Review of Economic Studies (2006) **73**, 357–380 0034-6527/06/00130357$02.00

Social Learning and Norms in a Public Goods Experiment with Inter-Generational Advice[1]

ANANISH CHAUDHURI
University of Auckland

SARA GRAZIANO
Charles River Associates

and

PUSHKAR MAITRA
Monash University

First version received May 2003; final version accepted October 2005 (*Eds.*)

We study a linear public goods game using an inter-generational approach. Subjects in one generation leave advice for the succeeding generation via free-form messages. Such advice can be private knowledge (advice left by one player in generation t is given only to his or her immediate successor in generation $t+1$), public knowledge (advice left by players of generation t is made available to all members of generation $t+1$), and common knowledge (where the advice is not only public but is also read aloud by the experimenter). Common knowledge of advice generates a process of social learning that leads to high contributions and less free-riding. This behaviour is sustained by advice that is generally exhortative, suggesting high contributions, which in turn creates optimistic beliefs among subjects about others' contributions. We suggest that socially connected communities may achieve high contributions to a public good even in the absence of punishment for norm violators.

1. INTRODUCTION

There is now a voluminous experimental literature that uses voluntary contributions mechanisms to capture the tension between contributing to a public good or free-riding on others' contributions. Ledyard (1995) provides a review of much of this literature. Prior studies have documented that (1) in a one-shot version of the public goods game groups of subjects on average contribute between 40% and 60% of the optimal level with wide variations in individual contributions ranging from 100% contribution by some to 0% by others and (2) if the players interact repeatedly over a number of rounds then contributions often start out at between 40% and 60% of the social optimum and decline steadily over time as more and more players choose to "free-ride". Such free-riding has been the subject of intense study (see, for example, Andreoni, 1988; or Andreoni and Croson, 1998).

The linear public goods game is an excellent vehicle for understanding the inherent tension between cooperative and competitive behaviour in social dilemmas. The linear public goods

1. A longer version of this paper containing detailed discussions about the implications of our results is available from the Social Science Research Network at http://ssrn.com/abstract=580481. The instructions for the experiments, the original data, and the STATA program used to analyse the data are available on the journal's website http://www.restud.org.uk. All errors are the responsibility of the authors.

game is really an *n*-person prisoner's dilemma where free-riding is the dominant strategy Nash equilibrium in a one-shot version of the game and also the subgame perfect outcome in finitely repeated versions of the game. It is also the evolutionarily stable strategy in such situations. See the discussion in Miller and Andreoni (1991) among others. As is well documented in the literature, however, while free-riding does occur in finitely repeated versions of such games, the game-theoretic prediction of complete free-riding is clearly refuted even after a number of rounds.

In this paper we develop an inter-generational approach to a linear public goods game. A group of subjects is recruited into the laboratory and play the public goods game for 10 rounds (the exact experimental design and parameters are explained in Section 2). After his or her participation is over, each player is replaced by another player, his or her laboratory descendant, who then plays the game for another 10 rounds as a member of a fresh group of subjects. The generations are non-overlapping. Advice from a member of one generation can be passed along to his or her successor via free-form messages that generation t players leave for their generation $t+1$ successors. Pay-offs span generations in the sense that the pay-off to a generation t player is equal to what he or she has earned during his or her lifetime plus 50% of what his or her laboratory descendant earns. This provides an incentive to the subjects to pass on meaningful advice to their successors.

This inter-generational approach was pioneered by Schotter and Sopher (2001*a*,*b*, 2003), who point out that in real life people approach such social dilemmas in a manner that is different from those captured in previous experiments. When confronted with such situations, they have access to the wisdom of the past, in the sense that those who have faced the same dilemma before them (or at least immediately before them) are there to give them advice as to how to address the problem. Our conjecture is that playing a public goods game using such an inter-generational design will, over time, lead to the evolution of norms of cooperation, with later generations not only achieving higher levels of contribution but also managing to mitigate problems of free-riding. Norms or conventions of behaviour that arise during one generation may be passed on to the successors. Hence, we expect that outcomes in our inter-generational game will be more efficient than those reported in previous experimental work.

We believe that the concept of an evolutionarily stable strategy does not adequately capture the way in which social evolution, as opposed to biological evolution, might function. This is primarily because the concept of evolutionarily stable strategies does not allow for social learning, and therefore it might not be able to explain large patterns of human cooperation. To do so we need theories of cultural evolution or gene culture co-evolution along the lines of Cavalli-Sforza and Feldman (1981) and Boyd and Richerson (1985). Human societies create and pass on social conventions from one generation to the next and the inter-generational framework that we use in this paper is an attempt to capture the evolution of such social norms.

We incorporate three separate mechanisms for passing advice from one generation to the next. The first is the "*private knowledge of advice*" treatment, where advice from one subject in generation t is given to his or her immediate successor in generation $t+1$. The second is the "*public knowledge of advice*" treatment where advice from one generation of players is made public to the next generation in the sense that all the advice left by the former group is made available to all the members of the latter group. Here, each subject in the group knows that every other subject is looking at a sheet of paper that has the exact same information (same pieces of advice) written on it. Finally, in the "*common knowledge of advice*" treatment not only do the players receive the same sheet of paper with the advice from their predecessors, this advice is also read aloud by the experimenter for all members of the group to hear. Thus, in this treatment each subject not only knows that every other subject is looking at the same pieces of advice on the sheet of paper but each of them also knows that they have all heard that same information being read aloud.[2,3] Behaviour in these advice experiments is compared to behaviour in a replicator or "*no advice*" treatment, where we have multiple groups playing the public goods game with no advice linking them. This no-advice treatment serves as our control group.

We find that when the advice left by one group of subjects is "common knowledge", this advice has a significant positive impact. Contributions in the common knowledge of advice treatment average 64·4% (aggregated over all generations and all rounds), which is significantly higher than the average contribution levels attained in the "private knowledge" or "public knowledge" treatments as well as the "no advice" treatment.[4] We show that advice plays a crucial role in determining contributions and subjects write substantially different advice in the common knowledge treatment as opposed to other treatments. We will also show that the subjects manage to create and sustain a norm of high cooperation in the common knowledge treatment.

We proceed as follows. Section 2 explains the experimental design. Section 3 presents our main results. Section 4 talks about the nature of the advice left and how that advice impacts subsequent behaviour. Section 5 looks at how our different advice treatments impact subjects' beliefs and how those beliefs in turn affect contributions. Section 6 discusses some implications of our research findings and concludes.

2. EXPERIMENTAL DESIGN

All the experiments were carried out as non-computerized classroom experiments. A total of sixty-four sessions were held with five subjects in each session. The composition of the group remained unchanged during the course of a session. Our set-up then corresponds to a "partners" protocol as in Andreoni (1988). Each session constituted one generation (with one exception explained below) and consisted of five players playing the public goods game for 10 rounds. This group of five is then replaced by five successors who take their place and play on. When generations change, outgoing agents are allowed to pass on advice through free-form written messages to their successors.

Pay-off to an agent is the sum of the amounts that an agent earns during his or her lifetime plus 50% of what his or her successor earns in the next generation so there is partial intergenerational caring. This second payment is designed to act as an incentive for the subjects to leave meaningful advice. The subjects are paid their actual earnings from a session immediately upon the completion of the session. They are told that they will be contacted via e-mail/phone at a later date and given a second payment (based on the earnings of their successors). This second payment was handed out to the subjects after we had finished running all the sessions.

We performed a set of five different experiments at three different locations—University of Auckland (Auckland, New Zealand), Wellesley College (Massachusetts, U.S.A.), and Indian Statistical Institute (Calcutta, India). Details of the experimental design are presented in Table 1. In Figure 1 we present the specific structure of Experiment 3, run at the University of Auckland in March 2004, to illustrate the structure of Experiments 1–4.

2. McTavish and Shaklee (1977), Isaac and Walker (1988) and Dawes have shown that allowing subjects to communicate in social dilemma experiments enhances efficiency. Cooper, DeJong, Forsythe and Ross (1989, 1992) demonstrate similar results in coordination games. Communication in those studies takes the form of non-binding statements which are made by players who are actually going to play the game. In contrast, our advice statements are made by predecessors, and not by the subjects who are about to play the game.

3. This inter-generational approach is similar to the idea of "recurring games" introduced by Jackson and Kalai (1997). Also relevant in this context is Young's (1993) study of the creation of conventions in games with multiple equilibria such as coordination games or battle of the sexes games.

4. Bear in mind that in prior studies under anonymity, non-assortative matching and in the absence of explicit communication between group members or punishments and rewards, contributions usually start between 40% and 60% and then steadily decline from then onwards.

