THEORIES OF COMMITMENT, ALTRUISM AND RECIPROCITY: EVIDENCE FROM LINEAR PUBLIC GOODS GAMES

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Theories of commitment, altruism, and reciprocity have been invoked to explain and describe behavior in public goods and social dilemma situations. Commitment has been used to explain behaviors like water conservation and voting. Altruism has been applied to explain contributions to charities and intergenerational transfers and bequests. Reciprocity has been invoked to explain gift exchange and labor market decisions. This paper describes a set of experiments, which distinguish between these competing theories by testing their comparative statics predictions in a linear public goods setting. Results provide strong support for reciprocity theories over either theories of commitment or of altruism. (*JEL* C9, D64, H41, C72)

I. INTRODUCTION

Individuals in the United States made over $185 billion in philanthropic contributions in 2004, given in *Giving USA* (1996).[1] This behavior is inconsistent with traditional utility theory in which individuals care only for their own consumption. A number of alternative theories have been invoked to explain such philanthropic behavior in this and in other settings. This paper describes a set of experiments, which distinguish between three competing theories: commitment, altruism, and reciprocity, by testing their comparative statics predictions in a linear public goods setting.

In commitment theories, individuals choose the actions they would most prefer everyone would choose (Laffont 1975, and Harsanyi 1980). Thus, they choose the action that maximizes their private payoff, assuming that everyone else chooses the same action they do. Commitment theories are consistent with observed philanthropic behavior, voluntary cooperation in social dilemmas like water conservation (Laffont 1975), tax evasion (Baldry 1987), and voting, (Struthers and Young 1989), as well as voluntary contributions to public goods.

In altruism theories, the consumption of others appears positively as an argument in an individual's utility function (Becker 1974, Andreoni 1989, 1990). Models of altruism are also consistent with observed philanthropic behavior and have been used to explain intergenerational bequests, social security and other welfare systems (Coate 1995), and helping behavior in the workplace (Rotemberg 1994), as well as voluntary contributions to public goods.

In contrast, Sugden (1984) proposes a theory in which the principle of reciprocity acts as a constraint on traditional individual utility maximization. The principle says (roughly) that an individual may not free, cheap, or easy ride when others are contributing. Models of reciprocity are also consistent with observed philanthropic behavior (when others are contributing) and have been used to explain individual behavior in tax evasion (Bordignon 1993), helping in the workplace (Frey 1993)

ABBREVIATIONS

OLS: Ordinary least squares

MPCR: Marginal Per Capita Return

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1. The actual amount contributed by individuals in 1995 was $116,230,000,000. This number excludes charitable giving by corporations, foundations and bequests.

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and labor markets (Akerlof 1982), as well as voluntary contributions to public goods.

This paper presents four separate experiments designed to distinguish between these theories by comparing their comparative statics predictions. The results of the first experiment (presented in Section IV) demonstrate a significant and positive relationship between an individual's own contribution and his beliefs of the contributions of others in his group, consistent with theories of reciprocity and inconsistent with traditional self-interested theories or theories of commitment or altruism. The second and third experiments (presented in Section V) test the robustness of the first experiment by comparing an individual's own contributions and the actual contributions of others in his group in different settings. Similar results are generated. The final experiment (presented in Section VI) further investigates the specific *type* of reciprocity our subjects demonstrate. We find evidence for *median* reciprocity, where players try to match the median contribution of the rest of his group, rather than the minimum or maximum.

This paper is organized as follows. Section II briefly describes the public goods production function and the voluntary contribution mechanism used in this experiment. Section III outlines the three classes of theories and their implications. In Section IV we present the experiment and results designed to distinguish between the competing theories. Section V describes two additional experiments designed to test for the robustness of our results. Section VI describes another experiment, which investigates individual behavior in more detail. Finally, Section VII concludes.

II. PURE PUBLIC GOODS AND THE VOLUNTARY CONTRIBUTION MECHANISM

Pure public goods are goods that are both *nonrival* and *nonexcludable.*[2] The experiments described in this paper use a linear and pure public good to distinguish between our competing hypotheses. The mechanism used to fund the public good is the voluntary contribution mechanism, which most closely parallels philanthropic giving or contributing behavior. This mechanism has been examined extensively in previous literature; see Davis and Holt (1994), chapter 6 and Ledyard (1995) for complete reviews.

A. The Mechanism

The mechanism is structured as follows. Assume each player i in a group of N identical players has some endowment E_i, which can either be contributed to a group account and used to produce units of a public good or can be privately consumed. Call the amount contributed to the group account by i, x_i. The individual's earnings from private consumption is simply the amount consumed ($E_i - x_i$). The individual's earnings from contributions to the group account is a multiple of the sum of contributions by all participants in the group $P(\sum_{i \in N} x_i)$.[3]

There is a pure public goods problem whenever $1/N < P < 1$. When $P < 1$, contributing to the public good is never optimal for the self-interested individual. Contributing one unit to the public good earns him only P, and costs him 1. When $1/N < P$, contributing to the public good is always optimal for the group as a whole. Contributing one unit to the public good costs an individual 1, but earns NP for the group.

This mechanism of contributions to the public good in this game is purely voluntary, similar to the institution of charitable contributions.

B. Related Experiments

Marwell and Ames (1979) were the first to test public goods provision behavior in a linear and pure public good using the voluntary contribution mechanism. They found that when subjects play a one-shot, context-free public goods game they contributed around half their endowment to the public good and consumed the rest.

Later research suggests that when subjects play the same public goods game finitely repeated (with a subgame-perfect equilibrium of full free-riding), contributions in the first period are similar to those observed in Marwell and Ames, but decrease over time toward the free-riding solution (Davis and Holt 1994, Ledyard 1995). Although contributions reach their lowest point in the last period of the

2. That is, multiple agents can consume the good at the same time (nonrival) and it is not possible to exclude agents who did not pay for the good from consuming it (nonexcludable).

3. The multiple P is often called the marginal per capita return (MPCR) and is the marginal return to each individual on a contribution of one unit to the group account (Isaac and Walker 1988).

game, they do not quite reach the equilibrium outcome of full free-riding.

In the first of our experiments, we elicit subjects' beliefs about the contributions of their group and compare those beliefs with their contributing behavior. Some previous experiments have attempted to investigate the relationship between an individual's belief and their actions in public goods settings. However, most have deceived subjects about the true contributions of the other players (Weimann 1994). There is also a large literature in psychology on belief elicitation and manipulation in prisoners' dilemma games.

In contrast to most of this previous literature, in the experiment presented in this paper, no deception is used. Instead, players' beliefs of other players' behavior are elicited and compared with the players' own contributions.[4]

III. THREE THEORIES AND HYPOTHESES

In this section we present three types of theories, which have been used to explain economic behavior in various settings (including the voluntary provision of public goods) and between which we would like to discriminate: commitment, altruism, and reciprocity. In particular, we describe the development of each, point to settings in which it has been used, and describe the comparative statics hypotheses, which we will test.

In addition to these theories, however, we would like to retain the traditional hypothesis of pure self-interest as a benchmark. This hypothesis posits a utility function in which players are concerned only about their own earnings. In the notation above we have

$$U_i = (E_i - x_i) + P\sum_i x_i.$$

Whenever $1/N < P < 1$, then the optimal contribution $x_i^* = 0$, and thus $\delta x_i^*/\delta x_j = 0 \ \forall j \neq i \in N$.

