediction round, in the second round everyone will pick 1 but in period 1 put a high number on 1 or 7 to maximize payout.

The advice I give to you is very similar to the advice that was left for me. Someone will always choose the number 1 so if you choose number 1 every time then you will earn $7.00. When I started I started using #2 to see if I could earn a little more than 0.70. It Failed !! Stick with #1. Get your guaranteed $7.00. Good luck.

As you can see from looking at the history of the game, it is highly likely that at least one person will choose 1 every time. You can assure yourself that you will make 70 cents in every period by choosing 1 every time. This is the way to go to make the very likely maximum of $7.00

Although it seems like everyone would want to maximize their profit, they don’t. Some of the people seem to be in a defensive mood and go for what they are guaranteed. I tried high numbers at first but every time 1 was always the minimum. Try a high number at first and if doesn’t benefit you, go with 1 from then on.

Generation #3

My advice is to use the largest number in the first round to get a feel of what the minimum is going to be then pick the same number as the smallest X in order to maximize your pay-off.

Play the 7 to start with if every one plays the 7 all receive the highest pay-off but they may not. See what the lowest chosen is i.e. 4 is chosen regularly, see what the best pay-off is if the lowest choice is always 4…choose that #.

After the first two rounds I realized that player who chose the minimum of 4 would not jeopardize his/her pay-off of $1.00 to choose a different number. In choosing the same number I was able to earn more than by sticking with the 1 number.

Pick what the smallest value is in round 1.

You should pick 4 to maximize your payout. Someone will always pick the middle of the number. When it comes to the prediction 1^{st} round put a high number on #7 and the balance on #4. In the second prediction round put all or most of your choices on #4 to maximize payout.

My advice is to pick # close to first minimum choice observed. This will net you the most money for your painful cause which is about 20 min. Good luck.

You can make $7.00 easily by choosing 1 every time, but I chose to have fun and pick my favorite number to start with. I then stayed in the range of the minimum chosen for each round and this proved to be profitable.

Consistently choose a middle number so that the rest of the group does too. A choice of 4 with a minimum of 4 yields $1.00 every round.

Generation #4

Pick a high number for maximum pay-off, i.e. 7, 6

The smartest thing is for everyone to choose seven, but no one understands this by looking at my results and previous experiment history. Your best choice is to always pick 1 to guarantee a payout of $7.00

After the first 2 or 3 periods notice which number is being repeated. Stay with that number so you will receive the maximum bonus.

Pick the smallest value in round 1. I would also pick the smallest number in every round.

When he starts picking the actual number, go with that same number. If he picked example 5 for actual you need to pick 5 all the way through the game. Never change that.

My advice is good. If you want to make the most maximum allowed by the group, pick the minimum number allowed in the first round. Good luck.

I found that by picking the minimum number every time proved to be profitable. I started at my best number then worked my way towards the minimum number. Good luck!

I would say play the middle number so that payoff will be $1.00 – however there may be an idiot playing a favorite or lucky number thereby throwing the whole thing off!!

Generation #5

Pick a low number for maximum pay-off, i.e. 1

The concept of this experiment is to pick the no. with the best possible outcome. I recommend that you pick the lowest no. possible. By choosing 1 there's greater possibility to earn the biggest pay-off of .70 if 1 is the actual.

Start high, hoping everyone starts high. The higher everyone goes the higher the pay-off. After 2 or 3 rounds choose the minimum bid with the highest pay-off. One person choosing X for 1 will bring down the whole group.

Always choose 1 because no matter what the other people choose, you'll always have earned 70 cents. Always choose 1 and you'll be in control.

When he tells you the first minimum # chosen, use that number as the choice of X the whole way. Never change it !! Good luck!

Choose the value of X as equal to the minimum of from the previous round.

Unless everybody else in the room picks high as well, you're better off picking the minimum. I started in the middle range (at 4) but was undercut and lost money. In this situation I found it the most profitable to pick the minimum.

My advice is to guess low. Let's say 1-3. Be constant with your guess, the lower the better off you be. Good luck.