TABLE 1

Design of the experiments

Experiment number, location, and time	Groups in no-advice treatment	Generations in private knowledge of advice treatment	Generations in public knowledge of advice treatment	Generations in common knowledge of advice treatment	Subjects in each group	Total number of subjects	Total number of data points
#1 Wellesley College October 2002	6 (5 plus 1 progenitor group)	5	–	6	5	85	850
#2 Indian Statistical Institute February 2004	5 (4 plus 1 progenitor group)	4	–	4	5	65	650
#3 University of Auckland March 2004	4 (3 plus 1 progenitor group)	3	3	3	5	65	650
#4 Wellesley College May 2004	1 progenitor group	4	4	4	5†	62	620
#5 University of Auckland April–May 2004	–	–	4	4	5	40	400
TOTAL	16	16	11	21		317	3170

† In Experiment 4 at Wellesley College we had two generations in the public knowledge treatment and one generation in the common knowledge treatment where only four people showed up. As every experimenter knows there are occasions when in spite of one's best efforts the exact number of subjects required do not show up. We have chosen to include these generations with four players in our data. Our results would remain unchanged if we excluded these groups.

In running each of our inter-generational experiments we started by running a "Progenitor" experiment in which five subjects played the public goods game for the first time and hence with no advice. They did, however, leave advice for their successors at the end of their session. This generation was the progenitor of all the generations in the three advice treatments (private knowledge, public knowledge, and common knowledge) that followed in the sense that the first generations in each treatment used the advice of this progenitor generation. We also carried out a set of replicator sessions with no advice or generations—here we ran the public goods game with five players in each session playing for 10 rounds with no advice linking them. Contributions in these sessions serve as a benchmark against which we compare contributions in the other treatments.[5] We should point out that the different treatments within each experiment are not independent since all the advice treatments start with the same progenitor generation. But in order to study the evolution of advice and behaviour we need to start with a common progenitor. This is an initial conditions problem whose impact diminishes with each passing generation. What constitutes an independent observation here is each separate experiment as a whole giving us four independent observations. Because we hold the initial advice constant (within each

5. We would like to draw the reader's attention to the unusual challenge created by these inter-generational games. All these experiments involve playing a game with non-overlapping generations of players. This means that we recruit generations of players sequentially into the laboratory and before we can do a session using generation t we must first complete the session with generation $t-1$. Given that the generations are connected to one another via advice each experiment in this paper constitutes one time series. Thus, one needs to run multiple experiments to generate multiple time series of data. But at the same time, in order to allow time for behaviour to evolve, we must run our experiments for several generations. This tends to be both time and money intensive. Thus, there is a trade-off between running more generations in each treatment as opposed to running more replications.

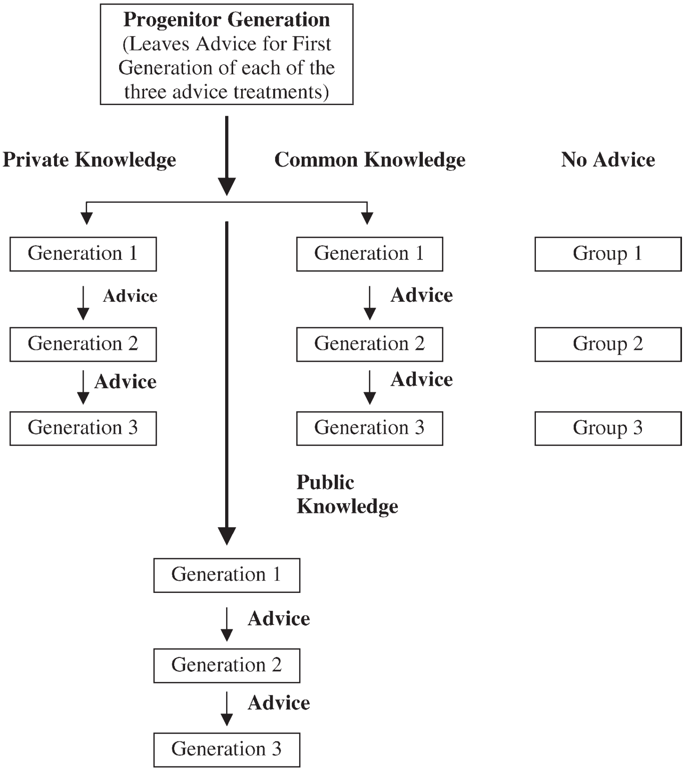

FIGURE 1

Structure of Experiment 3 (University of Auckland—March 2004)

location) across the different treatments, any difference in the advice left by later generations can be attributed to the evolution of norms within each treatment.

One clear and consistent result that we obtain is that common knowledge of advice makes a large difference in generating high contributions, while contributions in the private and public knowledge treatments are not different from those obtained in the no-advice treatment. Are the high contributions in this treatment due to the fact that the advice left by the subjects is much more exhortative, with a majority of subjects advising their successors to choose a high contribution—and often the maximal contribution of 10 tokens—to the public good? Or is it because the advice is actually read aloud? To answer this question we conduct Experiment 5 where we control for the quality of advice by presenting the same advice to a number of groups under two different conditions—public knowledge and common knowledge of advice. We have four groups of five subjects each in each of the two treatments. So the *only* difference between the two treatments was that in one case the (common) advice was read aloud by the experimenter and in the other it was not. Experiment 5, then, is not strictly inter-generational any more since each group here receives the same advice.[6] See Appendix B for the advice used in Experiment 5.

6. These sessions are run with different instructions than the ones for the inter-generational games. Subjects here are told that the advice they are getting comes from a group that played the game prior to them, which is true. The actual advice used comes from Generation 1 of the common knowledge treatment of Experiment 3 carried out at Auckland. They are also told that they are not succeeded by another generation and are paid 150% of their own earnings in lieu of a second payment. The instructions here are similar to the ones used for the no-advice groups except that these groups receive advice.

The public goods game was played in the following way. Each group, consisting of five subjects, played the game for 10 rounds. In each round, a subject had an endowment of 10 tokens. At the beginning of each round (t), each participant (i) had to make a decision on how many of the 10 tokens (in integers) he or she wanted to contribute to a public account and how many tokens he or she wanted to keep in his or her private account. Total tokens placed in the public account were added up, doubled, and then divided equally among all five participants. Total contributions to the public account, the doubled amount, and the returns to each participant from the public account were announced at the end of each round. Denoting contributions to the public account by player i in round t as C_{it}, the pay-off for each subject in any round was $\Pi_{it} = 10 - C_{it} + 0{\cdot}4\sum_{i=1}^{5} C_{it}; t = 1, \ldots, 10$. Each successive round proceeded in exactly the same manner. If agents care only about their monetary pay-offs then it follows that full free-riding is a dominant strategy while the social optimum is full contribution to the public account in the stage game. A subject's total earnings is the sum of the per-round pay-offs over 10 rounds. Tokens were converted to U.S. dollars at the rate of 1 token = US\$0·05.

At the beginning of each session subjects were presented with a set of written instructions that were read out loud to them. See Appendix A for these instructions. However, before we started round 1 in each session (with the exception of the no-advice and progenitor sessions) and before the advice was made available to the players, we asked them what they thought each member of the group (including the subject) would contribute to the public account in round 1. After they had made this prediction, we made the advice available to them, and in the case of the common knowledge treatment this advice was also read aloud. Immediately after that we again asked them for their prediction about contributions to the public account in round 1. Actual contributions to the public account in round 1 were revealed at the very end of the session without identifying individual subjects making those contributions. Subjects were paid based on the accuracy of their predictions using a quadratic scoring rule. This payment was separate from what they could earn in the public goods game and was a small fraction of what they could earn in the game itself. See the Additional Instructions in Appendix A for this scoring rule, which is adapted from Van Huyck, Battalio and Beil (1990). The two prediction rounds were followed by the 10 rounds of the public goods game. After the last round, subjects were asked to write advice to their successors and leave. The subjects were also asked to separately indicate a round 1 contribution to their successors by writing a specific number.[7] When writing advice, each subject knew whether it was to be made public to all five subjects in the next generation or to be read privately by his or her successor. In addition to what he or she earned during the session, each subject was also paid 50% of what his or her successor earned as a second payment at a later date. Each session lasted about 40 minutes (the advice sessions took a little longer than the ones without advice) and the average pay-off to the subjects was \$14·00 (or its purchasing power equivalent in Auckland and Calcutta).

3. RESULTS

3.1. *Evolution of contributions over rounds*

We start by analysing the pooled data from the inter-generational games (Experiments 1–4). We will discuss the results from Experiment 5 later (in Section 4) when we talk about the role of advice in our experiments. Figure 2 presents the evolution of average contribution (aggregated over all generations) over the 10 rounds for each of the four treatments. In every round average contribution in the common knowledge treatment exceeds that in the other three treatments. Average contributions in the common knowledge treatment start at 75% in round 1 and even in the 10th

7. In all experiments except Experiment 1 we made this suggested token contribution available to the successor along with the written advice.

