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Reciprocity in groups: Information-seeking in a public goods game

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Abstract

Questions remain about the details of the reciprocal strategies people use in the context of group cooperation. Here we report an experiment in which participants in public goods games could access information about the lowest, median, or highest contribution to the public good before making their own contribution decisions. Results suggest that people have clear preferences for particular pieces of information and that information preferences vary systematically across individuals as a function of their contribution strategies. Specifically, participants playing reciprocal strategies sought information about the median contribution, free riders preferred to view the highest contribution, and altruists had inconsistent preferences. By including a treatment in which people could pay to see information rather than obtaining it for free, we found that people were willing to incur costs to acquire information, particularly those using a reciprocal strategy. Further, adding a cost to view information decreased aggregate contributions, possibly because the motivation to induce others' reciprocal contributions diminished under these conditions. Copyright © 2007 John Wiley & Sons, Ltd.

THE UBIQUITY OF SOCIAL DILEMMAS

Social dilemmas pit individual interest against group interest. If everyone acts in his or her self-interest in a social dilemma, the group as a whole is worse off than if everyone chooses to behave 'cooperatively' or 'altruistically' (Dawes, 1980; Komorita & Parks, 1995; Liebrand & Messick, 1996; Messick & Brewer, 1983).

Social dilemmas occur at many different levels, ranging from dyads to large numbers of people, and can occur both in the context of the production of a good that can be consumed (i.e., public goods

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problems) and in the context of limiting consumption of a resource by members of a group (i.e., commons dilemmas) (Hardin, 1968). For example, at the level of the dyad, the well-known (one-shot) Prisoner's Dilemma (PD) game models a situation in which two people are better off if they cooperate, but will choose to defect if they follow their economic self-interest. At the level of international affairs, everyone is better off to the extent that firms curb pollution, but an individual firm following its own interests will generally choose not to pay for costly pollution controls.

THE PSYCHOLOGY OF RECIPROCITY

Because social dilemmas entail potentially conflicting motives—maximizing net benefits for the self versus maximizing the joint benefits for all the parties involved—a great deal of work has examined the motives that operate in these situations, the contextual variables that influence operating motives, and individual differences in the relative strengths of these motives (e.g., Dawes, 1980; Kollock, 1998).

One extremely important motive identified early in the development of this research agenda was the 'norm of reciprocity', which Gouldner (1960) referred to as a cross-culturally recurring 'universal' norm (see also Brown, 1991). Put in motivational terms, this norm refers to one's motivation to benefit those who have benefited oneself and, in its negative form, the converse. (For more recent work and a precise formulation, see Gintis, 2000, on 'strong reciprocity'.)

In the context of the social dilemma then, the norm of reciprocity implicates a strong motive to respond to cooperation with cooperation and defection with defection. Simplifying slightly: The strength of the norm of reciprocity potentially transforms the PD payoffs because people want to cooperate if and only if the other person cooperates, preferring mutual cooperation to defection when their counterpart has chosen to cooperate (see Kelley & Thibaut, 1978; Van Lange, 1999).

The reason that such a motive might exist as a cross-cultural universal norm was given a theoretical boost from biology with Trivers's (1971) theory of 'reciprocal altruism'. Using the PD game as a model, Trivers showed how the motive to reciprocate could evolve under the appropriate ecological conditions. This proposal was extended by Axelrod's (1984) famous computer tournament that showed how Tit-for-Tat, a strategy that cooperated on the first play of a repeated PD game and then reciprocated the previous move by its partner, could be evolutionarily successful against many other strategies.

Since the formulation of these ideas, there has been tremendous theoretical development that in turn has spawned a vast corpus of empirical findings across the natural and social sciences (Diekmann, 2004; Kollock, 1998; Kopelman, Weber, & Messick, 2002). Details about the psychology of reciprocity have been illuminated using the PD game (e.g., Friedland, 1990; Komorita, Chen, & Parks, 1993; Komorita, Hilty, & Parks, 1991; Komorita, Parks, & Hulbert, 1992), including variables such as the influence of social identity (Orbell, van de Kragt, & Dawes, 1988; Wit & Wilke, 1992). The theory of reciprocal altruism has stimulated research efforts aimed at understanding the cognitive mechanisms involved in maintaining reciprocal relationships (see Cosmides & Tooby, 2006, for a recent review). Crucially for our analysis below, in games such as the PD, there is a great deal of evidence that people differ in the relative strength of certain motives (selfishness, cooperativeness, etc.) in these interactions (e.g., McClintock & Liebrand, 1988; Parks & Rumble, 2001; Van den Bergh, Dewitte, & De Cremer, 2006; Van Lange, 1999; Van Lange & Visser, 1999).

RECIPROCITY IN GROUPS

Of course, many social dilemmas occur in groups larger than dyads. Decisions about water use during a drought represent resource dilemmas (see Liebrand, 1997), and decisions about contributions to public

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goods, such as public radio, represent public goods problems (e.g., Shang & Croson, 2006). Reciprocity in social dilemmas seems to be just as important a motive in groups as it is in dyads. However, elucidating the details of reciprocity in groups is an intricate task because (1) specifying people's reciprocal strategies with precision is complex (Parks & Komorita, 1997; see below) and (2) as in the dyadic case, both theory and a substantial amount of empirical evidence support the view that there are important individual differences in people's reciprocal motives.

Strategies

For dyads, reciprocity is relatively straightforwardly specified. In the PD game, for example, Tit-for-Tat (Axelrod, 1984) responds to cooperation with cooperation and defection with defection. Extending the PD game to multiple players opens a breadth of strategies. For example, in a group consisting of three individuals, if only one of two other players in one's group cooperates, one can cooperate if only one other person cooperates or restrict cooperation to the case in which both others cooperate. The range of possible strategies broadens as the number of players increases (Boyd & Richerson, 1988; see Parks & Komorita, 1997, for a discussion).

The evidence that reciprocity plays an important role in social dilemmas has been mounting for some time. A wealth of data indicates that a substantial number of participants in these experiments contribute as a function of their beliefs about the level of cooperation of other group members. First, players' contributions correlate closely with their reported expectations of other group members' contributions (Bornstein & Ben-Yossef, 1994; Braver & Barnett, 1974; Croson, 1998; Dawes, McTavish, & Shaklee, 1977; Komorita et al., 1992; Messick, Wilke, Brewer, Kramer, Zemke, & Lui, 1983; Yamagishi & Sato, 1986), though this effect is meditated by various factors, such as similarity of group members (Parks, Sanna, & Berel, 2001). Also, many players, though not all, tend to contribute in greater amounts when they are able to observe that other players in the group have already committed some of their endowment to the public good (Dorsey, 1992; Kurzban & Houser, 2001; Kurzban, McCabe, Smith, & Wilson, 2001). Finally, players are willing to incur costs to punish those who contribute relatively little to the public good, hinting at anger directed toward low contributors (Fehr & Gächter, 2002; Yamagishi, 1986). Taken together, these findings strongly suggest that at least some substantial fraction of the population is trying to play some sort of reciprocal strategy in public goods games.

To Whom do People Reciprocate?