<u>Generation #6</u>

If you've got a "sharp" class, <u>all</u> should choose 7 for MAX pay-off. Most likely someone will pick 1 though.

To predict:

Put 1 in each column to keep subtraction minimum i.e. 7 – 1, 6 – 1, 5 – 1, 4 – 1, 3 – 1, 2 – 1, 1-1

OR

Put about 4 or 5 in 2nd prediction 1 column as most will be picking the min # played a lot

i.e. 7 – 1, 6-0, 5 - 1, 4 - 0, 3 - 0, 2 - 0, 1 – 5

The lower the number you pick the better. Since you will at least get 70 cents if at least one other person (you for example) picks one.

Start for your X value high, hoping everyone starts high. The higher everyone goes the higher the pay-off. After or 3 rounds choose the minimum bid with the highest pay-off. If the minimum is consistent, pick that for your X value, it probably won't change. One person choosing 1 for X will bring down the whole group.

Well, the optimal is if everyone chooses 7. But there is usually someone who does not see that fact. If one looks at the track record the number 4 generated the highest earnings per round. I wold give 7 or 4 a chance for one or two rounds. If the lowest number chosen is still 1 obviously one in the group has not gotten the idea to maximize earnings. Then the number 1 should be chosen for the next 8 rounds. Good luck. Hope you get a "smart" group.

In order to win some amount of money (as opposed to zero) when he tells you the minimum # chosen use that number as the choice of X the whole way. Don't change it!

Choose the value of X as the lowest value possible to add to the balance steadily.

The best case scenario is if everyone picks high. At first I chose numbers on the high side but then I found at least one person in my group was choosing 1. This caused me to lose money. So, I began to choose 1 for the remainder of the rounds to be "safe" and still earn pretty good money. My advice is start picking high #s and hope everyone in your group will do likewise.

My advice is that you should pick numbers 4 or below because you will make the most consistent earnings.

Private Advice Only Treatment (Subjects get advice from their immediate predecessor but do not get to see the history of past plays)

Generation #1

Choose minimum number because you will still get a better pay-off. At first I made a choice for higher #, but I got bad pay-off. So it is safe to go with lower # in chart.

If you choose 1, it maybe small but a guaranteed payoff of 70 cents. Where if you choose anything else you are not guaranteed a steady payoff.

Choose 1 all the time so that you are guaranteed you will get money from 0.7 to 1.3

Have fun.

If everyone chooses 7 everyone wins. However if someone picks 1 everyone else will also start picking 1 to maximize profit. When predicting for the first round pick high on 7 and scatter a few through the rest of the #s. On the second prediction all or close to all with be choosing 1.

Someone will pick 1, might as well be you

Pay attention to the payoff table and think what everyone else will do.

If everyone picks higher numbers then you will make the most money but more than likely everyone will pick smaller values so that is your best bet.

Generation #2

Predict some 7's on the first round guess of what others will do. We had 3. Predict 2 low scores of 1. Pick 1's on all. By the last round all but one were at 1. Good luck:

If you take some risk, payoff will be larger. Don't always go for the "sure" low numbers.

Choose number 1, as you know someone will. It has the largest payoff against itself, when chosen as the lowest number. This way you are guaranteed 0.70.

To minimize losses do one's across. On prediction some will do 7, some 3 or 4 and some 1's. By the end all will choose 1 by the end.

If everyone chooses 7 everyone wins. However if someone picks a number lower than 4 the profit is not as high.

Study the table and then pick 1, because someone will pick it anyway.

Choose a lower X for higher average return

Choose "1" every time. And predict everyone else will too.

Generation #3

Always pick one for the largest payoff

Don’t always go for the “sure” low minimum. But follow your instincts.

Choose number 1, some one will. It will have the largest payoff. There will always be someone that picks it. This way you will get a guaranteed 0.70

Minimize your losses by picking 1 every time – somebody will always pick 1. On the predictions, the 1st time, some will pick 7 and 3 and more will pick 4 and 1. On the second prediction, everyone will pick 1.