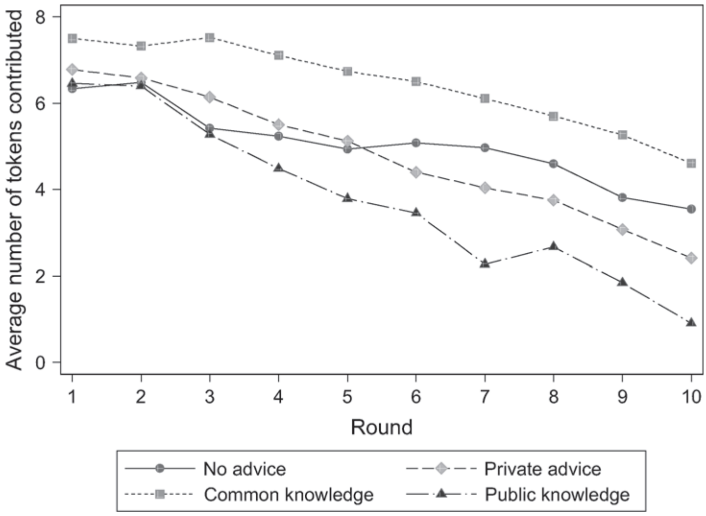

FIGURE 2

Average contribution by round and treatment

round contributions in the common knowledge treatment are still at a robust 46·1%. Contributions in the private knowledge treatment start at 67·8% in round 1 and fall to 24·1% in round 10. In the public knowledge treatment, contributions start at 64·5% in round 1 and decline to 9·1% by round 10. In the no-advice treatment, contributions start at 63·3% and drop to 35·5% by round 10. Overall, average contributions are 64·4% for the common knowledge groups, 47·8% for the private knowledge groups, 37·5% for the public knowledge groups and 50·4% for the no-advice groups. In the common knowledge treatment 45% of the subjects contribute their entire token endowment to the public good in round 1. Even in round 10, 30% of the common knowledge subjects contribute all 10 tokens to the public good. Thus, any end-game effects are small in this treatment. At the other extreme, in the public knowledge treatment, while nearly 30% of the players contribute the maximum in the first round, no one does so in the last round. In the private knowledge and no-advice sessions a little more than 5% of the subjects contribute the maximum amount in the last round. Finally, using a Kruskal–Wallis equality of populations rank test with the group means as the observations, we reject the null hypothesis that there are no treatment differences ($\chi^2(3) = 178{\cdot}09$, $p = 0{\cdot}0001$).

3.2. *A random effects Tobit model of contributions*

We want to understand the temporal pattern of contributions (C_{it}) in the different treatments and the factors that affect contributions. Each subject's contribution is bounded by 0 from below and by 10 (the token endowment) from above, and thus we estimate this model as a random effects Tobit.[8] For the sake of comparison, we also compute the random effects GLS regression, where we do not account for the upper and lower censoring of the dependent variable. Note, however, that these estimates are inconsistent.

8. We cannot compute the corresponding fixed effects Tobit model as there does not exist a sufficient statistic allowing the fixed effects to be conditioned out of the likelihood function. We do examine the robustness of the results by computing the unconditional Tobit estimates with player fixed effects. These unconditional fixed effects Tobit estimates are however biased.

TABLE 2

Regression results for contributions to the public account using data for Experiments 1 *through* 4

	RE Tobit regression for contribution	FE Tobit regression for contribution	RE regression for contribution
Private knowledge	0·0045	4·8528***	−0·1265
	(0·5330)	(1·0332)	(0·1432)
Common knowledge	1·5884***	4·2153***	0·2910*
	(0·5350)	(1·0156)	(0·1487)
Public knowledge	−0·6728	−1·7870	−0·2819
	(0·5910)	(1·2258)	(0·1900)
$1/t$	4·9684***	4·6378***	2·0067***
	(0·6591)	(0·6394)	(0·4498)
Wellesley I	0·5607	2·2490**	0·1726
	(0·5123)	(0·9771)	(0·1392)
ISI	−0·7933	−4·4546***	0·0131
	(0·5670)	(1·1269)	(0·1659)
Wellesley II	−1·1875**	−7·0133***	−0·2783*
	(0·4986)	(0·8293)	(0·1541)
Lag contribution ($C_{i,t-1}$)	0·8091***	0·8569***	0·8320***
	(0·0532)	(0·0508)	(0·0257)
Lag difference from group average ($\Lambda_{i,t-1}$)	0·6301***	0·7522***	0·3177***
	(0·0612)	(0·0637)	(0·0330)
Constant	−0·4625	0·1652	0·0715
	(0·4504)	(1·0880)	(0·1868)
Log likelihood	−4526·6953	−4252·4272	
Wald† χ^2	783·42***	2459·46***	2668·01***
σ_ε	2·8834***		2·1378
	(0·0593)		
χ^2 test for σ_u =0	218·77***		
Joint significance of player fixed effects		767·3038***	
χ^2 test for equality of treatments‡	18·21***	27·89***	13·74***
χ^2 test for equality of location effects‡	12·14***	45·22***	8·34**
Number of observations	2313	2313	2313
Number uncensored	1511	1511	
Number lower censored	400	400	
Number upper censored	402	402	
Number of players	257		257

Standard errors in parentheses.
Fixed effects Tobit: unconditional Tobit with player fixed effects.
FE: fixed effects; RE: random effects.
*Significant at 10%.
**Significant at 5%.
***Significant at 1%.
† For the fixed effects Tobit regression this is a likelihood ratio test.
‡ For the fixed effects Tobit regression this is an F-test.

Table 2 presents the regression results for contribution by player i in round t (C_{it}). The set of independent variables include the following: (1) three treatment dummies—private knowledge, public knowledge, and common knowledge, with the no-advice treatment as the reference category; (2) inverse of time ($1/t$), which allows us to both capture the non-linearity in the effect of time on contributions and also distinguish between the effects of early and later rounds on contributions; (3) a set of location dummies, Wellesley I, ISI, and Wellesley II, with Auckland as the reference category; (4) contribution made by each subject in the previous round $(C_{i,t-1})$; (5) the deviation of an individual's contribution from the group average in the previous round $(\Lambda_{i,t-1})$.

TABLE 3

Random effects regression of change in contribution, by treatment and NEGDEV

	$\Lambda_{i,t-1} \leq 0$ (NEGDEV = 1)	$\Lambda_{i,t-1} > 0$ (NEGDEV = 0)
No advice	0·5666***	−0·0014
	(0·1444)	(0·1368)
Private knowledge	0·6194***	0·1104
	(0·1189)	(0·1086)
Common knowledge	0·4956***	0·2643**
	(0·1099)	(0·1360)
Public knowledge	0·6072***	0·0380
	(0·1638)	(0·1724)

Dependent variable is ΔC_{it} ($= C_{it} - C_{i,t-1}$). Coefficient estimate of $\Lambda_{i,t-1}$. Other explanatory variables included are $1/t$ set of location dummies, $C_{i,t-1}$, and a constant term. Standard errors in parentheses.
*Significant at 10%.
**Significant at 5%.
***Significant at 1%.

$\Lambda_{i,t-1}$ is defined as $\Lambda_{i,t-1} = C_{g,t-1} - C_{i,t-1}$where $C_{g,t-1} = \frac{1}{5}\sum_{j=1}^{5} C_{j,t-1}$ is the average group contribution in the previous round. A positive $\Lambda_{i,t-1}$ implies that individual i contributed less than the group average in the previous round and a negative $\Lambda_{i,t-1}$ implies that individual i contributed more than the group average in the previous round; and (6) a constant term.

The random effects Tobit regression results are presented in column 2 of Table 2. First, relative to the no-advice sessions (the reference category) contributions are significantly higher in the common knowledge sessions. However, there are no significant differences between contributions in the other two advice treatments (private or public) relative to the no-advice treatment. We also conduct a test for the equality of the treatment dummies. The null hypothesis that the treatment dummies have similar effects on contributions is rejected using a standard χ^2 test. Second, contributions fall over time—as t increases, $1/t$ decreases and this is associated with a reduction in contributions and hence the positive coefficient of $1/t$. Third, an increase in the previous round's contribution increases the current round's contribution—the coefficient estimate of $C_{i,t-1}$ is positive and statistically significant. Finally, the coefficient estimate of $\Lambda_{i,t-1}$ is positive and statistically significant. This implies that an increase (decrease) in $\Lambda_{i,t-1}$ is associated with an increase (decrease) in contributions. When an individual's contribution in the previous round is less (more) than the group average for the previous round, he or she responds by increasing (decreasing) contributions in the next round. Moreover, the further away the individual is from the group average in round $t-1$, the greater is the increase or decrease in his or her contribution in round t. In the interest of parsimony we omit a discussion of the alternative specifications contained in columns 3 and 4 of Table 2 except to point out that they corroborate the results of the random effects Tobit model.