Precisely how people in public goods experiments condition their decision on their beliefs about others' level of cooperation remains a matter of some debate, in part because commonly employed methods provide participants information about the aggregate or mean contribution decisions of other members of their group. This, of course, allows only strategies that respond to this information. Reciprocal strategies might, however, be tied to individual group members' contributions, rather than to the mean or other summary statistic (but see Parks & Komorita, 1997). Indeed, evidence from real world contributions to public radio suggests that people's contribution amounts are influenced by information about one specific donor's contribution amount, despite the fact that contributions come from a vast number of donors (Shang & Croson, 2006). Other real world examples include work groups in which some but not all members can be monitored. Indeed, in some cases, a single individual's behavior can

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have important effects on work groups (Felps, Mitchell, & Byington, 2006). Given the inherent noise and imperfection of monitoring, one might expect that in non-laboratory settings, access to summary information about others' behavior would be the exception rather than the rule.

This possibility is central to the hypotheses investigated here. In particular *models of reciprocity in the context of groups suggest that, to avoid being the victim of inequity* (e.g., Fehr & Schmidt, 1999), *people care about and will reciprocate to the least cooperative member of a group* (Kurzban et al., 2001; Sugden, 1984). A related possibility derives from Croson's (1998) finding that people reciprocate to the median contributor in a public goods game. This suggests the alternative hypothesis that people will reciprocate to the median, rather than the least cooperative member of a group. These two possibilities regarding reciprocity in groups motivate Hypothesis 1 below.

Individual Differences

Just as simulations and analytical models have shown that multiple types can persist in populations under replicator dynamics in dyadic interactions (e.g., Aktipis, 2004), simulations and analytic models of social dilemmas with multiple players have shown that populations can equilibrate to, or, at least, reach stability in, a state in which multiple types coexist (Bowles & Gintis, 2004; Dugatkin & Wilson, 1991; Lomborg, 1996; see de Heus, 2000, p. 280, for a discussion of this conclusion).

These models are consistent with decades of empirical evidence that suggest that there are important individual differences in social dilemmas involving multiple players (Budescu, Au, & Chen, 1997; Fischbacher, Gächter, & Fehr, 2001; Goeree & Holt, 2002; Isaac, Walker, & Thomas, 1984; Kortenkamp & Moore, 2006; Liebrand, 1984; see Au & Kwong, 2004 and Kopelman et al., 2002 for reviews; see Kurzban & Houser, 2005, for a recent discussion of the link between individual differences observed in social dilemmas and the simulations that yield mixed populations). In conjunction with the discussion of reciprocity, above, the prediction that there will be substantial, quantifiable individual differences in the motives that people bring to bear in these games motivates Hypothesis 2, below.

In particular, in light of the accumulating evidence, we assume here that there are three types of players with, broadly, three different dominant motives. Specifically, previous research suggests that most of the variation in play is captured by a typology consisting of free riders, who want to maximize their own gains independent of others' payoffs; strong cooperators, who have seemingly altruistic motives; and reciprocators, who, by conditioning their contribution on previous contributions made by other group members, appear to be motivated by some form of aversion to inequity (Fischbacher, Gächter, & Fehr, 2001; Kurzban & Houser, 2005). Taken all together, existing theory and data suggest that different people bring to bear different motives in social dilemma games. However, there is at present little research that directly addresses this question while simultaneously attempting to illuminate the most prevalent strategy, reciprocity. The research reported here represents a step in this direction.

THE CIRCULAR PUBLIC GOODS GAME

A standard method for investigating social dilemmas is the public goods game. In a typical experiment, participants are randomly assigned to groups of n players (usually, $4 \leq n \leq 8$) and faced with a decision to divide a monetary endowment, w, provided by the experimenter. Money is allocated into two

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accounts, a Private Account and a Group Account. Money placed into the Private Account is simply kept by the investing individual. Money placed in the Group Account, x, is increased by a commonly known constant h ($1 < h < n$) and shared equally among all group members. In this environment, agent i's payoff function is given by:

$$\pi_i = (w - x_i) + \frac{h \sum_i x_i}{n}$$

When $1 < h < n$, each unit invested in the Group Account yields the *group* a positive marginal return of $h - 1$. However, investment in the Group Account yields the investing *individual* marginal returns, $h/n - 1$, which is negative given that $h < n$. Thus investment in the Group Account yields a benefit to the group but is costly for the individual. In this (one-shot) game, the unique Nash equilibrium is to contribute zero to the Group Account. A player's contribution to the Group Account is therefore an index of cooperation.

Investigations of reciprocity, both analytic and empirical, use repeated games to examine the phenomenon (Ledyard, 1995; Trivers, 1971). Formally, in the language of game theory, the game that is repeated is referred to as the 'stage game'. It is known that when a social dilemma occurs as a stage game that is repeated, uniform cooperation can be an equilibrium (Friedman, 1971). That is, in repeated social dilemmas, a rational, self-interested actor's best move is not necessarily to defect; it can be to cooperate. Importantly, reciprocity—the focus here—is one key strategy that can stabilize cooperation in repeated stage games (Axelrod, 1984; Axelrod & Hamilton, 1981).

We used the 'circular public good' method developed by Kurzban and Houser (2001). This game is essentially a repeated social dilemma, analogous to the repeated PD, but with more than two players. The circular public goods game consists of simultaneous initial contributions followed by sequential 'turns' in which participants, one at a time, may revise their contribution amount after viewing information about others' contributions. Each player receives an endowment and makes an initial allocation to the Individual and Group Accounts. Following these simultaneous initial contributions, players view information about others' current contributions to their group and may revise their own contribution. After each turn, there is a known probability ($p = .04$) that the game will end. When the game ends, players' current contributions are taken as the contributions for that game. Participants typically play 15–20 repetitions of this game within an experimental session.

So, in the circular game, each player faces, during each turn, a social dilemma, in which one's own outcomes are set in opposition to the group's outcome. However, the circular game allows us to investigate these decisions when players have information about others' contributions, which affords a look at the topic of interest here, reciprocal strategies. In the analysis below, therefore, reciprocity is indexed by players' decisions to contribute as a positive function of others' contributions.

HYPOTHESES AND PREDICTIONS

In the current experiments, an information-seeking paradigm is employed. Specifically, during each turn, participants choose among viewing the lowest, the median, or the highest contribution of the other members of their group. The rationale for this procedure is the assumption that *participants will seek the information that is most relevant to their contribution strategies*. If a player is motivated by some form of reciprocity, it follows that, to satisfy such a motive, the player must seek information relevant to responding to others' contributions. Given the possibility that people might be motivated to avoid inequity by matching the lowest (Kurzban et al., 2001; Sugden, 1984) or median (Croson, 1998)

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contributor, we hypothesize that people will seek information to accommodate this motive. Hence, our primary hypothesis of interest concerns the information preferences of reciprocal players.

Hypothesis 1: When given the opportunity to observe only one other group member's contribution to the public good, people will choose preferentially to observe the lowest (H1a) or the median (H1b) contributor to the group.

The findings described above regarding individual differences lead to our second hypothesis.

Hypothesis 2: There are observable individual differences in information preferences and these differences will correlate with individual differences in contribution patterns. In particular, reciprocating individuals will have a preference for the lowest or the median contribution (see Hypothesis 1), while strong free riders and strong cooperators will not show systematic preferences.

We add a treatment to look at the strength of these hypothesized desires to obtain information about others' contributions. Specifically, we run one condition in which information is free and one condition in which information can be purchased at a small cost. If reciprocators do use information about the contributions of others to make their decisions, we expect that they will be more willing to pay for this information than altruists and free riders.

Hypothesis 3: Participants who employ reciprocal strategies will be more willing to pay for information than others.