Everybody chooses 7, everybody wins.

In the first round, choose 7, hoping for intelligence in the room, then if everyone chooses 7 continue, in all other cases choose 1 after first round.

Always choose 1.

When you play choose “1” every time and predict the guess.

Generation #4

Pick numbers 3 or below

Don’t assume that everyone will always choose the minimum “sure thing”. Follow the highest payoff

Trust me, choose 1, there’s always that one person who always will for some reason. It’ll get you the most money.

Definitely pick 1 for every period!

If everyone chooses 7, everyone wins but beware of the one person who may choose 1.

During 1st period, choose 7, if everyone else chooses 7, keep with that #. If someone chooses something other than 7, choose 1 thereafter.

Always choose 1.

When you play choose “1” every time and predict the guess.

Generation #5

Pick numbers 1 through 3. 1 is the best choice.

Choose the minimum

Believe it or not, you should always pick the number 1.

Pick low numbers

For the most profit, choose the lowest number possible each time.

Always choose 1, you will make the most money. For predictions always think that all people will choose 1 except in round 1 where 3 people will choose 1.

Always choose 1, someone else will. On the table 1 gives the highest return. Anything else you pick will give you less.

1 is not always the smallest.

Generation #6

One is the best choice. Also use one in your predictions.

Watch the others but always choose the minimum

Choose # 1 always but don't expect others to catch on at first. On your first predictions, don't expect they'll choose #1.

Always choose number 1. That is the only way to obtain the highest payoff.

For most money pick the lowest number. If you want to gamble you could pick high but everybody else has to do the same. So I would just pick the lowest number.

Always choose 1. You will make the most money. For prediction in the first period put 5 people will pick 1. Then put 1 in each category above 1. The other predictions all people will choose 1.

Always choose 1, someone else will. On the table 1 gives the highest return. Anything else will give you less.

Alternating can be good.

<u>Public Advice Treatment (Subjects get to see the advice left by ALL the 8 players in the immediately preceding generation – however this advice is not read aloud – so this corresponds to the situation we have called "almost common knowledge")</u>

<u>Generation #1</u>

I was hoping that people would choose 7 in the first round to see if we as a group could maximize our profit. Once someone chose 1 in the first round, it was obvious that we weren't going to end up any better than what could be made at the lowest number level.

Stick with 1 as your choice regardless. This will be the highest payoff. In predictions keep them even (the numbers) and put zero in numbers higher than 4.

Always choose "1" for most profit.

You will get money by choosing 1 but you can't predict what everyone else will do. Follow your intuition and have fun. If everyone would pick 7, you would get more money. However somebody is always afraid to take a risk.

My advice is to choose the lowest number and keep with it. If you chose a higher number you won't make as much money.

Go for one or the lowest number you feel comfortable with. Good luck.

Choosing #1 seems to be the most lucrative way to go.

If everyone would only choose 7, everyone would get the highest amount. It's not a lot of money anyway so I don't understand why people don't just take a gamble and choose 7! I tried to do that but everyone has to do it to make it work. It was sort of frustrating that someone had to play it safe every time and choose 1. Take a chance!! Choose 7 right away!

Generation #2

Stick with #7 all of you.

Everyone ought to choose 7 on the first period. United you stand, divided you fall.

Have fun – don't always choose the number you think others will do to get some money. We're not talking big dollars here.

The only reason to pick any number other than 7 is so that someone else makes less than you. If you all pick 7 everyone makes the same and everyone makes the most. After someone decides 1 is good – just go with 1, they are not going to change. The obviously don't understand the value of group agreement.

If everyone chooses 7 all will make the most money but once someone picks one they will or someone else will continue with that number so to maximize your earnings you will need to as well. Start off with 7 and maybe everyone will realize the advantage and you will all be lucky.

Always choose #7 to max profit, otherwise everyone will bottom-out and max profit will not be achieved.

If everyone picks 7 each time, the payoff is highest. Higher numbers consistently used by everyone are better.