We now focus separately on the responses of those below and above the group average in a particular round. We define an indicator variable NEGDEV $= 1$ if $\Lambda_{i,t-1} \leq 0$ (*i.e.* the individual contributed at least the group average or more in round $t-1$), 0 otherwise. In Table 3 we present random effects GLS regression results for how contributions change between rounds $t-1$ and t for these two groups of subjects. The dependent variable is $\Delta C_{it} = C_{it} - C_{i,t-1}$.We run two separate regressions for each of our four treatments (private knowledge, public knowledge, common knowledge, and no advice), that is, eight regressions in all. For each treatment the first regression includes only those individuals who contributed at least the group average or more in round $t-1$ (for whom NEGDEV = 1) and the second regression includes those who contributed less than the group average in round $t-1$ (*i.e.* for whom NEGDEV = 0). Independent variables include the following: (1) inverse of time (1/2), (2) the location dummies, (3) contribution made by each subject in the previous round ($C_{i,t-1}$), (4) deviation from the group average in the previous period ($\Lambda_{i,t-1}$), and (5) a constant term. We present the coefficient estimates for $\Lambda_{i,t-1}$ only (the full set of results is available on request). A positive and statistically significant coefficient associated with $\Lambda_{i,t-1}$ when NEGDEV $= 1$ (*i.e.* $\Lambda_{i,t-1} \leq 0$) implies that the higher the individual's contribution above the group average in round $t-1$ the greater is the fall in contribution between rounds $t-1$ and t. On the other hand, a positive and statistically significant coefficient associated with $\Lambda_{i,t-1}$ when NEGDEV $= 0$ (*i.e.* $\Lambda_{i,t-1} > 0$) implies that the lower the individual's contribution below the group average in round $t-1$ the greater is the increase in contribution between rounds $t-1$ and t. The coefficient estimate of $\Lambda_{i,t-1}$ is always positive and significant for NEGDEV $= 1$, implying that the more an individual contributed above the group average in round $t-1$, the greater is the reduction in contribution in the next round. It is however worth noting that this tendency to converge to the group average is the weakest for the common knowledge of advice treatment. However, when NEGDEV $= 0$, the coefficient estimate of $\Lambda_{i,t-1}$ is positive and statistically significant only for the common knowledge of advice treatment—that is, the lower the individual's contribution below the group average in round $t-1$, the greater is the *increase* in contribution between rounds $t-1$ and t. For the other treatments, deviations below the group average do not have a statistically significant effect on change in contributions between the rounds. It is worth noting that this result contrasts with those obtained by Keser and van Winden (2000) who find that players respond by increasing their contributions if they are below the group average even in their no-advice sessions. Thus, we find that when subjects contribute more than the group average in one round, they tend to reduce their contribution in the next round, but this is less so in the common knowledge treatment compared to the other treatments. Only in the common knowledge treatment, however, do we observe the phenomenon of individuals increasing their contribution when they were below the group average in the previous round. The net effect is that contributions are significantly higher in the common knowledge treatment. It appears, therefore, that the common knowledge treatment leads to the creation of virtuous norms that manage to sustain high levels of cooperation.

3.3. *Evolution of contributions across generations*

We have noted in Figure 2 and Table 2 that when we aggregate contributions over generations then they do decline across the 10 rounds. This, however, does not give us the full picture. It is worth taking a look at the evolution of contributions over generations in the different treatments. The relevant histograms are presented in Figure 3. We restrict ourselves to the first three generations because we have data for at least three generations in all of our experiments. From Panel A of Figure 3 we see that there is no discernible change in the distribution of contributions for the private knowledge treatment over these three generations. Average contributions in the private knowledge treatment go from 47·6% in generation 1 to 57·5% in generation 2 to 55% in generation 3. In the public knowledge treatment (Panel B) the proportion of zero contributions increases from 28% in generation 1 to 66% in generation 3 and the average contributions are 37·6%, 31%, and 15·4% for generations 1, 2, and 3, respectively. In the common knowledge treatment (Panel C) the mass of contributions moves to the right (towards 10) over the three generations and the proportion of contributions equalling 10 increases from 18% in generation 1 to close to 50% in generations 2 and 3. Average contributions are 63%, 75%, and 70% in generations 1, 2, and 3, respectively.

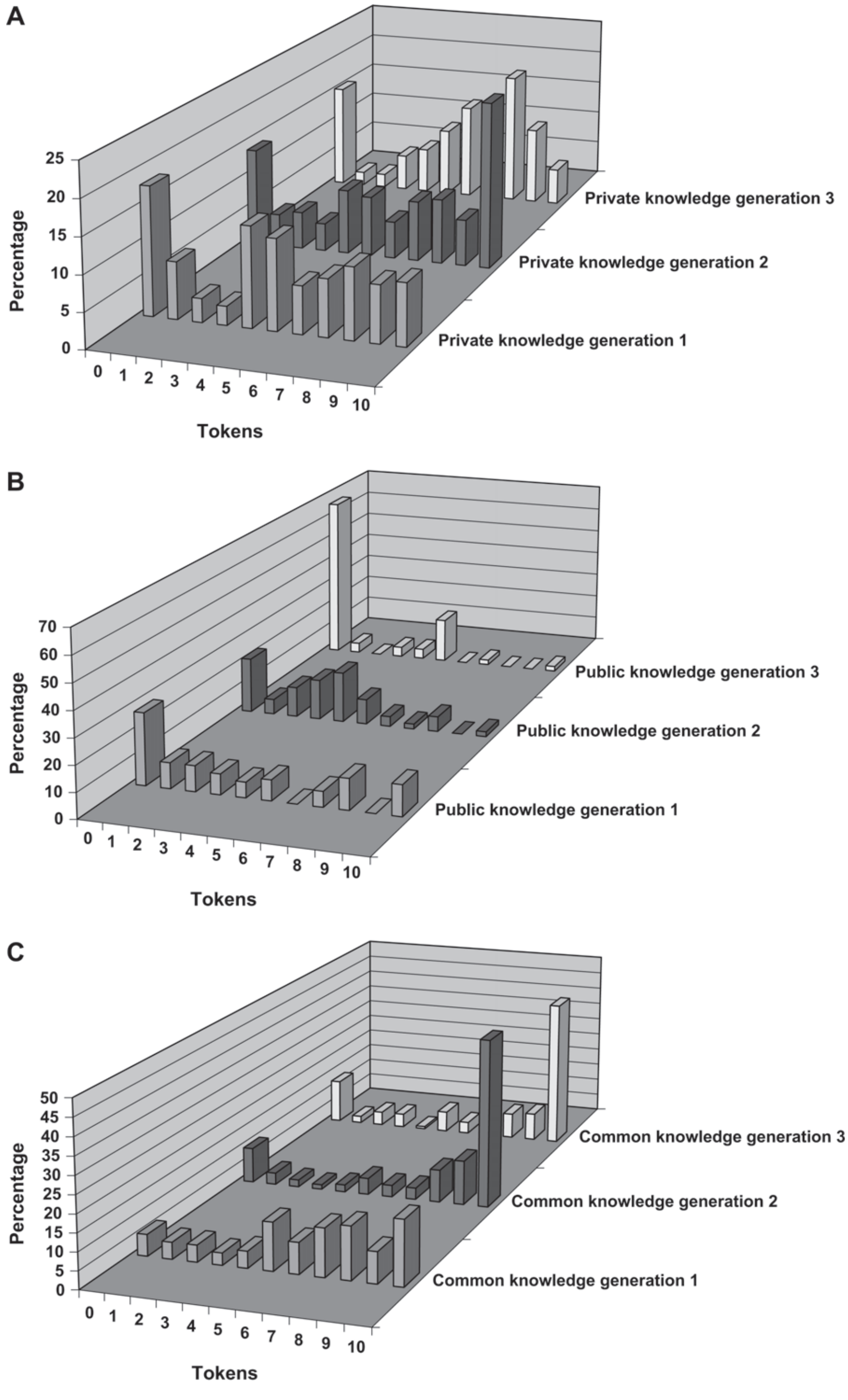

FIGURE 3

Histogram of contributions by generation in the different advice treatments. Panel A, private knowledge; Panel B, public knowledge; Panel C, common knowledge

4. ADVICE

In order to understand the impact of advice on contributions and beliefs we first need to quantify the advice left by the subjects. Most of the advice left specified some kind of a dynamic rule such as "Start off by giving 10 tokens to the public account. From here, you can see what other people are doing. By the end you should put most of your tokens in your private account". However, in the common knowledge treatment, especially in the later generations, the advice gets very strong with literally every subject exhorting his or her successors to choose "all 10 all the time!" Or they advised their successor to "Contribute 10 for the first round—establish trust right away, and keep it up. Contribute 10 every time and everyone wins. Once one person starts cheating, it all breaks down. Don't let it! Give 10 regardless". In coding this advice what helps us is the fact that we asked each subject to leave not only free-form advice but also specify (separately) a token amount that he or she recommended to his or her successor as a suggested round 1 contribution. So, in coding the advice, we simply use this suggested contribution number. Advice that suggested choosing more than one number such as "Contribute 7 or 8 tokens" was simply assigned the average of the two numbers. The complete set of advice left by subjects is available from the corresponding author. The advice left in the common knowledge treatment is far more exhortative than the public or private knowledge treatments. Close to 60% of the advice in the common knowledge treatment suggests contributing all 10 tokens. This is, in fact, the modal advice in the common knowledge treatment. Compare that to the fact that less than 20% of subjects suggest contributing 10 tokens in either the private knowledge or the public knowledge treatments. Interestingly, nearly 40% of players in the public knowledge treatment suggest contributing 0 tokens. This is also the modal advice in this treatment.