Further, assume that reciprocal motives include both (1) the preference for contributing as a positive function of others' contributions, and (2) contributing to induce others to contribute. If so, contributions should decrease when these motives are undermined. Basic economic principles imply that Costly Information will be consumed less frequently than Free Information. Therefore, charging individuals to observe information should decrease the strength of both reciprocal motives. The expected result of decreasing the second of these two motivations is particularly clear: If players believe that their contributions are less likely to be observed, then they should be less concerned that low contributions will be seen and matched by other players, decreasing their payoff from the public good.

Hypothesis 4: Charging players for the opportunity to observe others' contributions should lead to greater free riding (i.e., lower contributions to the public good).

SUMMARY

The experiment reported below was conducted to investigate these hypotheses. Participants played circular public goods games and were given the opportunity to observe the contribution of one other group member, either for free or at a cost.

METHOD

Participants

A total of 108 participants were recruited from the University of Pennsylvania using a web-based recruitment system. Participants were told that they would earn $5 for showing up and would earn additional money during the course of the experiment.

DOI: 10.1002/ejsp

Procedure

A four-player circular public goods game was repeated 10–19 times. The number of games varied across sessions because some sessions' participants proceeded more slowly than others, limiting the number of games that could be played within the time allotted. Each game consisted of initial contributions followed by 4–36 turns (unknown to participants), in which contributions could be changed. Because our interest was in within-game (rather than between-game) reciprocity, after each game groups were randomly recomposed (Andreoni, 1988; Croson, 1996).

The circular public goods game was conducted by computer. Participants were seated at computer terminals separated by partitions so they could not see one another. Once seated, they read instructions that explained the game. Following the instructions, participants completed a 10-item quiz that ensured their understanding of the game (Andreoni, 1995; Houser & Kurzban, 2002). After all participants successfully completed the quiz, the experiment began.

At the beginning of each game, endowments of 50 tokens (participants were informed that 5 tokens = \$1) were placed in the Individual Account of each participant. Participants simultaneously made initial contributions by typing an amount from 0 to 50 that they would contribute to the Group Account. Following initial contributions, one at a time, each participant took a turn; they had 30 seconds to view information—the low, median, or high contribution (excluding the participant's own previous contribution)—and could choose to change their contribution amount. After the pre-determined random number of turns following initial contributions, the game ended, and the most recent contribution amounts determined participants' payoffs for that game. Participants earned one token for each token in the Individual Account, while tokens in the Group Account were doubled ($h = 2$) and divided equally among the four players. Both their payoff and the aggregate contribution to the Group Account were reported to participants between games. After each game, groups were recomposed randomly, and the next game began. Participants were subsequently paid their average payoff across games in addition to their \$5 show-up payment. They received their earnings privately in a sealed envelope and were dismissed.

Treatments

There were two treatments. In the Free Information condition ($n = 56$), players chose to view any one of the three possible pieces of information (low, median, high) at no cost. The Free Information condition was run in four experimental sessions consisting of 12, 12, 16, and 16 individuals. Participants did not know exactly how many others were in their session.

In the Costly Information condition ($n = 52$), participants could choose not to view information or to pay a small fee (two tokens) if they viewed information. Participants were permitted to view at most one piece of information in each turn. The fee was assessed only if the participant viewed the information on the turn before the game ended. This prevented participants from being charged for information multiple times within the same game. The Costly Information condition was run in four sessions consisting of 8, 12, 16, and 16 individuals.

RESULTS

All analyses and figures exclude initial contributions because participants knew that they would have at least one chance to change this amount, making these contributions, in effect, 'cheap talk'. Apparently

DOI: 10.1002/ejsp

realizing this, nearly all participants made initial contributions of 50, including individuals who consistently contributed 0 in all other turns. Game 19, which was reached in only a fraction of the experimental sessions, was excluded in analyses using Game as an independent variable because of the small number of observations in both conditions.

Contributions

We begin the analysis looking at contributions to the Public Good. In the Free Information condition, the mean (*SD*) contribution was 24 (20) tokens. Contributions decayed with repetition (turns) from about 70% of the endowment to 25% ($F(1,30) = 292.75$, $p < .001$, $\eta^2 = 0.91$; see Figure 1a). Contributions did not, however, decrease across games ($F(1,16) = 1.47$, $p = .24$, $\eta^2 = 0.08$; see Figure 1b). In the Costly Information condition, the mean (*SD*) contribution was 17 (19) tokens. Contributions decayed with repetition (turns) from about 50% of the endowment to 8% ($F(1,30) = 103.24$, $p < .001$, $\eta^2 = 0.78$; see Figure 1a). Again, mean contributions did not decline across games ($F(1,16) = 0.14$, $p = .71$, $\eta^2 < 0.01$) (see Figure 1b). The within- but not between-game decline in both conditions is consistent with individuals viewing reconstituted groups in new games as relatively independent of previous games (Andreoni, 1988; Croson, 1996).

An ANOVA conducted on the mean contributions in each session (4 per condition) indicates that contributions were significantly lower in the Costly Information condition ($F(1,6) = 77.17$, $p = .05$, $\eta^2 = 0.50$), as predicted by Hypothesis 4.

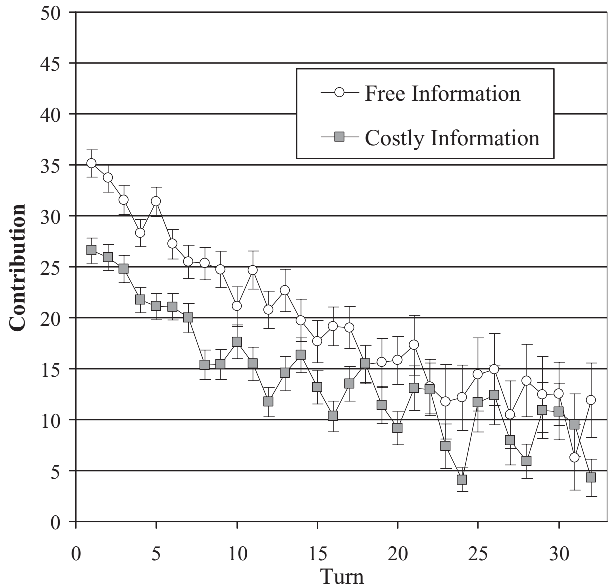
To summarize, we find that contributions decrease within (but not between) games, the pattern typically observed in repeated public goods games, and contributions are greater when information about others' contributions is free.

Information-seeking

We now turn to the question of which information participants chose to look at, the lowest, median, or highest current contribution to the Public Good, starting with the Free Information condition. Here, participants made an average (*SD*) of 53 (12) information decisions. Our interest was in how often participants chose each type of information. We express information preferences as percentages of all choices for clarity. We find that the mean (*SD*) percentages, across participants, for low, median, and high information were 35% (28), 35% (30), and 30% (27), respectively.[1] While the roughly equal distribution across information types might reflect individuals choosing randomly, another possibility is that individual differences in information preferences underlie this pattern (see Hypothesis 2). To investigate this possibility, we test whether, for each individual, information preferences were distinguishable from a random distribution. We therefore conducted a chi-square analysis of information choices for each of our 56 participants in the Free Information condition. For 53 of these participants, information choices differed significantly from chance. That is, nearly all participants favored one type of information.[2]

[1]Subjects' information preferences might not be independent. Participants could, in principle, influence one another's information preferences through their contribution decisions, which are themselves influenced by their own information preferences. This seems unlikely because individual preferences were relatively stable—on average (*SD*), participants chose their preferred information type 68% (16) of the time—even though group composition changed many times during an experimental session. In the Costly Information condition, looking only at individuals who paid for information more than 10 times, this figure is 69% (19).
[2]For brevity, we summarize, rather than report exhaustively, these statistical tests. In these analyses, the degrees of freedom for the Chi Square statistic was $(2, N)$, where $35 \leq N \leq 75$. The value of the test statistic ranged between 6.4 and 111, and all *p*s < .05. A conservative Bonferroni adjustment requiring $p < .0009$ (.05/56) yields 44 of 56 individuals differing from adjusted chance levels.