When individuals care only about their own payoffs, a pure public goods problem like the one our subjects face generates a unique equilibrium in which all players fully free-ride (contribute zero). In this free-riding equilibrium, an individual's contribution is independent of what others in the group contribute. Thus, our benchmark *free-riding hypothesis* is that (1) subjects will always contribute zero to the public good; and (2) (the comparative static prediction) there will be no correlation between what an individual contributes and what others in his group contribute.

A. Commitment Theories

Theories of this kind typically rely on Kantian reasoning on the part of individuals. These theories then go on to generate behavior, which involves (1) positive levels of contributions to public goods, but also (2) contributions that do not change as the contributions of others changes. Collard (1978) calls these "Kantian" theories and Sugden (1984) refers to the principle underlying this behavior as the "principle of unconditional commitment."

Laffont (1975) analyzes the case where individuals believe that others will act as they do, then maximize their utility given that belief. Under these beliefs, he shows that individuals voluntarily contribute nonzero amounts toward public goods and social welfare increases.[5] Similarly, Harsanyi (1980) describes the principle of "rational commitment" in which an individual takes the action "which will maximize social utility if it is followed by everybody in this kind of situation." (116). For our purposes, this implies that individuals simply contribute the level she would most prefer that every member of the group would contribute (independent of her beliefs). If everyone behaves according to this principle, the argument goes, public goods are funded and social welfare increases.

Commitment theories have been used to describe behavior in water conservation (Laffont 1975), lack of littering (Laffont 1975), tax evasion (Baldry 1987), voting (Struthers and Young 1989), and other voluntary public goods provision (Bordignon 1990).

Commitment theories imply that an individual maximizes the utility function

$$U_i = (E_i - x_i) + P\sum_i x_i,$$

subject to his belief that $x_i = x_j \ \forall j \neq i \in N$.

4. A similar technique of belief elicitation has been used in public goods games in a slightly different context. In these studies, voluntary contribution mechanisms are run which have interior Nash equilibria (rather than a boundary equilibrium). Authors then elicit subjects' beliefs about others' behavior and categorize subjects based on whether they play best responses to their own beliefs.

5. Laffont (1975) also discusses the social benefits of a government convincing the population that this belief is true.

Integrating the constraint into the objective function yields

$$U_i = (E_i - x_i) + PNx_i.$$

Whenever $\frac{1}{N}<P<1$, then the optimal contribution $x_i^* > 0$,[6] and thus $\delta x_i^*/\delta x_j = 0 \ \forall j \neq i \in N$.

So commitment theories have two important implications, which we can test in a public goods setting, yielding the *commitment hypothesis*. First, they predict strictly positive (but constant) levels of contribution. Second, (the comparative static prediction) they predict a zero correlation between one's contributions and the contributions of others. In particular, under commitment theories, each individual chooses the level of contributions which they prefer everyone would choose. As the actual contribution level of others changes, one's own contribution remains stable. Notice, this is the same comparative static prediction as generated by the benchmark theory of self-interest above. Later in our statistical analyses we will look to the absolute level of contributions to distinguish these theories.

B. Altruism Theories

A second set of theories of altruism assume that individuals care directly about the consumption or utility of others. These theories then go on to generate behavior that involves (1) positive levels of contributions to public goods, but also (2) contributions which are negatively related to the contributions of others.

In Becker (1974), for example, an individual's utility is defined over not only his own consumption, but also the consumption of others (positively in the case of altruism). Collard (1978) distinguishes between this type of altruism, which he calls commodity-related, and altruism in which an individual's utility is defined over his level of consumption and the utility of others (positively in the case of altruism), which he calls utility-related.[7]

Models of altruism have been influential in explaining economic behavior in many settings, including charitable contributions and volunteer behavior, for example, as given in Smith, Kehoe, and Cremer (1995), social security and other welfare systems as in Coate (1995), intergenerational bequests and macroeconomic growth in Chakrabarti, Lord, and Rangazas (1993), fertility in Becker and Barro (1988), and behavior in the workplace in Rotemberg (1994). Other studies have examined altruism from an evolutionary perspective, either describing evolutionary reasons for altruistic preferences or determining the evolutionary outcomes of societies with heterogeneously altruistic individuals as given in Bergstrom and Stark (1993).

However, recently, a number of papers have presented theoretical results which challenge theories of altruism as well as empirical data inconsistent with these models. For example, models of pure altruism imply full "crowding out" of both voluntary contributions and subsidies,[8] although there is little evidence of crowding out empirically, in Clotfelter (1985) or experimentally, in Andreoni (1993). Models of altruism explaining bequests and intervivos transfers have similarly found little support in the data, for example, Cox (1987) and Altonji, Hayashi and Kotlikoff (1992) as have models for charitable giving, for example, Khanna, Posnett, and Sandler (1995).

Andreoni (1989, 1990) generalized previous models of altruism to incorporate into an individual's utility function not only the consumption (or welfare) of others, but also the "warm glow" of giving. A related paper, Abel and Warshawsky (1988), discusses the "joy of giving" and another, Feldstein (1975) models a similar process. Under this model of impure altruism, an individual cares not only about the consumption of others, but also receives some private goods benefit from their gift per se. Andreoni (1990) shows that impure altruism implies only partial crowding out, consistent with the empirical results. Models of impure altruism have been used to explain behavior in the supply of charity services by hospitals (Frank and Salkever 1991) and contributions to public goods and charities in general (Andreoni 1989, 1990).

A number of experiments have tested for the existence and malleability of (pure or

6. In fact, in this linear case, $x_i^* = E_i$.

7. Both Collard (1978) and Becker (1974) show that altruism need not lead to an infinite explosion of utility between multiple altruistic individuals as long as an individual's own utility (or consumption) is more important to him than another's.

8. That is, each dollar increase in government grants should result in a dollar decrease in private giving.

impure) altruistic preferences. Probably the best known are experiments in the dictator game, where one individual is given a sum of money to allocate in any way they wish between themselves and another; Camerer and Thaler (1995) present a review of such experiments. Subjects frequently allocate positive amounts to the other player in the game, and the amounts allocated change with the social distance between the players, the perception of neediness of the recipient, and other institutional factors.

For purposes of our study, we will test the comparative static predictions of models of pure and impure altruism. Under pure altruism, individuals maximize a utility function, which includes both their own private consumption and the consumption generated to the group from the public good as below:

$$U_i = U_i\left(\left[\{E_i - x_i\} + P\sum_i x_i\right], PN\sum_i x_i\right),$$

where $U_{i1} > 0$, $U_{i11} < 0$; $U_{i2} > 0$, $U_{i22} < 0$ (both personal consumption and altruistic consumption are normal goods with decreasing returns).

Whenever $1/N < P < 1$, then the optimal contribution $x_i^* > 0$. However, under this assumption $\delta x_i^*/\delta x_j < 0\ \forall j \neq i \in N$. This result is akin to crowding out; see Sugden (1982, 346) for a proof.