You will need to make the choice of X=7 each period to make the most $!. I believe all of us are in this pyramid scheme from one generation to the other.

Generation #3

Be ahead of everybody, start with a 6, then go down to 5, etc. You will be able to make the most money that way.

Choose #7. Don't be tempted to deviate but everyone must choose #7.

True, if everyone selects #7, you have max profit. But when you see the smallest # move down, you should follow.

If everyone continues to pick 7 you will maximize your profit. Anything else and profit maximization is not possible.

Start with 7! Everyone agree at least once. Once someone starts using one join them.

Follow the trend. Ideally you want to maximize at seven but inevitable someone doesn't get it.

Stay with 7 unless someone won't use that number. If they insist on a lower number go with it.

Pick #7 until after it is apparent that the number declines and then follow it down.

Generation #4

Don’t start with #7 because people will always start in the middle somewhere.

Choose 1 always. Although it would be nice to choose 7 and help everyone maximize, there’s always someone who doesn’t. So, be safe, always choose 1 and you know you will always make 70 cents because you’ll be the lowest number.

Follow the advice given on this sheet. Pick 7, then go down to 6 and so on. Everyone follow the trend.

Start and stick with 7 to maximize profit.

Follow your own instincts, do not go with the trend. There is no actual pattern.

Ideally everyone should choose 7 for max profit. However, most people won’t so start with 5 or 6 and then follow the trend should someone else go lower than you.

EVERYBODY READ THE ADVICE AND ALL PICK “7” TO MAKE THE MOST MONEY. IT IS EASY TO TAKE HOME MONEY IF EVERYONE PICKS 7.
Start with #7, then follow down 6, 5, 4, 3, 2, 1 when someone starts with 1 stick with it.

Generation 5

Ideally, everyone should pick 7 every time so you all make the maximum amount. However, someone is going to ignore this advice, so once that happens just pick 1.

Start in the middle, like 4 or 5, because everyone will start with 7, expect for probably 1 or 2 people. If someone picks 1, that is it, do not pick anything else.

Everybody has to pick 7. It is the best way to make a profit. If you are unsure if to choose 7, then you are screwing over everybody else who is trying to help you and themselves earn more!!

Everyone choose 7 to maximize profit. If the min goes down, follow it.

Start out mid-range, 4-5. Someone always stays safe and picks a lower number, but follow the trend down, as people pick lower numbers to insure at least average payoff. Stop at 2, though, even if the lowest number is always 1. Just in case, never be the lowest number. Good luck!

Start with 7 in the 1st round. If everyone sticks with 7, then 7 will maximize$ earned. If someone goes low, do not trust them to go high again. Go low to maximize your own $. Be smart – stick with 7 – do not be the one to go low on the first round. It is less $ for you!! Pick 7 and you will earn $13. Pick 1 you will only get $7.

Ideally, everyone would make the most money if everyone chooses 7 and stays with 7,but there is always someone who starts in the middle and continues to choose lower numbers. Start around 4 or 5 then follow the trend.

Try not to start with 1, but if you see a trend of 1 or another number, follow the trend to maximize your profits.

Generation 6 : First Generation of the Public-Advice Common Knowledge Treatment

Choose 7 all the time. In our group, everyone did so in every round and we all earned the maximum amount.

Everyone should always pick 7, you will make the most money and so will everyone else.

Choose 7, but follow any trends that may come about.

Pick 7 every time! Trust everyone to pick 7. I promise it works. It is not a trick. You make the most money. If you decide to be selfish and try to win rounds by picking a lower number, you end up making less profit.

Only pick 7. There is no reason not to. If you do, everybody wins. If you don't, you make less in the long run.

It is best to pick 7 all the time because everyone has the same goal and that's to make the most money. Since this advice is read before the experiment actually start, everyone will hear the same thing and everyone will pick 7. After the first round, it will be obvious if everyone will pick 7 and trust each other.

Pick 7 if you wanna more money. If you just wanna mess with everyone else and do not care about the money then 1 is your number.