DOI: 10.1002/ejsp



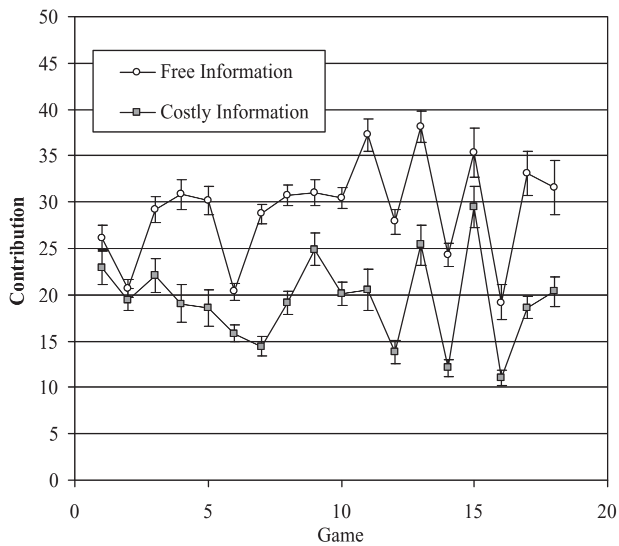


Figure 1. Contributions by Turn (1a, top) and by game (1b, bottom). Error bars are standard errors

Turning to the Costly Information condition, participants had an average (*SD*) of 73 (2) opportunities to pay to view information. They did so an average (SD) of 46% (32) of the time. Paying for information decreased across turns ($F(1,30) = 92.56$, $p < .001$, $\eta^2 = 0.76$), but not across games ($F(1,16) = 0.17$, $p = .68$, $\eta^2 = 0.01$). Again, percentages for each participant were calculated for each information type. Average (*SD*) percentages, across participants, for low, median, high, and no information (i.e., chose not to pay to view information) were 11% (15), 21% (23), 14% (15), 54% (32), respectively. Within-subject tests indicated that median was chosen significantly more than low ($t(51) = 2.63$, $p < .05$, $d = 0.50$), but the difference between median and high was not significant ($t(51) = 1.76$, $p = .085$, $d = 0.34$). Finally, a chi-square analysis on individuals choosing information

DOI: 10.1002/ejsp

more than 10 times ($n = 38$) revealed that 34 of 38 individuals differed significantly from chance in their choice of information to observe.[3]

To summarize, we find that in both conditions the vast majority of participants had information preferences that differed from a chance distribution of choices. Below, we extend this analysis in more detail by examining the relationship between player type and information choices.

Evaluating Player Type

In order to examine the link between individuals' contribution strategies and information-seeking, it is necessary to quantify contribution behavior. A continuous classification of player strategy was developed to characterize the extent to which individuals acted as reciprocators, free riders, and altruists. As discussed above, behavioral types have been reported in previous games with similar structures (e.g., Fischbacher et al., 2001; Kurzban & Houser, 2005).

To classify players' contribution strategies, for each participant, we conduct a straightforward OLS regression of contribution amount on information seen (see Figure 2). From this regression, we derive three measures. The Reciprocity Index (RI), which indicates the extent to which a participant's contribution decisions are influenced by the contributions of others, is simply the regression coefficient of the slope of the best fit line.[4] The Altruism Index (AI) is the y-intercept, which indicates how much the participant contributes when they have seen that another participant has contributed nothing. Finally, the Free-riding Index (FI) is determined by the value of the best fit line when the participant has seen that another participant has contributed 50, the maximum contribution. This value indicates how a participant acts when another participant is fully cooperative. For clarity, this value is subtracted from 50 so that high values correspond to greater free-riding.

Player types are regarded as mutually exclusive. Therefore, measures of player type should be interrelated. Indeed, because they are drawn from the best fit line of contributions on information seen, any combination of two values—two points or a point and the slope—uniquely determines the third value. This typology can be conceptualized as a simplex, in which the vertices are reciprocity, altruism, and free-riding, with high index values signifying proximity to the associated vertex (see Figure 3).

Of course, these measures are only meaningful with a sufficiently rich data set. Across conditions, participants averaged more than 50 contribution decisions following an opportunity to view information about others' contributions. Nearly all participants (91 of 94) viewed the full range of possible contributions (0–50), allowing us reasonable confidence in estimating the index values.

For each participant, the analysis of types was employed to determine RI, FI, and AI values.[5] For participants in the Costly Information condition, indices were computed for individuals who purchased

[3]In these analyses, the degrees of freedom for the Chi Square statistic was (2, N), where $19 \leq N \leq 73$. The value of the test statistic ranged between 6.2 and 96, and all ps $< .05$. A conservative Bonferroni adjustment requiring $p < .001$ (.05/38) yields 26 of 38 individuals differing from adjusted chance levels.

[4]As in similar analyses (e.g. Axelrod, 1984), what is here termed 'reciprocity' might reflect online computations of long-term self-interest or simple preferences to reciprocate (presumably evolved for capturing long-term benefits). Distinguishing between these proximate mechanisms is not of direct interest here. Our questions regarding responses to others' contributions do not hinge on which of these underlying cognitive systems is operative, because, *a priori*, both putative computational systems should be equally likely to take this information as input.

[5]Data used to establish these indices are not necessarily independent. A participant's contribution decision might be influenced not only by information seen in the current turn, but also by information seen in prior turns. To investigate this possibility, a multiple regression was conducted (Free Information condition) of contributions on information seen in the current turn, the previous turn, and two turns prior, controlling for turn ($n = 1473$). The overall model was significant ($F(4,1468) = 118.8$, $p < .001$). The coefficient on information seen in the current turn was significant ($F(1,1471) = 171.8$, $p < .001$, coefficient $= .38$). The coefficient on the previous turn was significant ($F(1,1471) = 13.4$, $p < .001$, coefficient $= .11$,) but less than one third as large. The effect of information seen two turns prior was not significant ($F(1,1471) = 2.23$, $p = .14$). Thus, when interpreting the results of the regressions reported in Table 1, it should be borne in mind that information seen in the immediately previous turn influences contribution decisions, though the influence is substantially smaller than that of information seen in the current turn.

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information at least 10 times ($n = 38$); the remaining 14 participants were excluded from analyses of player type. Table 1 (second column) reports the mean (*SD*) values of RI, FI, and AI for both the Free and Costly Information conditions.

Again, because strategies are mutually exclusive, index values must be negatively correlated within individuals. The correlations among RI/FI, RI/AI, and AI/FI were −.75, −.53, and −.16, respectively, in the Free Information Condition, and −.84, −.08, and −.47, respectively, in the Costly Information condition.

Having characterized individuals' strategies, we now turn to the relationship between contribution strategies and information-seeking.

Player Type and Information Choices

We conducted regression analyses of information choices on player type.[6] Table 1 (right three columns) reports the results. In both conditions, Reciprocity positively predicted median and negatively predicted high, while Free-riding showed the reverse pattern. No other regressions were significant.