Under impure altruism, individuals maximize a utility function, which includes the above as well as the amount *they* contributed to the public good, as below.

$$U_i = U_i\left(\left[\{E_i - x_i\} + P\sum_i x_i\right], PN\sum_i x_i, x_i\right),$$

where $U_{i1} > 0$, $U_{i11} < 0$; $U_{i2} > 0$, $U_{i22} < 0$; $U_{i3} > 0$, $U_{i33} < 0$ (personal consumption, altruistic consumption and warm glow consumption are normal goods with decreasing returns).

Again, whenever $1/N < P < 1$, then the optimal contribution $x_i^* > 0$. Also under this assumption, $\delta x_i^*/\delta x_j < 0\ \forall j \neq i \in N$. This result is akin to partial crowding out; an increase in the amount of the public good provided implies a decrease in an individual's own contribution, although the decrease is smaller than under pure altruism; see Andreoni (1989, 1451) for a proof. Thus our comparative static prediction from both types of theories of altruism (the *altruism hypothesis*) is that there will be a negative relationship between an individual's own contribution and (his beliefs about) the contributions of others in his group.

C. Reciprocity Theories

A final set of theories of reciprocity assume that individuals reciprocate or match the contributions of others. These theories then go on to generate behavior, which involves (1) positive levels of contributions to public goods, but also (2) contributions, which are positively related to the contributions of others.

Sugden (1984) describes a model in which individuals profit-maximize subject to an external constraint; the principle of reciprocity. This principle says that an individual must contribute the minimum of (1) the least any other member of his group is contributing and (2) the level of contribution he would most prefer that every member of the group make (the same as the level of contributions he would make under commitment theories). By assuming this principle as a constraint on behavior, Sugden derives the existence of (multiple) equilibria in settings of both identical and nonidentical players.

Reciprocal reasoning has been used to explain empirically observed individual behavior in tax evasion in Bordignon (1993), gift exchange in Kranton (1996), public goods provision in Hollander (1990), helping in the workplace in Frey (1993), and labor markets in Akerlof (1982).

A number of experiments have reported behavior consistent with reciprocity as well, including labor markets, trust games, common-pool resource games, and bargaining experiments; see Kagel and Roth (1995) for a review).

For purposes of our study, we will test the comparative static predictions of models of reciprocity, which predict a significant positive relationship between an individual's contributions to the public good and those of his group. In our notation, under this theory an individual maximizes his personal utility as given below:

$$U_i = (E_i - x_i) + P\sum_i x_i$$

subject to $x_i = \min(x_i^c, x_j\ \forall j \in N)$, where x_i^c is the optimal level of contribution under commitment theories

Whenever $1/N < P < 1$, then the optimal contribution $x_i^* > 0$. However, under this assumption in equilibria it can be that $\delta x_i^*/\delta x_j > 0\ \forall j \neq i \in N$. See result 4 of Sugden (1984, 780) for a proof. This theory is thus consistent with a positive correlation between one's own contribution and the contribution of other members of the group; this prediction will be our *reciprocity hypothesis*.[9]

It is worth noting that Sugden's model of reciprocity is a model of simultaneous (not sequential) matching of contributions. Players in this game do not wait to see what others have contributed, and then reciprocate their contributions. Instead, everyone makes contributions at the same time, maximizing their self-interest subject to the principle of reciprocity and given their beliefs of others' contributions. Thus our test of this theory of reciprocity will (of necessity) be a simultaneous one.

D. Summary

The experiments reported in this paper allow us to discriminate between the comparative statics of three classes of theories of behavior, all of which have been invoked to explain the voluntary provision of public goods. The first class of theories (commitment rules) predicts no correlation between an individual's contribution and the contributions of others, or his beliefs about them (a similar zero correlation is also predicted by traditional theories of full free-riding). The second class of theories (pure and impure altruism) predicts a negative correlation. Finally, the third class of theories (reciprocity) predicts a positive correlation. Appendix A lists these (and related) theories, and the possible predictions that they generate.[10]

9. It is worth noting that such a positive correlation has been assumed in theories of voluntary activities, for example, Cornes and Sandler (1984).

10. Thanks to an anonymous referee for suggesting this table, and a number of the alternative theories represented there. There are a number of theories which are not distinguishable using the data from this paper. For example, commitment theories make the same prediction as pure warm glow theories. Similarly, all theories may have equilibria, which look identical to self-interest theories if or when the parameters on others' payoffs are insufficiently large to induce individuals to contribute (in the case of altruistic theories), when the commitment level is sufficiently low (in the case of commitment theories) and when individuals coordinate on zero contributions (in the case of reciprocity theories). Thus if we find zero contributions and/or zero correlations, we will not be able to distinguish between these theories. In a similar way, we will not be able to distinguish between pure altruism and impure altruism; both can predict positive contributions and negative comparative statics.

It should be noted that all these models are models of one-shot behavior. In experiments, however, subjects seldom play equilibria on their first try. Rather, they adjust their behavior and converge toward equilibria. In order to give these equilibria their best chance, the experimental design involves two tenfold repetitions of a public goods game, consistent with previous experiments described in Davis and Holt (1994) and Ledyard (1995). Since the equilibria described above are equilibria of the stage game, they are also equilibria of the finitely repeated game (Smith 1990).

Sections IV, V, and VI below present the experiments which distinguish between these different theories.

IV. STUDY I: COMPARING CONTRIBUTIONS WITH ESTIMATED CONTRIBUTIONS OF OTHERS

This study tests the comparative static predictions of models of commitment, altruism, and reciprocity by comparing an individual's contribution with his belief about the contribution of others. Subjects play a finitely repeated, simultaneous move, linear public goods game. Before each period, they are asked to estimate the contributions of the other members of their group. The first subsection describes the experimental design and parameters, the second discusses results investigating the comparative statics of behavior, and the third addresses the accuracy of subjects' beliefs. The fourth subsection concludes.

A. Experimental Design and Parameters

This experiment was designed to replicate previous experiments in finitely repeated linear public goods games as closely as possible; see Davis and Holt (1994) and Ledyard (1995). The same structure of game and parameter values were used.

In each period of the game, each subject was endowed with 25 tokens, which could be allocated either to a private account, which paid 2¢ per token to the individual only, or to a group account (the public good), which paid 1¢ per token to each of the four members of the individual's group. Notice that each period of this experiment incorporates a pure public goods problem. Under traditional assumptions of self-interest, regardless of the decisions of the other players, each individual strictly prefers to place all of his tokens in his private account, earning 2¢ per token, than in the group account, earning 1¢ per token. However, the group as a whole earns 4¢ when a token is placed in the group account (1¢ to each of the four members) but only earns 2¢ when the token is placed in a private account. This yields a marginal per capita return (MPCR) of 0.5, similar to that in previous papers.

In a departure from previous experiments, each period of the game was divided into two stages: the "guessing" and the "decision" stages. In the guessing stage, subjects estimated the total number of tokens the other three members of their group would contribute to the group account in the upcoming decision stage.[11] They were compensated for accurate estimates.[12] In the decision stage, subjects made their personal and private contribution decisions, as in previous experiments.

At the end of each period, subjects were reminded of their own estimate and told the true aggregate contribution of the other three members of group, the total group contribution, and their earnings from both the estimation stage and the contribution stage.[13]

Subjects played two identical ten-period linear public goods games.[14] Subjects played the first game and then were told there was enough time to play a second, as in Andreoni (1988). The second game was always identical to the first.