Everyone must choose 7! That way everyone will earn the maximum amount of money in this experiment.

Generation 7

Pick 7 every time, EVERY TIME. If everyone picks 7 every time, everyone will make the max per round ($1.30 X 10 =$13.00), plus you can make the full $1.28 for each of the predictions rounds. Don't be stupid. Pick 7. Honestly, you're here for the money anyway, right?

If you don't start the first round with "7" then the pattern thereafter will be "7"or lower. Bottom line – you <u>must</u> begin the first period with a "7" …. Or else!!!!

Pick 7 for crying out loud! But if there is a weirdo who picks lower, pick that number too. Pick 7!!! Trust each other it will help you too!

For the first round, you must trust the other participants & choose 7. Choosing 7 gives the maximum payoff. The adjust your choice by following the trend after the first round. Be consistent!

It would be best for everyone to choose 7 each time. However, if one person consistently chooses a lower number, you will make more profit by conforming to them.

Picking 7 will yield the maximum payoff if everyone picks 7. So start out picking 7, however, some people are very untrusting and will pick 6 or 5 – if this happens, follow the trends, if everyone starts picking 6, start picking that also.

Chose 7 &and hope everyone else does. But it is important to follow any trends you notice.

The thrill of not choosing seven leads only to a smaller payoff than both you and everyone else could earn.

Generation 8

Everyone has to pick 7 every time. Trust the strangers. You all come here for the $, so pick 7 every time. Seriously.

I strongly advice you to pick **7 EVERY TIME**. Our group was advised to do so, and being smart, we all did so. So that way we **ALL** earned the full $13.00 for the rounds ($1.30*10=$13.00). We all were constraint with what each other would pick and it worked out for all of our benefits.

Pick 7 every time. Otherwise, you will drag in the street. Don't mess with this economics department. They mean business.

Everyone just has to start with 7. Trust everyone in the first round. There is no reason not to. If there will be someone who chooses other than 7, then you can adjust.

If everyone picks 7, the game goes fast and you make the maximum cash. If you pick lower than 7, you are an idiot. You will make less money and also screw over everyone else. So, just pick 7 and leave with $13!

Pick 7 every time. This will lead to maximum payoff! However, if someone starts picking 6, you should follow their lead. The best idea is to pick **7**!

There isn't much thinking to this experiment. Just pick 7 EVERY SINGLE TIME!! Be smart about this. You benefit from this as long as does everybody else. There is only ONE way to go. Just do it!

APPENDIX:
Instructions Private Advice

PLAYER ID #___________

Instructions

This is an experiment in the economics of market decision making. Various funding agencies have provided 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. These earnings will be paid to you in cash at the end of the experiment.

You will be in a market with 7 other people. In this experiment there will be a number of periods. In each period every participant will pick a value of X. The values of X you may choose are 1, 2, 3, 4, 5, 6 or 7. The value you pick for X and the smallest value picked for X by any participant, including your choice of X, will determine the payoff you receive.

You are provided with a table which tells you the potential payoffs you may receive. Please look at the table (on Page 2) now. The earnings in each period may be found by looking across from the value you choose on the left hand side of the table and down from the smallest value chosen by any participant from the top of the table. For example if you choose a 4 and the smallest value chosen is a 3 you earn 80 cents that period.

At the beginning of every period each participant will write down the value of X they have chosen on the Record Sheet. (Page 5) The smallest value of X chosen will be announced and each participant will then calculate his/her earnings for that period.

If you will now look at your record sheet you will see the following entries. MARKET PERIOD, BALANCE, YOUR CHOICE OF X, SMALLEST VALUE OF X CHOSEN, and YOUR EARNINGS. In the first period your BALANCE is zero. In the second period your BALANCE is the value of your earnings in the first period. In the third period your BALANCE is the value of your BALANCE in the second period plus the value of your earnings in the second period. And so on. Please keep accurate records throughout the experiment.

All payoffs in this experiment are designated in dollars and cents.