Of course, we cannot evaluate the link between type and information preference among individuals who did not purchase information in the Costly information condition. However, looking at those who purchased information less than 40% of the time ($n = 21$, or 40% of our sample), the number of individuals with mean contributions 0–10, 11–20, 21–30, 31–40, and 41–50, were 13, 1, 3, 2, and 2, respectively, suggesting that people who do not look at information tend to free ride.

To summarize, people who are showing more reciprocal strategies tend to observe the median information; people who free ride a great deal tend to observe the high information.

Exploratory Analyses

We conclude by asking three additional questions. We first asked whether people who used different strategies earned different amounts of money. To answer this, we categorized each participant as a reciprocator, altruist, or free rider using the maximum value of their scores on the AI, FI, and RI indices (multiplying RI by 50). In the Free Information condition, this yielded 29 reciprocators, 13 altruists, and 14 free riders. In the Costly Information condition, participants who purchased information fewer than 10 times were excluded, leaving 38 participants consisting of 26 reciprocators, 2 altruists, and 10 free riders. (Note that excluded individuals were more likely to be altruists or free riders, given that these strategies do not depend on information.) In the Free Information condition, the mean (*SD*) payoffs were 72.0 (5.9), 69.6 (7.0), and 71.9 (9.6) for reciprocators, altruists, and free riders, respectively. There were no significant differences among these values. In the Costly Information condition, the mean (*SD*) payoffs were 63.4 (5.8), 56.4 (13.8), and 70.0 (7.1) for reciprocators, altruists, and free riders, respectively. Free riders earned significantly more than reciprocators ($F(1,34) = 8.38$,

[6]Our analysis of information preferences as a function of player type had a potential endogeneity problem. Information preferences could have influenced our measure of player type if (1) information preferences substantially biased the distribution of observed contribution values, and (2) individuals' strategies were nonlinear functions of observed values. The rationale for the latter requirement is that a linear strategy is fully determined by any two different points, so if observed values are biased by information preferences, the typing procedure remains uncompromised. If both conditions obtained, our analysis contains a degree of circularity. We think this is unlikely for two reasons. First, typed participants observed an average of 50 contribution values, and nearly all (91/94) observed the full range of contribution values (0–50); thus information preferences did not restrict the range of observed values. Second, there is evidence that individuals' contribution strategies were linear functions of observed values as indicated by mean Pearson correlation coefficients across participants ($r = .51$ in Free Information, $r = .63$ in Costly Information).

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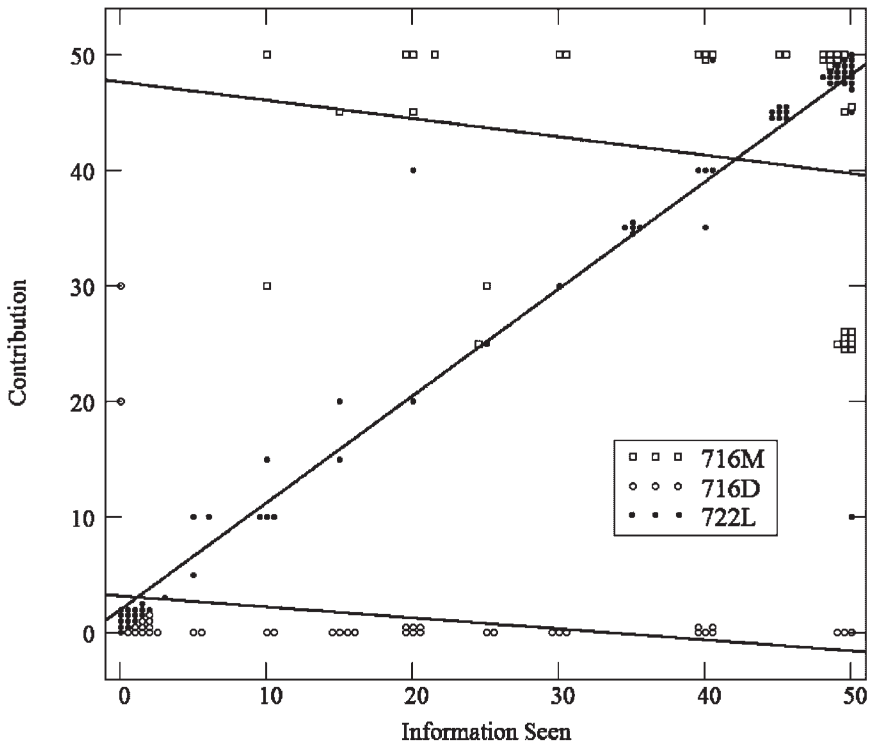

Figure 2. Examples of best fit line for three selected participants in the Free Information treatment that nicely illustrate the indices. The values of the indices (see text) are RI = 0.94, AI = 2.0, FI = 1.1 (722L), RI = −0.12, AI = 46.6, FI = 9.3 (716M), and RI = −0.08, AI = 2.7, FI = 51.4 (716D)

$p < .01$, $\eta^2 = 0.20$) and altruists ($F(1,10) = 4.76$, $p < .05$, $\eta^2 = 0.32$). The difference between reciprocators and altruists was not significant ($F(1,26) = 2.30$, $p = .14$, $\eta^2 = 0.08$).

Second, we asked whether people who used different strategies choose different information. We used the same classification scheme as above to look at information choices, collapsing across conditions. For individuals categorized as reciprocators ($n = 55$), the mean (*SD*) percentages for low, median, and high were 28% (28), 50% (28), and 23% (20), respectively. Paired *t*-tests revealed that median was chosen more than high ($t(54) = 4.98$, $p < .001$, $d = 1.10$) and low ($t(54) = 3.05$, $p < .01$, $d = 0.77$); there was no difference between high and low (see Figure 4). For free riders ($n = 23$), mean (*SD*) percentages for low, median, and high were 28% (26), 18% (24), and 53% (33), respectively. High was chosen more than median ($t(23) = 3.27$, $p < .01$, $d = 1.24$) and low ($t(23) = 2.25$, $p < .05$, $d = 0.86$); there was no difference between median and low. Among altruists ($n = 14$), mean (*SD*) percentages for low, median, and high were 43% (28), 30% (26), and 28% (25), respectively; these values did not differ significantly from one another.

Third and finally, we asked whether reciprocators were more willing to pay for information than altruists or free riders. This would afford the interesting but somewhat subtle prediction that the information reciprocators prefer should be disproportionately represented in the Costly Information condition. Because reciprocity predicted median in both experimental conditions, it follows that median should be chosen in greater proportion in the Costly Information condition than in the Free Information condition.