Twenty-four subjects, arranged in six groups of four, participated in this experiment. Subjects were undergraduate students at the University of Arizona. They were paid a $5 show-up fee along with their earnings in the experiment. Average earnings were $14.69, plus the $5 fee, for less than an hour of experimental time. The entire experiment was computerized; instructions were given through the computer screen, subjects entered their contributions via the keyboard and, at the end of each period, feedback about the outcome was displayed on the screen. Subjects could also access a "history" of past outcomes of their group at any time.

In the following subsections, we directly test the comparative statics of commitment, altruism, and reciprocity theories by investigating the relationship between an individual's beliefs of what others will contribute and his own contributions. Commitment theories predict a zero correlation, altruism theories a negative correlation, and reciprocity theories a positive correlation.

B. Results: Testing Comparative Statics

Overall. A random-effects regression as below compares an individual's contribution with his belief of what the rest of his group will contribute.

$$\text{CONT}_{it} = \alpha_0 + \alpha_1 \text{GUESS}_{it} + \alpha_2 \text{PERIOD} + \sum_{i \neq 1} \beta_i \text{GROUP} + \sum_{i \neq 1} \gamma_i \text{IND} + \varepsilon_i$$

The dependent variable is an individual *i*'s contribution to the public good in period *t*. Independent variables are the individual's GUESS of what the other three members of his group will contribute in this same period *t*, the PERIOD number, and an indicator variable for each group minus one (GROUP) and for each individual minus one in each group (IND). A random effects regression not only allows for individual and group-specific intercepts (from the indicator variables), but also individual and group-specific error terms. For a complete discussion of random effects regression, see Greene (1990). Results of the regression are reported in Table 1, parameter estimates for group and individual dummies are suppressed for ease of presentation.[15]

This regression reports a significant positive relationship between a subject's guess of what the other three members of his group will

11. Because they estimated the contributions of the other three members of the group, subjects could not influence the accuracy of their guess by strategically changing their own contribution.

12. In addition to their earnings from the public good, subjects earned 50¢ if their estimate was exactly right. If their estimate was a bit off, they earned 25¢ divided by the (absolute) distance between their estimate and the true contribution. This payment scheme leads to an approximation of a single-peaked curve.

13. Croson (2000a) compares contributing behavior between this treatment and a traditional linear public goods experiment treatment.

14. In addition, there were three practice periods before the first game began to familiarize subjects with the computer program and the process. Subjects were not paid their earnings during the practice periods and no practice periods were run before the second game. Raw data as well as the instructions used are available from the author.

15. The same regression including dummy variables for each group had similar results, as did one including dummies for the period numbers and a two-factor random effects regression (individual and period).

TABLE 1
Random Effect Regression: Contributions on Estimates, All Data

Individual Contributions	
Intercept (α_0)	1.385*
	(0.558)
GUESS (α_1)	0.202***
	(0.014)
PERIOD (α_2)	−0.099
	(0.075)
GROUP (β_i i = 2,..., 6) (Suppressed, Random)	
IND (γ_i i = 1 Excluded each Group) (suppressed, random)	
N	480
R^2 Adjusted	0.5098

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 2
Random Effect Regression: Contributions on Estimates, by Game

Individual Contributions	First Game	Second Game
Intercept (α_0)	3.077*	1.479**
	(1.378)	(0.472)
GUESS (α_1)	0.176***	0.114***
	(0.030)	(0.020)
PERIOD (α_2)	−0.295*	−0.004
	(0.145)	(0.070)
GROUP (β_i, i = 2,..., 6) (Suppressed, Random)		
IND (γ_i, i = 1 Excluded each Group) (suppressed, random)		
N	240	240
R^2 adjusted	0.4982	0.6796

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

contribute and his own contribution. This result strongly supports reciprocity theories over theories of commitment (which predicted a zero correlation) and altruism (which predicted a negative correlation).

The intercept in this regression was also positive, consistent with previous experimental results that subjects make positive contributions in similar games. The coefficient on period is not significant.

Identical regressions using only the data from the first game (the first ten periods) or the second game (the second ten periods) yield similar results, reported in Table 2.

The intercept and GUESS coefficient is similarly positive and significant in each individual game. The PERIOD coefficient is significantly negative in the first game, suggesting declining contributions over time, also observed in the previous experiments. However, by the second game, contributions appear to have stabilized and no further decrease is observed.

While these analyses examine the correlation between contributions and beliefs over time, alternatively, we can investigate the between-subject correlation between contributions and beliefs in only the first or only the last periods of the game. To do this, we estimate the following random effects ordinary least squares (OLS) regression

$$\text{CONT}_{it} = \alpha_0 + \alpha_1 \text{GUESS}_{it} + \sum_{i \neq 1} \beta_i \text{GROUP} + \sum_{i \neq 1} \gamma_i \text{IND} + \varepsilon_i$$

separately for only period 1 and only period 10.[16] Table 3 provides results from these regressions.

Again, consistent with the reciprocity model, we find a significantly positive relationship between an individual's contributions and his estimates of others' contributions. In addition, we observe positive (but highly variable) contributions in period 1 of the game and significantly lower contributions in period 10 of the games, consistent with previous experiments in this area, which document decreasing contributions over time.[17]

Individual Characterizations. A second type of analysis characterizes the behavior of individual subjects in the experiment. For each of the 24 subjects, we calculate the correlation between their contribution and their belief of the contribution of others in their group. In this way, we can identify individual subjects whose behavior is consistent with comparative statics

16. Notice we have two observations for each individual, one for period 1 of the original game and one for period 1 of the restart game. Thus, we include the individual dummies and random effects.

17. Identical regressions without the individual dummy variables yield similar results (the period 1 coefficient on GUESS is 0.192, $p < 0.01$, the period 10 coefficient on GUESS is 0.184, $p < 0.01$). Identical regressions run for each of the games separately on period 1 play also yield similar results (for the original game, the period 1 coefficient on GUESS is 0.215, $p < 0.01$ and for the restart game, the same coefficient is 0.313, $p < 0.01$).

TABLE 3
Random Effect Regression: Contributions on Estimates, Periods 1 and 10 Only

Individual Contributions	Period 1	Period 10
Intercept (α_0)	2.155	0.018
	(1.348)	(0.582)
GUESS (α_1)	0.163***	0.192**
	(0.041)	(0.057)
GROUP (β_i, $i = 2, \ldots, 6$) (Suppressed, Random)		
IND (γ_i, $i = 1$ Excluded each Group) (Suppressed, Random)		
N	48	48
R^2 Adjusted	0.4487	0.4565

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

of commitment, altruism, or reciprocity models. Table 4 depicts the results from this analysis.

Twenty-two out of 24 subjects (almost 92%) exhibited a positive correlation between their own contribution and their estimates of the contributions of others, consistent with models of reciprocity. Only two subjects exhibited a negative correlation, consistent with models of altruism, and none a zero correlation, consistent with models of commitment.