To examine the effect of advice received on contributions, we re-estimate the random effects Tobit regressions for contribution, but this time we include advice received as an additional explanatory variable. As before the dependent variable is C_{it}, the contribution by player i in round t. However, one must remember that for the common knowledge and public knowledge treatments each player received five "pieces" of advice. So for these players, what matters is the average advice they received. We therefore run separate regressions for the private knowledge treatment and the common knowledge and public knowledge treatments. The remaining explanatory variables are the same as in the regression results presented in Table 2. The regression results are presented in Table 4. Advice received (or average advice received as the case may be) is included as a continuous variable. Advice received does not have a statistically significant effect on contributions in the private knowledge treatment, but (average) advice received has a positive and statistically significant effect on contributions in the common knowledge and public knowledge treatments (see columns 2 and 3), implying that the higher the advice received the higher are the contributions in these two treatments.

We also present the Tobit regression results for contributions in the first and the last round (columns 4–7). Advice received (or average advice received) always has a positive and statistically significant effect on contributions in the first round.

As we have seen in Section 3, contributions are much higher in the common knowledge treatment compared to the other two advice treatments. Why is that the case? Is it simply because the advice is read aloud and everyone knows that everyone else is hearing the same advice? Or is it because the quality of advice evolves differently in the common knowledge treatment with the advice getting stronger over generations? We want to separate out these two effects. This is where Experiment 5 helps. In Experiment 5 we have four groups each in the public knowledge and common knowledge treatments.[9] Each of these groups receives the exact same advice except

9. We are confining our examination to these two treatments because they are the closest to one another in terms of information provided to the subjects. Moreover, we have shown that there are no significant differences between con-

TABLE 4

Effect of advice on contributions

	Random effects Tobit regression for contributions		Tobit regression for contribution in first round		Tobit regression for contribution in last round	
	Private advice	Common knowledge and public knowledge	Private advice	Common knowledge and public knowledge	Private advice	Common knowledge and public knowledge
$1/t$	4·6718***	6·1788***				
	(1·1404)	(1·1344)				
Common knowledge treatment		3·1170***		0·8136		0·3359
		(0·9579)		(1·1029)		(2·1054)
Wellesley I	−0·0720	−0·0221	−0·6743	2·5622*	−2·7869	1·0067
	(0·6506)	(1·1392)	(1·2390)	(1·5076)	(1·9507)	(2·0539)
ISI	0·2464	−3·5663***	−1·9745	−1·0649	−4·0255	1·3124
	(0·7142)	(1·2165)	(1·3510)	(1·3925)	(2·6407)	(2·1296)
Wellesley II	−0·6707	−1·4037	−1·4372	−1·0172	−5·0688**	0·8578
	(0·7313)	(0·8693)	(1·3751)	(1·1313)	(2·3285)	(1·9955)
Lag contribution	0·8224***	0·7951***			2·0132***	2·2546***
	(0·0908)	(0·0894)			(0·5387)	(0·3771)
Lag difference from group average	0·4471***	0·7623***			0·8464	1·1588***
	(0·1025)	(0·1101)			(0·5587)	(0·4114)
Advice received	−0·0243		0·3127**		−0·2434	
	(0·0872)		(0·1532)		(0·2553)	
Average advice received		0·6095***		0·9268***		−0·2318
		(0·2224)		(0·2244)		(0·4020)
Constant	−0·4526	−6·0435***	6·0809***	0·6112	−1·7646	−6·9028*
	(0·9956)	(1·5168)	(1·6513)	(2·0821)	(2·9228)	(3·9049)
τ			3·5412***	4·0658***	4·8324***	5·4815***
			(0·3585)	(0·4009)	(0·6946)	(0·6855)
Log likelihood	−1467·6807	−1882·6162	−176·5544	−217·1417	−117·3054	−171·1607
Wald† χ^2	306·99***	443·91***	10·80**	52·01***	48·32***	96·57***
σ_ε^2	2·6117***	3·0843***				
	(0·0923)	(0·0982)				
χ^2 test for $\sigma_u = 0$	35·70***	145·67***				
Number of observations	720	1053	80	117	80	117
Number uncensored	525	598	57	63	31	42
Number lower censored	132	186	5	9	43	50
Number upper censored	63	269	18	45	6	25
Number of players	80	117	80	117	80	117

Standard errors in parentheses.
*Significant at 10%.
**Significant at 5%.
***Significant at 1%.
†Likelihood ratio test for Tobit (rounds 1 and 10).

in the case of the common knowledge of advice treatment, in addition to receiving a sheet with all five pieces of advice written on it, this advice is also read aloud by the experimenter. In this case, therefore, any difference between the two treatments can be attributed solely to the reading aloud of advice since the content of the advice is the same in each case. In Figure 4 we present the corresponding average contributions by round and treatment. It is clear that the common knowledge groups do significantly better than the public knowledge groups with the

tributions in the public knowledge and those either in the private knowledge treatment or the no-advice treatment. Thus, any difference between the common knowledge and public knowledge treatments will also appear between common knowledge and the other two treatments.

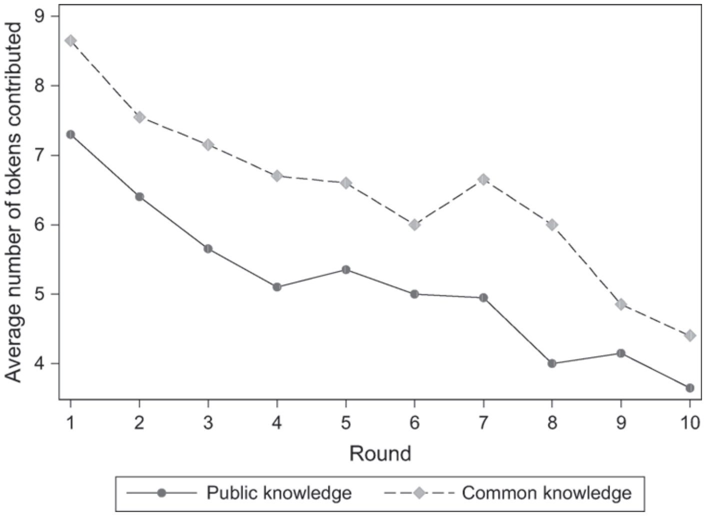

FIGURE 4

Average contributions by round for common knowledge and public knowledge treatments in Experiment 5

former achieving an average contribution of 64·5% while the latter average 51·5%. The non-parametric Wilcoxon rank-sum test rejects the null hypothesis that the two (independent) samples are drawn from populations with the same distribution ($z = 3{\cdot}18$, $p = 0{\cdot}0015$). However, it is also clear that the difference between these two groups is nowhere near as stark as the differences between the two treatments in our inter-generational experiments 1–4. So reading the advice aloud does make a difference, but it explains only a part of the difference in contribution levels over the two treatments. A larger part of the difference must be attributed to the impact of advice and the fact that advice is much stronger in the common knowledge treatment.

Advice left evolves very differently in the three treatments. Once again we restrict our attention to the first three generations of each treatment. The mean advice left is 6·8, 7·9, and 6·3 in generations 1, 2, and 3, respectively, in the private knowledge treatment, 7, 3, and 3·4 in generations 1, 2, and 3, respectively, in the public knowledge treatment, and 8·4, 8·8, and 9·3 in generations 1, 2, and 3, respectively, in the common knowledge treatment. The fact that advice evolves quite differently in the different treatments becomes even clearer in Figure 5, where we present the distribution of advice left by treatment and generation. The mass of the distribution of advice left moves to the right (towards 10) over the generations in the common knowledge sessions (Panel C) while it moves to the left (towards 0) in the public knowledge sessions (Panel B). No particular trend is apparent in the private knowledge sessions (Panel A).

First round contributions are highly correlated with advice received and the correlation is the highest for the common knowledge treatment. The correlation between advice received and first round contributions is 0·35, 0·43, and 0·65 for the private knowledge, public knowledge, and common knowledge treatments, respectively (and all of these are significantly different from 0). However, at the end of the session subjects in every treatment left advice that was significantly higher than their last round contribution. The mean last round contributions were 0·91, 2·41, and 4·61 for the public knowledge, private knowledge, and common knowledge sessions, respectively. Compare that to the mean advice left of 3·4, 6·3, and 9·3 for the three treatments. However, the correlation between the last round contribution and advice left was significantly different from 0 only for the common knowledge treatment.