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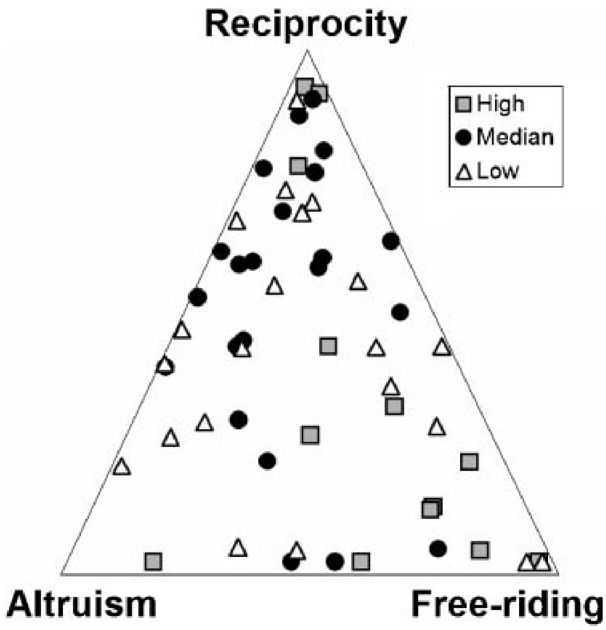

Figure 3. Reciprocity, Altruism and Free-riding indices for participants in the Free Information condition. Higher index values are closer to the associated vertex. Shape indicates participant's most frequently chosen information type. Note: Some index values were negative and thus fall off of the simplex opposite the given vertex; because the purpose of this graph is to illustrate which vertex each individual is closest to, negative index values are presented as '0' for clarity of presentation

In order to render the aggregate information-seeking data comparable across conditions, percentages were computed for the information preferences of each participant in the Costly Information condition *given that information was chosen* (i.e., ignoring cases in which no information was chosen). Then, mean percentages were computed across participants *weighted by the fraction of the time that information was chosen*. The weighted means (*SD*) were high 31% (18), median 45% (20), and low 24% (17). Median information was chosen significantly more in the Costly Information condition (45%) than in the Free Information condition (35%) ($t(106) = 1.73$, one-tail, $p < .05$,

Table 1. Regressions of information on player type index

Index	Mean (*SD*)	Low	Median	High
Free Information				
Reciprocity	0.43 (0.30)	ns, $\eta^2 = 0.02$	*Positive***, $\eta^2 = 0.16$	*Negative**, $\eta^2 = 0.09$
Free-riding	14.7 (14.9)	ns, $\eta^2 < 0.01$	*Negative**, $\eta^2 = 0.10$	*Positive***, $\eta^2 = 0.12$
Altruism	13.8 (11.6)	ns, $\eta^2 = 0.04$	ns, $\eta^2 = 0.04$	ns, $\eta^2 < 0.01$
Costly Information				
Reciprocity	0.56 (0.22)	ns, $\eta^2 = 0.02$	*Positive**, $\eta^2 = 0.15$	*Negative****, $\eta^2 = 0.28$
Free-riding	13.5 (12.6)	ns, $\eta^2 = 0.01$	*Negative**, $\eta^2 = 0.14$	*Positive***, $\eta^2 = 0.24$
Altruism	8.6 (6.9)	ns, $\eta^2 < 0.01$	ns, $\eta^2 < 0.01$	ns, $\eta^2 < 0.01$

Values in cells indicate whether the coefficient on the index (row) on information (column) was significantly different from zero, its direction if so (positive or negative), and the effect size, η^2. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

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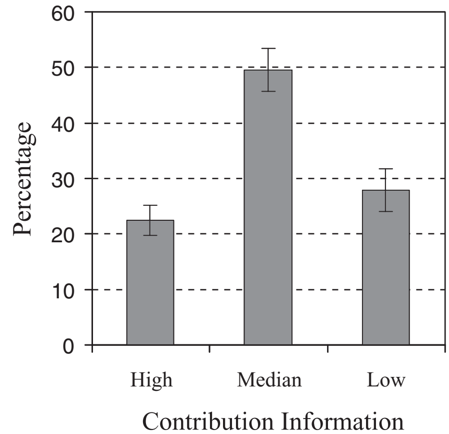

Figure 4. Reciprocators' information preferences. Mean percentages for information types chosen by reciprocators in both conditions ($n = 55$)

$d = 0.39$). Thus, reciprocators' preferred information choice (median) was disproportionately viewed in the Costly Information condition, indicating that reciprocators were more willing to pay for information than others.

To summarize this last set of analyses, we find that the answers to the questions posed above are that (1) free riders earn more, but only in the Costly Information condition; (2) reciprocators tend to choose information about the median contribution whereas free riders tend to choose information about the highest contribution; and (3) the Median information was chosen more frequently in the Costly Information condition.

DISCUSSION

Evaluation of Hypotheses

We began with four hypotheses. These hypotheses were as follows: People would have particular preferences in the information they observed (Hypothesis 1), there would be systematic individual differences in these preferences (Hypothesis 2), those who played more reciprocally would be more willing to pay for information than those who played less reciprocally (Hypothesis 3), and charging a price for information would increase the amount of free riding (Hypothesis 4). These hypotheses all received support, though with important caveats.

Hypothesis 1. Models that explain contributions in public goods games in terms other than reciprocity, such as confusion (Andreoni, 1995), altruistic preferences (Andreoni, 1990), and social identity (Brewer & Kramer, 1986) make no prediction that people will care about and endure costs to observe others' contributions.

In contrast, our data suggest that a substantial fraction of participants do care about others' contributions. We find that, consistent with the first hypothesis, (1) players have clear preferences in the information that they seek, as indicated by non-random distributions of information choices and (2) players are willing to incur costs to view others' contributions, choosing to pay to do so nearly half of the time that they were given the opportunity. These findings are consistent with models that posit reciprocity as a motive in public goods games, but are not obviously predicted by other models (described above).

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Hypothesis 2. Our findings regarding individual differences, consistent with hypothesis 2, suggest that information preferences must be disaggregated because the information people seek depends on their contribution pattern. Participants playing reciprocal strategies preferred to observe the median contribution to the public good, consistent with Croson's (1998) findings. This result sheds light on the question with which we began our inquiry: Which of the many possible different reciprocal strategies characterize the psychology of cooperation in groups? Reciprocal strategies are common, and they include a concomitant preference for information about the median contribution to the group. Free riders, in contrast, preferred to observe the highest contribution, as though they were chiefly interested in knowing how much money they were likely to earn. Information preferences were not consistent across altruists, suggesting one potentially important area of future inquiry.

Hypothesis 3. The particular information preference of reciprocators—the median—was chosen to a greater extent in the Costly Information condition than in the Free Information condition. This provides further evidence that reciprocators were more willing to pay for information than altruists and free riders.

These findings—that both information preferences and willingness to pay for information were correlated with contribution patterns—add to the weight of evidence that there are 'types' of players in public goods environments (Fischbacher et al., 2001; Kurzban & Houser, 2005), and that these types have potentially important effects on dynamics of play.

It is tempting to link these types to the tripartite 'social value orientation' (SVO) system developed in the context of dyadic interactions (Messick & McClintock, 1968). This system groups people into prosocials (concerned with mutually beneficial and equitable outcomes), individualists (concerned with maximizing one's own outcome), and competitors (concerned with maximizing one's relative advantage). These types might map, to some extent, onto our observed types. SVO has indeed been found to predict behavior in social dilemma contexts (Kramer, McClintock, & Messick, 1986; Parks & Rumble, 2001; Van Vugt, Meertens, & Van Lange, 1995; but see Parks, 1994). In particular, prosocials resemble our reciprocal types in that they have been shown to have stronger reciprocal preferences than the other two types (Van Lange, 1999; Van Lange & Kuhlman, 1994). Similarly, those individuals who chose not to pay for information in the Costly Information condition might be individualists or competitors. Finally, competitors might be distinguishable from individualists by the former's tendency to free ride—individualists will cooperate to serve their instrumental goal of inducing cooperation from others, whereas competitors are less likely do so.

More broadly, understanding the differences in play in public goods environments will be improved by linking behavior with underlying differences in motives, which might vary as a function of either situational features (e.g., the incentive structure in a given interaction) or stable individual differences (Kelley & Stahelski, 1970; Pruitt & Kimmel, 1977). Future work should be aimed at developing this connection, perhaps by assessing the SVO of people in these types of games and looking at the relationship between this variable and behavior. The present data, as indicated above, look only obliquely at individual differences in motives through the window of individual differences in behavior.