These results represent a statistically significant difference from random behavior. A chi-squared test comparing the actual categorization of subjects against a null hypothesis of equal probability of all three types rejects the null at $p < 0.01$.[18]

C. Results: Estimate Accuracy

In this experiment, each subject estimated what others in his group would contribute. One important question involves the accuracy of these estimates.

Figure 1 shows the average absolute estimation error made by each group in each period of the game. This error is calculated by computing the *absolute* error of each subject in each period (the distance between their guess and the other three subjects' actual contributions) and averaging within each group. If all subjects were extremely bad guessers, this average absolute

TABLE 4
Individual Characterizations: Correlation between Own Contribution and Guesses of Contributions of Others

	Positive	Negative	Zero
Number of Subjects	22	2	0
% of Subjects	91.67	8.33	0.00

estimation error could be as high as 75; they could guess that the other three subjects would contribute zero, for example, when the other three subjects instead contribute all 25. Instead, subjects appear to be fairly accurate in their estimations of others' behavior.

We can define an individual subject's estimation error as the difference between that subject's estimate and the actual contributions of the other members of his group. Over all in ten rounds, of the first game, only eight out of 24 subjects exhibited any significantly positive levels of error (overoptimism). In the second game, no subjects exhibited significant levels of error.[19] Throughout the experiment, most subjects provided unbiased guesses of what their counterparts in the public goods game would do.

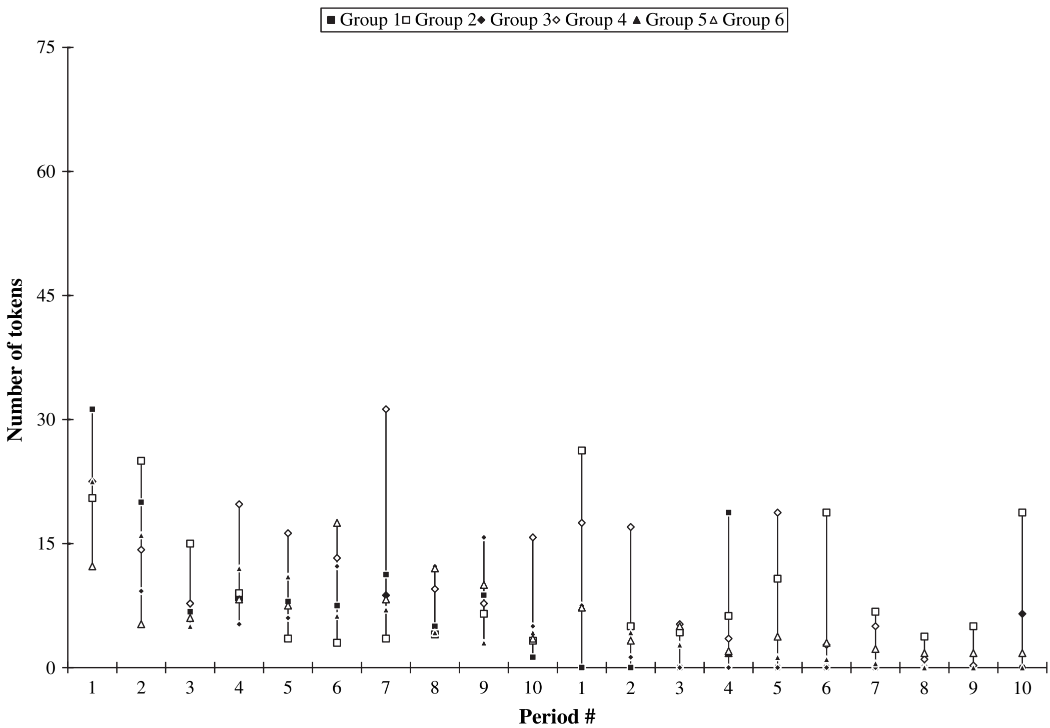
D. Conclusion

This study was designed to provide data which could distinguish between models of commitment, altruism, and reciprocity by comparing their comparative static predictions. In particular, we compared an individual's contribution in a public goods game with his beliefs about the contributions of others. Results from a random effects regression demonstrate a significant positive relationship, consistent with models of reciprocity and inconsistent with models of commitment or altruism. In addition, an analysis at the level of individual subject is run. Almost 92% of the subjects (22 out of 24) demonstrated a positive correlation between their own contributions and their beliefs of others' contributions, consistent with reciprocity models. The remaining 8% exhibit a negative correlation, consistent with models

18. A similar test excluding the observations of zero correlation was also run. The null hypothesis of equal number of positive and negative correlations was again rejected at $p < 0.01$.

19. The hypothesis that the mean of the distribution of errors in the first game is equal to zero can be rejected using a t-test at the 5% level for eight out of 24 subjects. It cannot be rejected for any subjects in the second game.

FIGURE 1
Average Absolute Estimation Errors



of altruism, and none exhibited a zero correlation, consistent with models of commitment and of traditional self-interest models.

In addition, we provide an analysis of the accuracy of subjects' beliefs in this setting. We find that subjects' beliefs are quite accurate. In the first game, only eight subjects out of 24 had significantly positive levels of error; in the second game no subjects did.

Although these results appear encouraging for reciprocity models, a few questions remain. First, it may be that asking subjects for their estimates of others' actions leads them to think reciprocally where they would not otherwise (an elicitation hypothesis). Second, it may be that the repeated game nature of this experiment is yielding the positive correlation and not reciprocity per se (a reputation hypothesis).

To answer these questions and test the robustness of our results, two more experiments were run and the comparative static predictions of our models re-analyzed. Neither of the experiments involved the elicitation of beliefs of others' actions. Instead, we compare an individual's contribution with the actual contribution of the other members of his group. Since in this experiment, subjects' elicited beliefs were quite accurate, we claim that the comparative static predictions from the models will transfer to this new context. The next section describes the new experiments and their results.

V. STUDY II: COMPARING CONTRIBUTIONS WITH ACTUAL CONTRIBUTIONS OF OTHERS

A. Testing the Elicitation Hypothesis

Our first question involves the extent to which asking subjects to estimate the contributions of others leads them to play reciprocally where they would not otherwise. To test this hypothesis, we ran a new experiment, identical to the first but excluding the estimation stage. Twenty-four subjects, different from the previous subjects but from the same subject pool, participated in this experiment, arranged in six groups of four. Average earnings for this experiment were $13.91 (plus the $5 show-up fee) for less than one hour of experimental time.

Here, we are interested in the correlation between subjects' contribution and the ACTUAL total contribution of others in this same period (unfortunately, we cannot compare an individual's contribution with his belief about the contributions of others when those beliefs are not elicited). A zero correlation is predicted by commitment theories, a negative correlation by altruism theories and a positive correlation by reciprocity theories. With this data, we estimate the random effects OLS regression

$$\mathrm{CONT}_{it} = \alpha_0 + \alpha_1 \mathrm{ACTUAL}_{it} + \alpha_2 \mathrm{PERIOD} + \sum_{i \neq 1} \beta_i \mathrm{GROUP} + \sum_{i \neq 1} \gamma_i \mathrm{IND} + \varepsilon_i$$

for both the previous experiment and this one. Results from these regressions are reported in Table 5 below.