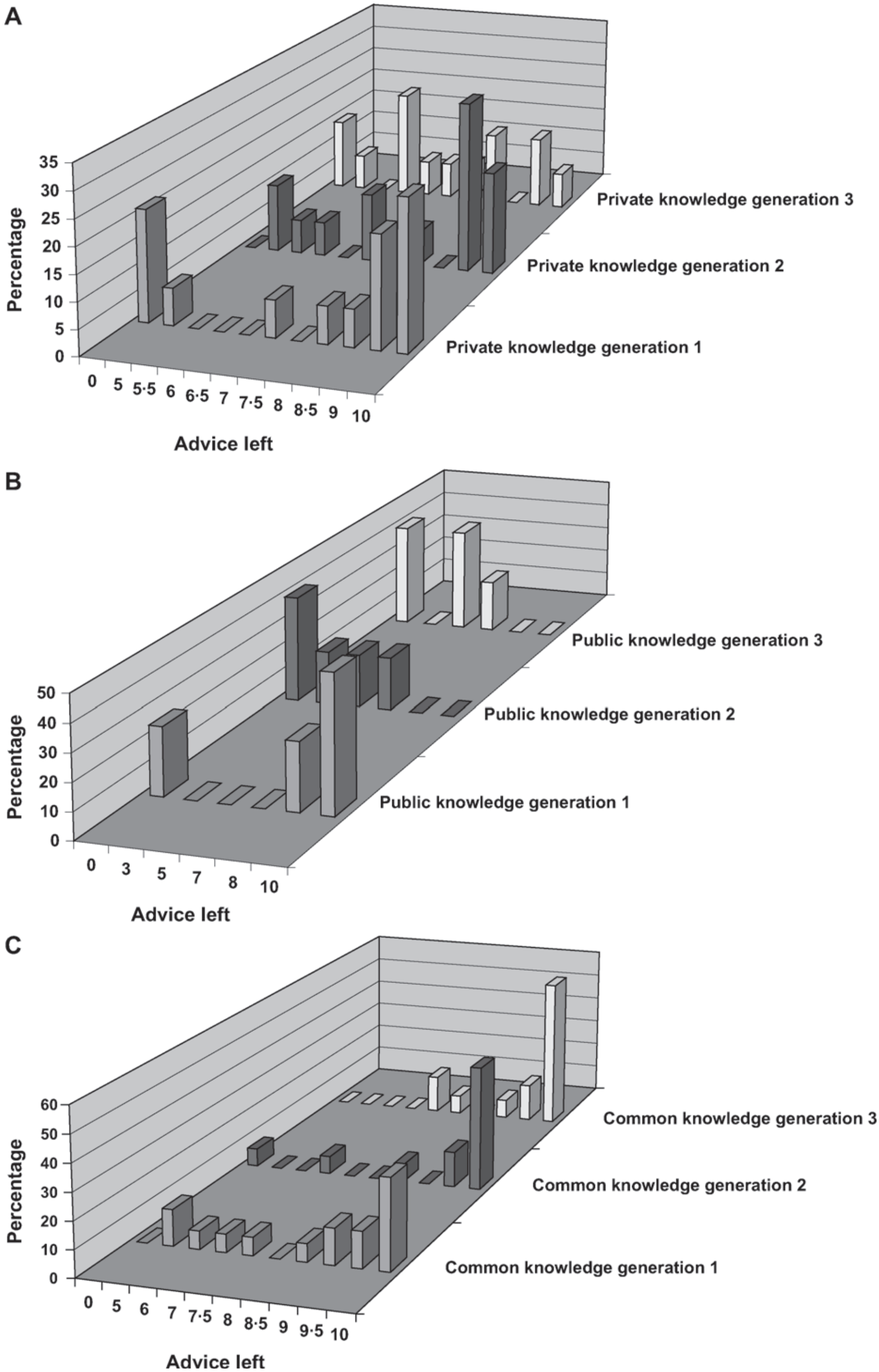

FIGURE 5

Evolution of advice over generations, by treatment. Panel A, private knowledge of advice; Panel B, public knowledge of advice; Panel C, common knowledge of advice

5. BELIEFS AND COOPERATION

One obvious way that advice influences behaviour is through its impact on the beliefs that subjects hold. As explained above, prior to starting the experiment we asked the subjects about contributions to the public good in round 1. Specifically each subject was asked to indicate how many subjects would choose to contribute 0, or 1, or 2, or ... 10 tokens to the public good in round 1. Since contributions are in integers, each subject can effectively choose one out of 11 strategies. Subjects' responses to the belief question give us insight about the frequency with which they think each strategy would be chosen within the group. Each subject makes this prediction for everyone in the group including him or her. Why should subjects' beliefs matter? First, we find significant positive correlation between average post-advice beliefs and contributions in round 1 with the correlation being the strongest in the common knowledge treatment (0·72) compared to both the public knowledge treatment (0·55) and the private knowledge treatment (0·54). Given that contributions typically decline over rounds within a session, it is essential for contributions to start at a high level for a group to be able to sustain high contributions over time. More optimistic beliefs about others' contributions make it more likely for contributions to start at a higher level. Second, it has now been documented that a large majority of subjects in experimental public goods games are *conditional cooperators* (Keser and van Winden, 2000; Fischbacher, Gächter and Fehr, 2001; Croson, 2002; Kocher, 2004; Burlando and Guala, 2005; Houser and Kurzban, 2005). Conditional cooperators are subjects whose contributions are positively correlated with the expected contribution of others. Given the existence of conditional cooperators, there are two possible arguments, one of which argues in favour and the other against common knowledge enhancing efficiency. In the presence of conditional cooperators and common knowledge, non-cooperators have more of an incentive to imitate the cooperators initially and free-ride later in the game. This might induce more free-riding in the common knowledge treatment. On the other hand, in the presence of conditional cooperators and given the large impact of advice on contributions, it is possible that the game that is effectively played has multiple equilibria where full defection is one equilibrium and full cooperation another with other equilibria in between.

We have collected data on the beliefs of the subjects about round 1 contribution to the public good. This allows us to classify subjects into relevant categories depending on their beliefs about contributions to the public good in round 1 and their actual contributions to the public good in round 1.[10] We define a subject as a *conditional cooperator* if for that subject contribution to the public account in round 1 $\in$ (stated beliefs about average group contributions in round 1 ± 1 token). Burlando and Guala (2005) classify subjects as conditional cooperators using the same metric. Any subject who contributes more than the expected average contribution plus one token is a *cooperator*, and anyone who contributes less than the expected average minus one token is a *non-cooperator*. Using this metric we find that 53·3% of our subjects are conditional cooperators, 32% are cooperators, and 14·7% are non-cooperators.

We explore the behaviour of the different types in Table 5. In specification 1 we regress contributions against the same set of dependent variables as in Table 2, except that here we only consider data from the three advice treatments and exclude the data from the no-advice sessions. In specification 2, we include two dummies for cooperator and conditional cooperator (with the non-cooperators being the reference category). In specification 3 we interact the dummies for cooperation status (cooperator or conditional cooperator) with the treatment dummies (common knowledge or public knowledge with the private knowledge treatment as the reference category).

10. We did not use a pay-off relevant scoring rule to elicit beliefs in Experiment 1, but did so in the other experiments. In Experiment 1 we simply asked the subjects about what they expected first round contributions to be, but the accuracy or lack thereof of their predictions did not impact their pay-offs. However, in this part of our analysis we have used data from all the experiments including Experiment 1. This is because this allows us to include more subjects in the analysis and also because the story remains unchanged if we exclude the subjects from Experiment 1.

TABLE 5

Random effects Tobit regression for contributions by cooperation status

	Specification 1	Specification 2	Specification 3
Common knowledge	1·5761***	1·6511***	
	(0·4777)	(0·4702)	
Public knowledge	−0·5925	−0·9047	
	(0·6749)	(0·7137)	
$1/t$	5·0026***	8·5844***	8·7383***
	(0·7924)	(1·4359)	(1·4034)
Wellesley I	0·7173	−0·2532	0·2486
	(0·6277)	(0·7331)	(0·7221)
ISI	−0·7650	−0·9327	−0·6845
	(0·5996)	(0·7433)	(0·5876)
Wellesley II	−1·0272	−1·5562**	−1·0761*
	(0·6566)	(0·7019)	(0·5850)
Lag contribution	0·8606***	0·7911***	0·7817***
	(0·0629)	(0·0710)	(0·0672)
Lag difference from group average	0·6969***	0·6775***	0·6848***
	(0·0726)	(0·0784)	(0·0765)
Cooperator		2·8608***	1·8879***
		(0·7577)	(0·6989)
Conditional cooperator		2·4296***	1·3687**
		(0·7205)	(0·6017)
Cooperator × common knowledge			2·1625***
			(0·7091)
Cooperator × public knowledge			−0·0868
			(1·0167)
Conditional cooperator × common knowledge			2·6401***
			(0·6488)
Conditional cooperator × public knowledge			−0·1977
			(0·9887)
Constant	−0·8454	−2·7782***	−2·5291***
	(0·5796)	(0·8910)	(0·5812)
Observations	1773	1576	1576
Number of players	197	197	197

Standard errors in parentheses.
*Significant at 10%.
**Significant at 5%.
***Significant at 1%.