Hypothesis 4. The lower levels of contributions in the condition in which information was costly support Hypothesis 4. This finding implies that players believe that others play reciprocal strategies. If players know that their own free riding behavior is less likely to lead to others' decreasing their own contributions, then the incentive to free ride is greater, leading to lower contributions throughout.

An alternative explanation for this result derives from the finding that social uncertainty tends to decrease contributions in pubic goods games (Liebrand, Wilke, Vogel, & Wolters, 1986; Wit & Wilke, 1998). For example, Wilson and Sell (1997) reported the finding that '[i]ncreased information about the past behavior of subjects. . .decreases levels of contributions to the public good' (p. 695). In the present experiments, in the condition in which participants had to pay for information about others, their uncertainty would obviously have been greater about other group members' contributions because the

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number of observations they had available was smaller. This effect is still the subject of debate and continued research (Van Dijk, Wit, Wilke, & Budescu, 2004).

LIMITATIONS AND CAVEATS

There are, of course, important limitations of the present studies. For example, it could be that allowing participants to request information increases the probability that people will use reciprocal strategies, in which case our method, rather than illuminating reciprocity, is eliciting it. We cannot rule out this possibility, but our behavioral findings are reasonably close to those observed in similar studies that we think such a possibility is unlikely (Kurzban & Houser, 2005). Similarly, it could be the case that observing certain distributions of information changes the way that players respond to the information they observe. For example, it could be that observing the 'high' information and, consequently, observing contributions that tend to be large, might cause less reciprocity and more free riding (driving our finding of the relationship between free riding and high information-seeking). If this is the case, then our analysis of the relationship between player type and information preferences has a potential circularity problem. We have no reason to believe that the distribution of values one observes changes how one responds to others' contributions, but we cannot rule this out, and this result should be approached with appropriate caution.[7]

Of course, the present research puts severe restrictions on the information available to participants, limiting inferences about their reciprocal preferences. Reciprocal strategies and motives might take many different forms (see e.g., Parks & Komorita, 1997), and substantial additional work will be necessary to clearly delineate people's reciprocal strategies. The information-search method used here represents a potentially important first step in developing techniques to understand the motives that people have in the context of social dilemmas, particularly because one important motive seems to be some form of group-based reciprocity.

In addition, because the focus here was on behavioral reciprocity, we have neglected a potentially important element of the psychology: A desire for 'fairness' or 'equity' (e.g., Fehr & Schmidt, 1999; Walster, Walster, & Berscheid, 1978). This omission should not be taken to imply that we believe that these are unimportant for understanding the psychology of cooperation and reciprocation in groups; however, the current methods are not well suited to examining this question in detail. Games in which people differ in their endowments, for example, might be better suited to investigating this very important issue (Goren, Kurzban, & Rapoport, 2003; Goren, Rapoport, & Kurzban, 2004).

Finally, as discussed above (see Footnotes 1–6), there are potential difficulties with the interpretation of the statistical analyses presented here, though, for the reasons indicated, we believe that they do not seriously undermine our general conclusions. Nonetheless, these potential analytical limitations should be considered when interpreting the data we present here.

BROADER IMPLICATIONS AND FUTURE DIRECTIONS

If individual differences in play in these games were simply the result of noise or confusion (Andreoni, 1995; Houser & Kurzban, 2002), we would expect contributions to decline from game to game and we would have no reason to expect any relationship between contribution decisions and information-

[7]We thank two anonymous reviewers for highlighting the importance of addressing these two issues.

seeking. In contrast, we find minimal decline over the course of play and that reciprocal behavior correlates with preferences for the median information.

This suggests that individual differences are not idiosyncratic, but rather reflect *strategic* types in our sample, with psychologically appropriate features clustering around each. This view is bolstered by recent work by Kurzban and Houser (2005), who found that the three types of players they were able to distinguish in their experimental games, reciprocators, altruists, and free riders, earned statistically indistinguishable amounts across games. This result occured because different types fared differently depending on the composition of the groups into which they were placed. This result was replicated in the Free Information condition, though not in the Costly Information condition, suggesting the sensitivity of the performance of these strategies to the details of the institution in which they are engaged.

Taken together, these observations might speak to an enduring puzzle, the ultimate evolutionary explanation for how cooperation in groups in humans evolved. The building weight of evidence that there are distinct types in the population which are visible under certain parameters of the game suggests the possibility that participant populations are at some sort of polymorphic equilibrium. Such an equilibrium can have many potential causes (Maynard Smith, 1982), and we feel it is premature to take a firm position on the question of whether populations are at indeed at some sort of equilibrium, and, if so, how it is maintained.

More generally, the results presented here, in combination with existing data, build support for the view that reciprocity is at least one piece of the puzzle in explaining cooperation in groups. It is also clear, however, that reciprocity does not account for all variability in play in public goods environments. A complete explanation for the wealth of observed data must incorporate differences among players in their willingness to contribute to public goods, the extent to which they condition their contributions on others' contributions, and the information that they seek when making their own contribution.

Reciprocal strategies appear to be one part of the explanation for cooperation in groups. The circular game and, in particular, the information-seeking technique, are well suited to exploring reciprocity in greater detail. It would be valuable, for example, to expand the size of the groups to see how preferences change as the range of possibilities expands. Similarly, providing different kinds of information among players' options, such as the mean and the range, might also help to clarify information preferences. Additional techniques should also be used to develop a richer picture of reciprocal play. For example, using viewing time as a dependent measure, which is increasingly easy given new technologies, could be promising in this respect (Biele & Rieskamp, 2004). Given that reciprocal actions are a function of information about the actions of others, detailed knowledge of regularities in information-seeking is potentially important for developing a deeper understanding cooperation in groups.

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REFERENCES

Aktipis, C. A. (2004). When to walk away: Contingent movement and the evolution of cooperation. *Journal of Theoretical Biology*, *231*, 249–260. DOI:10.1016/j.jtbi.2004.06.020

Andreoni, J. (1990). Impure altruism and donations to public goods: A theory of warm-glow giving. *Economic Journal*, *100*, 464–477.