Consistent with the reciprocity hypothesis, a significant positive relationship is found between an individual's contribution and the actual contribution of others in both the previous experiment (Guess) and this experiment (No Guess). First, focusing on the previous experiment, this relationship is a bit less strong than the relationship between an individual's contribution and estimate of others' contributions (where the coefficient was 0.202 rather than 0.164). The relationship appears somewhat weaker in this experiment (0.077 versus 0.164); nonetheless, it is still significant at the 1% level.[20]

Interestingly, subjects contributed on average significantly less in the previous experiment (when they were asked to estimate the contributions of others) than in this one, as can be seen by the difference in intercept between the two regressions. This difference is explored in more detail in a related paper, Croson (2000a). Finally, both regressions show a significant decrease in contributions over the course of the games, consistent with evidence from previous experiments.

In a parallel to our first analysis, we can also compare within an individual the correlation between the individual's contributions and the actual contributions of others in their group. Table 6 provides those results for the previous experiment and this experiment.

In the previous experiment (Guess), 21 out of 24 subjects (87.5%) exhibited a positive correlation between their own contribution and the actual contributions of others in their group, consistent with reciprocity theories. Only three subjects exhibited a negative correlation, consistent with altruism theories, and no subjects exhibited a zero correlation. The pattern in this experiment (No Guess) is similar, 19 out of 24 subjects exhibited a positive correlation (79%), only five, a negative correlation, and none exhibited a zero correlation. These results represent a statistically significant difference from random behavior. A chi-squared test comparing the actual categorization of subjects against a null hypothesis of equal probability of all three types rejects the null at $p < 0.01$, for each experiment independently as well as for both of them together.[21]

While there are some differences in the *level* of contributions between games in which estimates of others' contributions are elicited and

TABLE 5
Random Effect Regressions: Contributions on Others' Contributions

Individual Contributions	(1) Guess	(2) No Guess
Intercept (α_0)	3.195***	10.639***
	(0.634)	(1.288)
ACTUAL (α_1)	0.164***	0.077**
	(0.021)	(0.025)
PERIOD (α_2)	−0.226**	−0.692***
	(0.085)	(0.136)
GROUP (β_i, $i = 2,\ldots, 6$) (suppressed, random)		
IND (γ_i, $i = 1$ Excluded each Group) (Suppressed, Random)		
N	480	480
R^2 Adjusted	0.3750	0.3296

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

20. Although the effect is somewhat smaller in the no guess treatment, the difference is not statistically significant. A regression of contributions on the actual contributions of others, the treatment, controls for group, individual and period, and the interaction of actual contributions of others and treatment finds no significant effect of the interaction term ($\beta = -0.0172$, $p = 0.2650$). Thus the strength of the effect of actual contributions of others on own contributions is not statistically different in the two treatments.

21. A similar test excluding the observations of zero contributions was also run. The null hypothesis of equal number of positive and negative correlations was rejected at $p < 0.01$ for all four treatments as well as the combined data.

TABLE 6
Individual Characterizations: Correlation between Own Contribution and Actual Contributions of Others

	Positive	Negative	Zero
Guess			
Number of Subjects	21	3	0
% of Subjects	87.50	12.50	0.00
No Guess			
Number of Subjects	19	5	0
% of Subjects	79.17	20.83	0.00

where they are not, results from this subsection demonstrate that the *comparative statics* of reciprocity theories remain most consistent with the data, even when beliefs are not elicited. This allows us to reject the elicitation hypothesis.

B. Testing the Reputation Hypothesis

A further concern is that the positive correlation observed is arising from some sort of reputation development rather than from reciprocity. In both our original experiment and the second experiment presented above, subjects were formed into groups, which remained constant for the duration of the experiment. This matching procedure is by far the most common one used in previous experiments. However, in this setting it may be another cause of our results. For example, if all subjects were playing in a way consistent with Kreps et al. (1982) and all subjects believed all subjects were playing in this way, we might observe a positive correlation similar to the one we observed, but for reputational rather than reciprocal reasons. The experiment reported in this subsection was designed to test this alternative explanation.

A different set of 24 subjects participated in this experiment (Strangers). The experiment was run in two separate sessions of 12 subjects each. Subjects played the same game as in the previous experiments. After each period of the game, however, subjects were randomly reassigned to new groups of four as in Andreoni (1988) and Croson (1996). Thus, it was extremely unlikely a subject would play with the same group of three other people more than once during the session. This type of matching scheme has been demonstrated to reduce reputation effects. For an explanation of why, see Andreoni (1988). Average earnings for this experiment were \$11.83 (plus the \$5 show-up fee) for less than one hour of experimental time.

Here, we are again interested in the correlation between subjects' contribution and the ACTUAL total contribution of others with whom he is matched in this same period. If the previously observed positive correlation is being caused by reputational issues (the reputation hypothesis) we should observe a zero correlation in this experiment. Thus, with this data, we estimate the random-effects regression

$$\text{CONT}_{it} = \alpha_0 + \alpha_1 \text{ACTUAL}_{it} + \alpha_2 \text{PERIOD} + \sum_{i \neq 1} \beta_i \text{IND} + \varepsilon_i.$$

Note that we have no group dummy variables, as the groups were not fixed trial to trial. Instead, we include dummy variables for each individual except one. Results from these regressions are reported in Table 7 below.

Consistent with the reciprocity hypothesis, a significant positive relationship is found between an individual's contribution and the actual contribution of others in this experiment as well. Although the relationship appears somewhat weaker in this experiment than in previous ones (suggesting some reputation formation may be going on), nonetheless, it is still significant at the 1% level, supporting theories of reciprocity over those of commitment or altruism.[22]

In similar analysis to that above, we also compare, within an individual, the correlation between their contributions and the actual contributions of others in their group. Table 8 provides those results for this experiment.

As in previous experiments, most of the subjects exhibited positive correlations between their own contributions and contributions of

22. Remember that Sugden's notion of reciprocity is a simultaneous rather than a sequential one. It is not that subjects in this experiment are "rewarding" their group members for past performance. Instead, they are trying to "match" the contributions they expect of others in their group. In addition, as in footnote 19, we find no significant effect of the interaction term in comparing treatment and the actual contribution of others ($\beta = 0.0208$, $p = 0.1519$). Thus the strength of the effect of actual contributions of others on own contributions is not statistically different in the two treatments.

TABLE 7
Random Effect Regression: Contributions on Others' Contributions, Strangers

Individual Contributions	**Strangers**
Intercept (α_0)	7.449***
	(0.830)
ACTUAL (α_1)	0.058**
	(0.021)
PERIOD (α_2)	−0.546***
	(0.106)
IND (β_i, $i = 2,\ldots, 24$) (Suppressed, Random)	
N	480
R^2 Adjusted	0.3864

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

others, consistent with reciprocity theories (almost 71%). Only three out of 24 subjects exhibited negative correlations, consistent with altruism theories. In contrast to previous experiments, however, four subjects exhibited zero correlations between their own contributions and the contributions of others. Closer inspection reveals that these correlations were generated by four subjects who fully free-rode (contributed zero) throughout the entire experiment. This result of more free-riding and lower contributions in strangers experiments than among stable groups is consistent with previous research, as in Croson (1996).

These results represent a statistically significant difference from random behavior. A chi-squared test comparing the actual categorization of subjects against a null hypothesis of equal probability of all three types rejects the null at $p < 0.01$.