The coefficients of the non-interacted cooperation status dummies show the contribution of these dummies, while the coefficients of the interaction terms show us the additional contribution of the treatment dummy (relative to the private advice treatment). It should be noted that in specifications 2 and 3 we restrict the sample to periods 2–10 as period 1 data are used to determine the types (cooperation status). It is clear from specification 2 of Table 5 that in general both the cooperators and the conditional cooperators as a group contribute more than the non-cooperators, and the difference is significant at 1%. Specification 3 implies that the contribution of both these groups (cooperators and non-cooperators) is significantly higher in the common knowledge treatment than their contribution in the private knowledge treatment. The coefficients of both the interaction terms involving the cooperation status dummy and the common knowledge treatment dummy are positive and significant at the 1% level. However, the coefficients for the two interaction terms for the public knowledge treatment are not significantly different from 0 implying that the contributions made by the cooperators and the conditional cooperators in this treatment are not significantly different from those made by them in the private knowledge treatment. We find that in the presence of conditional cooperators, common knowledge does enhance efficiency mostly because the advice left in this treatment is more exhortative.

6. DISCUSSION OF OUR RESULTS AND SOME CONCLUDING REMARKS

Our results then imply that the process of social learning created by allowing subjects to leave "common knowledge" advice in an inter-generational framework can lead to high contributions to the public good. Common knowledge leads to strongly exhortative advice that enables subjects to start out with high levels of contribution and sustain that cooperation over time.

Why does common knowledge make such a difference? Rabin (1993) has pointed out that, if one assumes the existence of reciprocal preferences then it is possible to think about the public goods game as a coordination problem with high contributions as efficient and low contributions as inefficient equilibria. The central problem in the public goods game then becomes one of equilibrium selection. Common knowledge of advice results in successful coordination at high levels of contribution. Chwe (2001) emphasizes the role of common knowledge in fostering coordination and suggests that "in order to understand how people solve coordination problems, we need to look at social processes that generate common knowledge". Chaudhuri, Schotter and Sopher (2004), in their study of an inter-generational version of the Van Huyck *et al.* (1990) minimum effort game (a coordination game with multiple Pareto-ranked equilbria), find that when advice from a previous generation is "common knowledge", subjects manage to attain the Pareto-efficient (pay-off dominant) outcome. Brosig, Ockenfels and Weimann (2003) also demonstrate how communication can sustain cooperation by providing an opportunity for coordinating behaviour. Orbell, Dawes and van de Kragt (1990) study a public goods game where subjects can make non-binding promises about what they will contribute. They find that such non-binding promises lead to significantly higher contributions *only when all the members of the group promised to contribute* (our italics): a situation analogous to our common knowledge treatment where everyone has heard everyone else hearing exhortative advice encouraging high contributions.

Our results also have implications for research on altruistic punishment in humans. Fehr and Gächter (2000, 2002), Gächter, Hermann and Thöni (2003), and Masclet, Noussair, Tucker and Villeval (2003) show that conditional cooperators are willing to punish non-cooperators even if such punishment has pecuniary costs. Punishment of non-cooperators enables subjects to sustain high levels of cooperation over time. Our results suggest that in the presence of a majority of conditional cooperators, communities may be able to create inherent social norms that lead to high levels of contribution even in the absence of punishment mechanisms. See Gächter and Thöni (2005) and Page, Putterman and Unel (2005) for studies that also document high cooperation even in the absence of punishment opportunities.

One other issue needs to be pointed out here. Punishments can certainly sustain high contributions but, as Casari and Luini (2004) point out, a higher contribution rate with heavy punishment can sometimes yield lower earnings than a lower contribution rate without punishment. In the Masclet *et al.* (2003) paper average earnings in the monetary punishment condition amount to 57·5% of the maximum possible while in Noussair and Tucker (2005) average earnings are of the order of 63·4% when only monetary punishments are available, and 68% when subjects have recourse to both monetary and non-monetary punishments. Average earnings in our common knowledge treatment are 82% of the social optimum.[11]

11. In our common knowledge treatment we get average contributions of roughly 64%, that is, people contribute 6·4 out of their 10 token endowment keeping 3·6 tokens in the private account. If all five players contribute 6·4 tokens each then we get a total of 32 tokens in the public account which gets doubled to 64 and distributed equally giving each subject a return of 12·8 tokens from the public account and therefore a net earning of 16·4 tokens. Given that the social optimum would be an earning of 20 tokens each per round, this implies that in our common knowledge treatment earnings amount to 82% of the social optimum.

Our results then have interpretable implications for other areas of research—such as charitable giving and environmental protection—that focus on the resolution of social dilemmas and the creation of cooperative norms.

APPENDIX A

Instructions

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

You are in a market with 4 other people. The experiment will consist of 10 decision rounds. At the beginning of each round each participant will have an endowment of 10 tokens. In each round, each participant will choose—in whole numbers—how many tokens (ranging from 0 to 10) to allocate to a private account and how many tokens (ranging from 0 to 10) to allocate to a public account. For each round, these two numbers should add to 10, the total number of tokens you have for that round. At the beginning of each round you will write the number of tokens you wish to contribute to the public account on the Decision Form (page 7) and hand it to the experimenter. The experimenter will then add up the total contributions to the public account and announce it publicly. The total number of tokens invested in the public account will be **doubled** and divided equally among all 5 participants. Your personal earnings for this round will equal the number of tokens you invested in your private account plus the number of tokens you get back from the public account (the latter may be a fractional amount). You will keep track of your contributions to each account and your earnings on the Record Sheet (page 5). Please take a look at the Record Sheet now to see how you will keep your track of your contributions and your earnings. The experimenter will explain.

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

In private knowledge of advice treatment use the following paragraph next:

Unless you are in the first group to participate in this experiment, when you start the experiment you will receive written advice on how to make your decisions from a single subject who participated in the experiment immediately prior to you. At the end of your 10 decision rounds you will leave advice to a new subject on how to make decisions. On top of what you make in this session of the experiment, you will receive an additional payment equal to 50% of the earnings of the subject to whom you give advice. Please write your advice on the sheet provided (page 6), and write or print legibly. In writing advice we encourage you to specify a contribution amount or range to the next player. You will be notified by email or telephone when your second payment is ready.

For the public knowledge of advice treatment replace the previous paragraph in italics with the following paragraph:

Unless you are in the first group to participate in this experiment, when you start the experiment you will receive written advice on how to make your decisions from a group of subjects who participated in the experiment prior to you. Each of you will get to see the advice left by all the players in this group prior to you. So each of you is looking at the exact same set of advice as everybody else. ***[In the common knowledge of advice treatment add the next sentence here: Besides providing you with this advice the experimenter will also read the advice out loud prior to starting the experiment.]*** *At the end of your 10 decision rounds you will be asked to leave advice to the next group of players in the experiment. Each of you is paired with another player, who you do not know and who will participate in the experiment immediately after you. On top of what you make in this session of the experiment, you will receive an additional payment equal to 50% of the earnings of this subject. Please write your advice on the sheet provided (page 6), and write or print legibly. In writing advice we encourage you to specify a contribution amount or range to the next player. You will be notified by email or telephone when your second payment is ready.*

If you have any questions, please ask them now.

Subject ID ____________________

Additional Instructions

Before the beginning of the actual experiment, i.e. before Round 1, you will be asked to predict how many tokens every participant will choose to contribute to the public account in Round 1. When you are asked to do so, please write down your prediction of how many people will contribute 0, or 1, or 2, or 3, or 4, or 5, or 6, or 7, or 8, or 9 or 10 tokens in the space provided on page 3. Please take a look now. When you add your predictions of the number of people that will contribute 0, or 1, or 2, or 3, or 4, or 5, or 6, or 7, or 8, or 9 or 10 tokens they should add to 5. You are predicting for everyone in the group including you.

You will be paid for each of your correct predictions as follows. Your earnings will equal 50 cents less the sum of squared differences between your predictions and the actual choices.

EXAMPLES: Suppose that 5 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	5	0	25
Red	0	5	25
		Total	50
			$50-50=0$

	Predict	Actual	Sq. Diff
Blue	5	5	0
Red	0	0	0
		Total	0
			$50-0=50$

	Predict	Actual	Sq. Diff
Blue	3	3	0
Red	2	2	0
		Total	0
			$50-0=\underline{50}$

	Predict	Actual	Sq. Diff
Blue	4	1	9
Red	1	4	9
		Total	18
			$50-18=\underline{32}$

You will make this prediction once before you get to read the advice and once after you get to read the advice.

You will be told the actual choices made for round 1 at the end of the experiment.

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

Subject ID_____

Prediction BEFORE Reading Advice

Tokens	**Predict**	**Actual**	**Sq. Diff**
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
TOTAL			

Earnings = 50 - ____ =

When you are done, tear off this sheet and hand it to the experimenter.

Subject ID_____

Prediction AFTER Reading Advice

Tokens	Predict	Actual	Sq. Diff
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
TOTAL			

Earnings = 50 - ____ =

When you are done, tear off this sheet and hand it to the experimenter.