<u>Unless you are in the first group</u> 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 <u>immediately prior to you</u>. This subject will earn an additional payment equal to your earnings in the 10 decision rounds that you will complete in this experiment. 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 the earnings of the subject you give advice to. Please write your advice on the sheet provided (Page 6). Please write or print legibly. You will be notified by e-mail or telephone when your second payment is ready.

Each of you is paired with another player, who you do not know and who will participate in the experiment <u>immediately after you.</u> You will receive a second payment, equal to the amount that this player, who will participate in the experiment immediately after you, makes in his or her session. You will be told how to collect this second payment after the instructions have been read.

To be sure that everyone understands the instructions please fill out the sheet labeled questions on Page 3 now. Do not put your name or participant number on the question sheet. 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!!!

PAYOFF TABLE

SMALLEST VALUE OF X CHOSEN

YOUR CHOICE OF X	7	6	5	4	3	2	1
7	1.30	1.10	.90	.70	.50	.30	.10
6	---	1.20	1.00	.80	.60	.40	.20
5	---	---	1.10	.90	.70	.50	.30
4	---	---	---	1.00	.80	.60	.40
3	---	---	---	---	.90	.70	.50
2	---	---	---	---	---	.80	.60
1	---	---	---	---	---	---	.70

QUESTIONS

Please look at your payoff table and fill in the following blanks.

Your choice of X	The smallest value of X chosen	Your earnings
4	2	____________
2	2	____________
5	5	____________
6	4	____________

EXTRA INSTRUCTIONS

Occasionally you will be asked to predict what every participant will choose for X. When you are asked to do so, please write down your prediction of how many people will pick 7, 6, 5, 4, 3, 2, and 1. When you add your predictions of the number of people that will pick each value i.e. 7, 6, 5, 4, 3, 2, 1, they should add to 8.

You will be paid for each of your correct predictions as follows. Your earnings will equal 128 cents less the sum of squared differences between your predictions and the actual choices.

EXAMPLES: Suppose that 8 people each had a red ball and a blue ball, and that they were all asked to put one and only one of the balls into an urn. At the same time they each were asked to predict the number of red balls and the number of blue balls that would end up in the urn. With a payment rule like that above they would find their earnings as follows:

	Predict	Actual	Sq.Diff
Blue	8	0	64
Red	0	8	64
	Total		128
	128 - 128 =		0

	Predict	Actual	Sq. Diff
Blue	8	8	0
Red	0	0	0
	Total		0
	128 - 0 =		128

	Predict	Actual	Diff
Blue	4	4	0
Red	4	4	0
	Total		0
	128 – 0 =		128

	Predict	Actual	Sq. Diff
Blue	6	2	16
Red	2	6	16
	Total		32
	128 – 32 =		96

You will be told the actual choices made for the periods you were asked to make predictions at the end of the experiment.

IF YOU HAVE ANY QUESTIONS PLEASE ASK THEM NOW!!!

RECORD SHEET

SEX M F PARTICIPANT #
circle one

MARKET PERIOD	1	2	3	4	5	6	7	8	9	10	11
BALANCE	0										
YOUR CHOICE OF X											
SMALLEST VALUE OF X CHOSEN											
YOUR EARNINGS											

Period ____

Predict Actual Sq.Diff

7 ____ ____ ____

6 ____ ____ ____

5 ____ ____ ____

4 ____ ____ ____

3 ____ ____ ____

2 ____ ____ ____

1 ____ ____ ____

Total ____

128 - ____ = ____

Period ____

Predict Actual Sq.Diff

7 ____ ____ ____

6 ____ ____ ____

5 ____ ____ ____

4 ____ ____ ____

3 ____ ____ ____

2 ____ ____ ____

1 ____ ____ ____

Total ____

128 - ____ = ____

Period ____

Predict Actual Sq.Diff

7 ____ ____ ____

6 ____ ____ ____

5 ____ ____ ____

4 ____ ____ ____

3 ____ ____ ____

2 ____ ____ ____

1 ____ ____ ____

Total ____

128 - ____ = ____

ADVICE