While there are more free riders and lower contributions in this experiment than in previous ones, results are still supportive of the comparative statics of reciprocity theories over those of commitment or altruism. A significant and positive relationship is found between an individual's contribution and the contribution of others in his group.

C. Conclusion

In this section we presented the results of two further experiments, which test the robustness of our previous result. The first demonstrates a positive relationship between an individual's contribution and the contributions of others even when beliefs are not elicited. The second demonstrates a similarly positive relationship even when reputational concerns are severely reduced. We conclude that reciprocal concerns in this setting are robust. Having demonstrated support for theories of reciprocity in three different settings, we now turn to Study III, which provides a characterization of the *type* of reciprocity that individuals exhibit.

TABLE 8
Individual Characterizations: Correlation between Own Contribution and Actual Contribution of Others, Strangers

	Positive	**Negative**	**Zero**
Number of Subjects	17	3	4
% of Subjects	70.83	12.50	16.67

VI. STUDY III: TYPES OF RECIPROCITY

In Sugden's (1984) model of reciprocity, he suggests that actors will match the *minimum* contribution of others. In contrast, however, we can imagine different *types* of reciprocity in which subjects try to match the median contribution of others, or possibly even the maximum. The experiment reported in this study distinguishes between these different specifications of reciprocity.

A. Experimental Design and Parameters

Twenty-four subjects, distinct from previous participants but from the same subject pool, participated in this experiment. Subjects were arranged into groups of four and played two ten-round games retaining the same groups. All parameter values were the same as in the previous experiments, and no elicitation of beliefs was made.

In contrast to the previous experiments, however, after each period subjects were informed not only of the aggregate contribution of the other three members of their group, but also of the *individual* contributions of the other three members of the group (as in Croson 2000b). Thus subjects could attempt to match either the maximum, the minimum, or the median contribution. As before, subjects took home their earnings from the experiment (average $14.03) plus their $5 show-up-fee.

B. Results: Testing Comparative Statics

In this experiment, we again observe a positive relationship between an individual's own contribution and the actual contribution of others in their group. With this data, we again estimate the random effects OLS regression

$$\text{CONT}_{it} = \alpha_0 + \alpha_1 \text{ACTUAL}_{it} + \alpha_2 \text{PERIOD} + \sum_{i \neq 1} \beta_i \text{GROUP} + \sum_{i \neq 1} \gamma_i \text{IND} + \varepsilon_i$$

Results from this regression are shown in Table 9 below.

As before, we observe a significantly positive relationship between one's own contribution and the actual contributions of others in one's group. The intercept is significantly positive, and the period variable significantly negative, consistent with results from previous experiments.

A parallel analysis as above involving correlations at the individual level also yields similar results, as shown in Table 10.

Almost 88% (21 subjects out of 24) exhibit a positive correlation, consistent with theories of reciprocity. Only two subjects out of 24 (8.33%) exhibit a negative correlation, consistent with theories of altruism. One subject's behavior yields a zero correlation; closer inspection shows that subject contributes nothing throughout the entire experiment. Thus, we classify him as a free rider. These results represent a statistically significant difference from random behavior. A chi-squared test comparing the actual categorization of subjects against a null hypothesis of equal probability of all three types, rejects the null at $p < 0.01$.

This experiment demonstrates similar evidence in favor of theories of reciprocity as previous ones. In addition, however, we can use the data to compare between different types of reciprocity. This is done in the next subsection.

TABLE 9
Random Effect Regression: Contributions on Others' Contributions, Full

Individual Contributions	Full
Intercept (α_0)	10.078***
	(1.286)
ACTUAL (α_1)	0.098***
	(0.024)
PERIOD (α_2)	−0.436**
	(0.133)
GROUP (β_i, i = 2, …, 6) (Suppressed, Random)	
IND (γ_i, i = 1 Excluded each Group) (Suppressed, Random)	
N	480
R^2 Adjusted	0.4555

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

C. Different Types of Reciprocity

These data allow us to compare three different types of reciprocity: maximum, minimum, and median. In maximum reciprocity, subjects would attempt to match the maximum contribution of the other three members of their group. In minimum reciprocity, subjects would attempt to match the minimum contribution of the other three members of their group. Finally, in median reciprocity, subjects would attempt to match the contributions of the median contributor of the other three members of their group.

Our goal is to determine which of these three models of reciprocity best fits the data. That is, which of the minimum, maximum, or median contribution of an individual's partners better predicts an individual's own contribution. We estimate four random effect OLS regressions, as given below:

$$(1)\quad \text{CONT}_{it} = \alpha_0 + \alpha_1 \text{MIN}_{it} + \alpha_2 \text{PERIOD} + \sum_{i \neq 1} \beta_i \text{GROUP} + \sum_{i \neq 1} \gamma_i \text{IND} + \varepsilon_i$$

$$(2)\quad \text{CONT}_{it} = \alpha_0 + \alpha_1 \text{MAX}_{it} + \alpha_2 \text{PERIOD} + \sum_{i \neq 1} \beta_i \text{GROUP} + \sum_{i \neq 1} \gamma_i \text{IND} + \varepsilon_i$$

TABLE 10
Individual Characterizations: Correlation between Own Contribution and Actual Contributions of Others, Full

	Positive	Negative	Zero
Number of Subjects	21	2	1
% of Subjects	87.50	8.33	4.17

$$(3)\quad CONT_{it} = \alpha_0 + \alpha_1 MED_{it} + \alpha_2 PERIOD + \sum_{i \neq 1} \beta_i GROUP + \sum_{i \neq 1} \gamma_i IND + \varepsilon_i$$

$$(4)\quad CONT_{it} = \alpha_0 + \alpha_1 MIN_{it} + \alpha_2 MAX_{it} + \alpha_3 MED_{it} + \alpha_4 PERIOD + \sum_{i \neq 1} \beta_i GROUP + \sum_{i \neq 1} \gamma_i IND + \varepsilon_i$$

Results from these regressions are shown in Table 11.

Evidence from these regressions suggests that median reciprocity is a better predictor than either minimum or maximum reciprocity. First, in the individual regressions (1), (2), and (3), the *t*-statistic is higher for the median contribution than for either of the others. In addition, in the regression that includes all measures (4), only median is significantly different from zero. This suggests that the median contribution of the others in a subject's group is a better predictor of that subject's own contribution[23] than either the maximum or the minimum. In all of these regressions, we observe a similar result as above of significantly positive contributions (positive intercept coefficient), which decrease over time (negative PERIOD coefficient) as in previous studies.

Another way to demonstrate this relationship is through a standardized regression. Here, the same regression equations are run as above, except the independent measures (MIN, MAX, and MED) are standardized to be distributed normally with mean 0 and variance 1. In these regressions, the absolute size of the coefficients can be compared directly. Results from the standardized random effects regressions are shown in Table 12.