Record Sheet

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

TOTAL EARNINGS:
Earnings from the game: ________________
Earnings from first prediction: ________________
Earnings from second prediction: ________________
TOTAL: ________________

Subject ID_________

ADVICE:

Please write your advice to the next player here. Continue on reverse if necessary.
Please recommend a specific contribution amount (or a range) for round 1:___

Decision Form

Round	Tokens in Public Account
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

APPENDIX B. ADVICE USED FOR THE COMMON KNOWLEDGE AND ALMOST COMMON KNOWLEDGE TREATMENTS IN EXPERIMENT 5 AT AUCKLAND—APRIL–MAY 2004

It would be good to give generously in the first two or three rounds as others do as well and so the returns are high. As you go on, maybe keeping at least 5 tokens in the private account is also good as it is yours to keep anyway.

Suggested first round contribution: 7

Please contribute more but not too much at private account.

Suggested first round contribution: 5

Do not listen to anyone else's advice! Here is the maths. Public 10 × 5 players = 50 (which gets doubled) = 100/5 = 20 each. Private 10 = 10 ea. You must trust each other. Always give 10. If you get greedy and only start paying in a little to the public then the group (you are in the group!) loses. For everyone to win (and get the highest possible amount) give 10 always to the public account. Trust me, trust the other players. Always give 10! Be smart — group max = your pay max. Nobody likes a greedy person either! If everyone listens to me then you should predict everyone to choose 10! Good luck.

Suggested first round contribution: 10

By having more invested return will be more unless your group is very conservative. Take the first few rounds to see whether your group is aggressive. If your group is, then throw all you have at it. If not then invest 1 or 2.

Suggested first round contribution: 10

The contribution amounts of the others in the group is unexpected, so just contribute average money in different rounds.

Suggested first round contribution: 6

Acknowledgements. We are grateful to the University of Auckland Research Council, the University of Auckland Business School, and Wellesley College for providing the funds to conduct the experiments for this study. We thank Andrew Schotter and Barry Sopher for getting us started on this line of research. We are deeply indebted to two anonymous referees and the Managing Editor of this journal (Bernard Salanié) for extensive and thoughtful comments on earlier versions of the paper. The paper is vastly improved as a result of their feedback. We thank Steve Tucker for providing us with the data from two of his papers. We also thank Catherine Eckel, Al Roth, Brit Grosskopf, Rachel Croson, Phil Levine, Brock Blomberg, Lata Gangadharan, Michael McBride, Tim Hazledine, Les Oxley, and seminar participants at New York University, Wellesley College, University of Auckland, University of Otago, University of Canterbury, Indian Statistical Institute (Calcutta), Monash University, Deakin University, Australian National University, and RMIT University and at a large number of conferences for feedback. We are grateful to Debasis Mondal at ISI-Calcutta and Cliff Kurniawan at Auckland for excellent research assistance. We are indebted to Amita Majumdar, Tarun Kabiraj, Saurabh Ghosh, and B. V. Rao at ISI-Calcutta and Susan Skeath, Akila Weerapana, and Nancy Marshall at Wellesley for their help in facilitating experimental sessions.

REFERENCES

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

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

BOYD, R. and RICHERSON, P. J. (1985) *Culture and the Evolutionary Process* (Chicago: Chicago University Press).

BROSIG, J., OCKENFELS, A. and WEIMANN, J. (2003), "The Effect of Communication Media on Cooperation", *German Economic Review*, **4** (2), 217–241.

BURLANDO, R. and GUALA, F. (2005), "Heterogeneous Agents in Public Goods Experiments", *Experimental Economics*, **8** (1), 35–54.

CASARI, M. and LUINI, L. (2004), "Team Production and Peer Punishment" (Paper Presented at the Annual Meetings of the Economic Science Association, University of Amsterdam, Amsterdam).

CAVALLI-SFORZA, L. L. and FELDMAN, M. W. (1981) *Cultural Transmission and Evolution: A Quantitative Approach* (Princeton, NJ: Princeton University Press).

CHAUDHURI, A., SCHOTTER, A. and SOPHER, B. (2004), "Talking Ourselves to Efficiency: Coordination Conventions in an Inter-Generational Minimum Game with Private, Almost Common and Common Knowledge of Advice" (Working Paper, C. V. Starr Center for Applied Economics, New York University).

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

COOPER, R., DEJONG, D., FORSYTHE, R. and ROSS, T. W. (1989), "Communication in the Battle of the Sexes Game: Some Experimental Results", *Rand Journal of Economics*, **20**, 568–587.

COOPER, R., DEJONG, D., FORSYTHE, R. and ROSS, T. W. (1992), "Communication in Coordination Games", *Quarterly Journal of Economics*, **107**, 739–771.

CROSON, R. (2002), "Theories of Commitment, Altruism and Reciprocity: Evidence from Linear Public Goods Games" (Working Paper, Wharton School of Management, University of Pennsylvania).

DAWES, R., MCTAVISH, J. and SHAKLEE, H. (1977), "Behavior, Communication, and Assumptions About Other People's Behavior in a Commons Dilemma Situation", *Journal of Personality and Social Psychology*, **35**, 1–11.

FEHR, E. and GÄCHTER, S. (2000), "Cooperation and Punishment in Public Goods Experiments", *American Economic Review*, **90** (4), 980–994.

FEHR, E. and GÄCHTER, S. (2002), "Altruistic Punishment in Humans", *Nature*, **415**, 137–140.

FISCHBACHER, U., GÄCHTER, S. and FEHR, E. (2001), "Are People Conditionally Cooperative? Evidence from a Public Goods Experiment", *Economics Letters*, **71** (3), 397–404.

GÄCHTER, S., HERMANN, B. and THÖNI, C. (2003), "Understanding Determinants of Social Capital: Trust, Cooperation, and Informal Sanctions in a Cross-Societal Perspective" (Working Paper, Universität St. Gallen and CESifo).

GÄCHTER, S. and THÖNI, C. (2005), "Social Learning and Voluntary Cooperation Among Like-Minded People", *Journal of the European Economic Association*, **3** (2–3), 303–314.

HOUSER, D. and KURZBAN, R. (2005), "An Experimental Investigation of Cooperative Types in Human Groups: A Complement to Evolutionary Theory and Simulations", *Proceedings of the National Academy of Sciences*, **102** (5), 1803–1807.

ISAAC, M. and WALKER, J. (1988), "Communication and Free-Riding Behavior: The Voluntary Contribution Mechanism", *Economic Inquiry*, **26** (4), 585–608.

JACKSON, M. O. and KALAI, E. (1997), "Social Learning in Recurring Games", *Games and Economic Behavior*, **21**, 102–134.

KESER, C. and VAN WINDEN, F. (2000), "Conditional Cooperation and Voluntary Contributions to Public Goods", *Scandinavian Journal of Economics*, **102** (1), 23–39.

KOCHER, M. (2004), "Conditional Cooperation in the Public Goods Experiments and its Behavioral Foundations" (Paper Presented at the Annual Meetings of the Economic Science Association, University of Amsterdam, Amsterdam).

LEDYARD, O. (1995), "Public Goods: Some Experimental Results", in J. Kagel and A. Roth (eds.) *Handbook of Experimental Economics*, Ch. 2 (Princeton, NJ: Princeton University Press) 111–194.

MASCLET, D., NOUSSAIR, C., TUCKER, S. and VILLEVAL, M. (2003), "Monetary and Nonmonetary Punishment in the Voluntary Contributions Mechanism", *American Economic Review*, **93** (1), 366–380.

MILLER, J. H. and ANDREONI, J. (1991), "Can Evolutionary Dynamics Explain Free Riding in Experiments?", *Economics Letters*, **36** (1), 9–15.

NOUSSAIR, C. and TUCKER, S. (2005), "Combining Monetary and Social Sanctions to Promote Cooperation", *Economic Inquiry*, **43** (3), 649–660.

ORBELL, J., DAWES, R. and VAN DE KRAGT, A. (1990), "The Limits of Multilateral Promising", *Ethics*, **100**, 616–627.

PAGE, T., PUTTERMAN, L. and UNEL, B. (2005), "Voluntary Association in Public Goods Experiments: Reciprocity, Mimicry, and Efficiency", *Economic Journal* **115**, 1032–1053.

RABIN, M. (1993), "Incorporating Fairness into Game Theory and Economics", *American Economic Review*, **83** (5), 1281–1302.

SCHOTTER, A. and SOPHER, B. (2001*a*), "Advice and Behavior in an Inter-generational Trust Game" (Mimeo, Center for Experimental Social Science, New York University, New York, September 2001) (forthcoming in *Experimental Economics*).

SCHOTTER, A. and SOPHER, B. (2001*b*), "Advice and Behavior in Intergenerational Ultimatum Games: An Experimental Approach" (Mimeo, Center for Experimental Social Science, New York University, New York, September 2001) (forthcoming in *Games and Economic Behavior*).

SCHOTTER, A. and SOPHER, B. (2003), "Social Learning and Coordination Conventions in Intergenerational Games: An Experimental Study", *Journal of Political Economy*, **111** (3), 498–529.

VAN HUYCK, J., BATTALIO, R. and BEIL, R. (1990), "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure", *American Economic Review*, **80**, 234–248.

YOUNG, P. (1993), "The Evolution of Conventions", *Econometrica*, **61** (1), 57–84.