Again, we see that the median contribution of the other players is a better predictor of a subject's own contribution than either the maximum or the minimum. The standardized coefficient on MED is higher than either of the other two, and in the final regression (4), only MED remains significantly different from zero. Again we observe significantly positive contributions (positive intercept coefficient), which decrease over time (negative PERIOD coefficient) as in previous studies.[24]

D. Conclusion

This experiment sheds light on exactly what subjects in this experiment might be trying to reciprocate. First, our results are consistent with the comparative statics of reciprocity theories in yet another setting, this time where subjects are given information about the full distribution of their group's contributions, not just the total. Then, we test whether the minimum, maximum or median contribution of the other three players is a better predictor of a subject's own contribution. We find significant evidence for median reciprocity, suggesting that subjects try to match the median or average contributions of others, rather than the minimum (as suggested by Sugden's theory of reciprocity) or the maximum.

VII. DISCUSSION AND CONCLUSION

The experiments reported in this paper tested comparative statics predictions of three models consistent with observations of voluntary public goods provision; commitment, altruism, and reciprocity. The results support the reciprocity model in which individual

23. Notice it is quite possible for an individual's contribution to be above the maximum (or below the minimum) of the other three members of his group. In fact, the contributions of one person in each group in each period will have this characteristic.

24. A closely related type of reciprocity to median reciprocity is mean or average reciprocity. Indeed, if we rerun the regressions in Tables 11 and 12 with minimum, maximum, and average contributions of others, the results support average reciprocity over either minimum or maximum. Comparing median and average reciprocity directly is quite difficult, as they are highly correlated ($r = 0.9217$, $p < 0.0001$). Thus using both in the same regression will increase the standard errors and decrease the likelihood of finding any significant results. However, a regression with these two as independent variables plus the usual controls for groups, individuals and period suggests that median is a slightly better predictor than average (for median, $\beta = 0.159$, $p = 0.096$; for average $\beta = 0.091$, $p = 0.521$). When we use standardized independent variables, the results again are directionally in favor of median reciprocity over average reciprocity (for median, $\beta = 1.62$, $p = 0.098$; for average $\beta = 0.723$, $p = 0.521$). However, given the colinearity of these two measures, we do not consider this analysis conclusive evidence for either median or average reciprocity as the measure of the central tendency toward which subjects are reciprocating. We have kept median as the main measure in the text, because it is parallel with maximum and minimum as representing one group member's contribution.

TABLE 11
Random Effect Regressions: Contributions under Full Information

Individual Contributions	(1)	(2)	(3)	(4)
Intercept	13.187****	11.542****	11.297****	10.698****
	(0.971)	(1.309)	(1.032)	(1.360)
MIN	0.140*			0.016
	(0.072)			(0.078)
MAX		0.131***		0.037
		0.050		(0.056)
MED			0.212****	0.190***
			(0.048)	(0.060)
PERIOD	−0.543****	−0.538****	−0.469****	−0.453****
	(0.133)	(0.131)	(0.130)	(0.134)
GROUP (β_i, i = 2,. . .,6) (Suppressed, Random)				
IND (γ_i, i = 1 Excluded each Group) (Suppressed, Random)				
N	480	480	480	480
R^2 Adjusted	0.4399	0.4437	0.4584	0.4565

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

contributions are positively related to the contributions of others or to their beliefs about those contributions.

Reciprocal behavior is also supported by anecdotal evidence. Charities eliciting contributions often suggest a particular level as the "standard" gift or report the size of their "average" contribution. Presumably this influences individual's beliefs of what others are giving, thus causing them to give more.

Even the very wealthy seem to exhibit reciprocal behavior, in this example from *Forbes Magazine*,

> "Seattle's Lakeside Upper School counts. . . Bill Gates among its alumni. Rumor has it a fundraiser for the high school put the bite on Gates,

TABLE 12
Random Effect Regressions: Contributions under Full Information, Standardized

Individual Contributions	(1)	(2)	(3)	(4)
Intercept	13.869****	13.841****	13.458****	13.370****
	(0.819)	(0.806)	(0.800)	(0.821)
MIN std	1.262*			0.142
	(0.649)			(0.706)
MAX std		1.153***		0.329
		(0.440)		(0.495)
MED std			2.165****	1.943***
			(0.492)	(0.611)
PERIOD	−0.543****	−0.538****	−0.469****	−0.453****
	(0.133)	(0.131)	(0.130)	(0.134)
GROUP (β_i, i = 2, . . . 6) (Suppressed, Random)				
IND (γ_i, i = 1 Excluded each Group) (Suppressed, Random)				
N	480	480	480	480
R^2 Adjusted	0.4399	0.4437	0.4584	0.4565

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$.

who asked: 'How much is everyone else giving?' About $75 he was told. 'So put me down for $75,' said Gates. (22 January 1996, 18).[25]

While median-matching behavior like this is consistent with the reciprocity principle, it may be adaptively rational as well. Societies whose members follow this principle are more likely to be able to supply public goods than societies whose members practice self-interest utility maximization. One can also imagine an individually rational reason to behave reciprocally. If the quality or reliability of charitable groups is not known, individual contributors may use the contributions of others as a signal for how much they should contribute themselves, as in Vesterlund (2003).

This study examines the factors that motivate individuals to make voluntary contributions in social dilemma situations. In particular, it finds support for reciprocity theories over commitment theories, altruistic theories, and traditional free-riding theories. We find a significant and positive relationship between an individual's contribution and his belief about the contributions of others in his group, as well as between an individual's contribution and the actual contributions of the others in his group. These results suggest that players act as though part of their objective is to match the contributions of other members.

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25. Another example of reciprocal behavior is found in the entertainment industry. During the making of *Titanic*, when the film was running over budget and failed to make the planned release date, director James Cameron voluntarily gave up fees for the film as well as his percentage of the profits in order to assuage concerns of executives at 20th Century Fox and Paramount Picture Studios. Once *Titanic* became the third-biggest grossing film of all time, those waived fees and percentages total to approximately $50 million. A report in *Newsweek* (1998) says that studio heads are now considering voluntarily and unilaterally paying Cameron the very fees he had agreed to waive.

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APPENDIX A:

Theories, Assumptions, and Predictions

Name	Utility Function	Assumptions	Equilibrium Levels	Equilibrium Comparative Statics
Self-Interest	$U_i = (E_i - x_i) + P\sum x_i$	$U_{i1} > 0$	0	0
Commitment	$U_i = (E_i - x_i) + PNx_i$	$U_{i1} > 0$	0 or +	0
Pure Altruism	$U_i = U_i([\{E_i - x_i\} + P\sum_i x_i], PN\sum_i x_i)$	$U_{i1} > 0$, $U_{i11} < 0$; $U_{i2} > 0$, $U_{i22} < 0$	0 or +	0 or –
Impure Altruism	$U_i = U_i([\{E_i - x_i\} + P\sum_i x_i], PN\sum_i x_i, x_i)$	$U_{i1} > 0$, $U_{i11} < 0$; $U_{i2} > 0$, $U_{i22} < 0$, $U_{i3} > 0$, $U_{i33} < 0$	0 or +	0 or –
Pure Warm-Glow	$U_i = U_i([\{E_i - x_i\} + P\sum_i x_i], x_i)$	$U_{i1} > 0$, $U_{i11} < 0$; $U_{i2} > 0$, $U_{i22} < 0$	0 or +	0
Reciprocity	$U_i = (E_i - x_i) + P\sum x_i$ s.t. $x_i = \min(x_i^c, x_j \, \forall j \in N)$	$U_{i1} > 0$	0 or +	0 or +