Andreoni, J. (1995). Cooperation in public goods experiments: Kindness or confusion? *American Economic Review*, *85*, 891–904.
Andreoni, J. (1988). Why free ride? Strategies and learning in public goods experiments. *Journal of Public Economics*, *37*, 291–304.
Au, W. T., & Kwong, Y. Y. (2004). Measurements and effects of social value orientation in social dilemmas: A review. In R. Suleiman, D. V. Budescu, I. Fischer, & D. Messick (Eds.), *Contemporary psychological research on social dilemmas*. New York: Cambridge University Press.
Axelrod, R. (1984). *The evolution of cooperation*. New York: Basic Books.
Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science*, *211*, 1390–1396.
Biele, G., & Rieskamp, J. (2004). Reciprocity, reinforcement learning, and local adaptation learning as models of cooperation in social group dilemmas. *Presentation at the Human Behavior and Evolution Society Meeting, Berlin, Germany*.
Bornstein, G., & Ben-Yossef, M. (1994). Cooperation in intergroup and single-group social dilemmas. *Journal of Experimental Social Psychology*, *30*, 52–67. DOI: 10.1006/jesp.1994.1003
Bowles, S., & Gintis, H. (2004). The evolution of strong reciprocity: Cooperation in heterogeneous populations. *Theoretical Population Biology*, *65*, 17–28. DOI: 10.1016/j.tpb.2003.07.001
Boyd, R., & Richerson, P. J. (1988). The evolution of reciprocity in sizable groups. *Journal of Theoretical Biology*, *132*, 337–356. DOI: 10.1016/S0022-5193(88)80219-4
Brewer, M. B., & Kramer, R. M. (1986). Choice behavior in social dilemmas: Effects of social identity, group size, and decision framing. *Journal of Personality and Social Psychology*, *50*, 543–549.
Braver, S. L., & Barnett, B. (1974). Perception of opponent's motives and cooperation in a mixed-motive game. *Journal of Conflict Resolution*, *18*, 686–699. DOI: 10.1177/002200277401800408
Brown, D. (1991). *Human universals*. Philadelphia: Temple University Press.
Budescu, D. V., Au, W. T., & Chen, X. P. (1997). Effects of protocol of play and social orientation on behavior in sequential resource dilemmas. *Organizational Behavior and Human Decision Processes*, *69*, 179–193.
Cosmides, L., & Tooby, J. (2006). Neurocognitive adaptations designed for social exchange. In D. B. Buss (Ed.), *The handbook of evolutionary psychology* (pp. 584–627). Hoboken, NJ: Wiley.
Croson, R. T. A. (1996). Partners and strangers revisited. *Economics Letters*, *53*, 25–32.
Croson, R. T. A. (1998). Theories of altruism and reciprocity: Evidence from linear public goods games. Unpublished manuscript, University of Pennsylvania.
Dawes, R. (1980). Social dilemmas. *Annual Review of Psychology*, *31*, 169–193.
Dawes, R. M., McTavish, J., & 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.
de Heus, P. (2000). Do reciprocal strategies work in social dilemmas? *Personality and Social Psychology Review*, *4*, 278–288.
Diekmann, A. (2004). The power of reciprocity: Fairness, reciprocity, and stakes in variants of the dictator game. *Journal of Conflict Resolution*, *48*, 487–505. DOI: 10.1177/0022002704265948
Dorsey, R. E. (1992). The voluntary contributions mechanism with real time revisions. *Public Choice*, *73*, 261–282. DOI: 10.1007/BF00140922
Dugatkin, L. A., & Wilson, D. S. (1991). ROVER: A strategy for exploiting cooperators in a patchy environment. *American Naturalist*, *138*, 687–701.
Fehr, E., & Gächter, S. (2002). Altruistic punishment in humans. *Nature*, *415*, 137–140.
Fischbacher, U., Gächter, S., & Fehr, E. (2001). Are people conditionally cooperative? Evidence from a public goods experiment. *Economic Letters*, *71*, 397–404.
Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, *114*, 817–868.
Felps, W., Mitchell, T. R., & Byington, E. (2006). How, when, and why bad apples spoil the barrel: Negative group members and dysfunctional groups. *Research in Organizational Behavior*, *27*, 181–230.
Friedland, N. (1990). Attribution of control as a determinant of cooperation in exchange situations. *Journal of Applied Social Psychology*, *20*, 303–320.
Friedman, J. (1971). A non-cooperative equilibrium for supergames. *Review of Economic Studies*, *38*, 1–12.
Gintis, H. (2000). Strong reciprocity and human sociality. *Journal of Theoretical Biology*, *206*, 169–179. DOI: 10.106/jtbi.2000.2111
Goeree, J. K., & Holt, C. A. (2002). Private costs and public benefits: Unraveling the effects of altruism and noisy behavior. *Journal of Public Economics*, *83*, 255–276.

Goren, H., Kurzban, R., & Rapoport, A. (2003). Social loafing vs. social enhancement: Public goods provisioning in real-time with irrevocable commitments. *Organizational Behavior and Human Decision Processes*, *90*, 277–290. DOI: 10.1016/S0749-5978(02)00527-7

Goren, H., Rapoport, A., & Kurzban, R. (2004). Commitment in a real time step level public goods game with asymmetrical players and continuous contributions. *The Journal of Behavioral Decision Making*, *17*, 17–37. DOI: 10.1002/bdm.455

Gouldner, A. W. (1960). The norm of reciprocity: A preliminary statement. *American Sociological Review*, *25*, 161–178.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*, 1243–1248. DOI: 10.1126/science.162.385931243

Houser, D., & Kurzban, R. (2002). Revisiting kindness and confusion in public goods games. *The American Economic Review*, *92*, 1062–1069.

Isaac, R. M., Walker, J. M., & Thomas, S. (1984). Divergent evidence on free riding: An experimental examination of possible explanations. *Public Choice*, *43*, 113–149.

Kelley, H. H., & Stahelski, A. J. (1970). Social interaction basis of cooperators' and competitors' beliefs about others. *Journal of Personality and Social Psychology*, *16*, 66–91.

Kelley, H., & Thibaut, J. W. (1978). *Interpersonal relations: A theory of interdependence*. New York: Wiley.

Kollock, P. (1998). Social dilemmas: The anatomy of cooperation. *Annual Review of Sociology*, *24*, 183–214. DOI: 10.1146/annurev.soc.24.1.183

Komorita, S. S., Chen, D. K., & Parks, C. (1993). Effects of incentive and reciprocity on cooperation in social dilemmas. *Journal of Experimental Social Psychology*, *29*, 252–267. DOI: 10.1006/jesp.1993.1011

Komorita, S. S., Hilty, J. H., & Parks, C. D. (1991). Reciprocity and cooperation in social dilemmas. *Journal of Conflict Resolution*, *35*, 494–518. DOI: 10.1177/0022002791035003005

Komorita, S. S., & Parks, C. D. (1995). Intergroup relations: Mixed-motive interaction. *Annual Review of Psychology*, *46*, 183–207. DOI: 10.1146/annurev.ps.46.020195.001151

Komorita, S. S., Parks, C. D., & Hulbert, L. G. (1992). Reciprocity and the induction of cooperation in social dilemmas. *Journal of Personality and Social Psychology*, *62*, 607–617.

Kopelman, S., Weber, M., & Messick, D. (2002). Factors influencing cooperation in commons dilemmas: A review of experimental psychological research. In E. Ostrom, T. Dietz, N. Dolšak, P. C. Stern, S. Stonich, & E. U. Weber (Eds.), *The drama of the commons* (pp. 113–156). Washington, DC: National Academy Press.

Kortenkamp, K. V., & Moore, C. F. (2006). Time, uncertainty, and individual differences in decisions to cooperate in resource dilemmas. *Personality and Social Psychology Bulletin*, *32*, 603–615. DOI: 10.1177/0146167205284006

Kramer, R., McClintock, C. G., & Messick, D. M. (1986). Social values and cooperative response to a simulated resource conservation crisis. *Journal of Personality 54*, 576–582. DOI: 101.1111/1467-6494.ep8970799

Kurzban, R., & Houser, D. (2001). Individual differences and cooperation in a circular public goods game. *European Journal of Personality*, *15*, S37–S52. DOI: 10.1002/per.420

Kurzban, R., & Houser, D. (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*, 1803–1807. DOI: 10.1073/pnas.0408759102

Kurzban, R., McCabe, K., Smith, V. L., & Wilson, B. J. (2001). Incremental commitment and reciprocity in a real time public goods game. *Personality and Social Psychology Bulletin*, *27*, 1662–1673. DOI: 10.1177/01461672012712009

Ledyard, J. (1995). Public goods: A survey of experimental research. In J. Kagel, & A. Roth (Eds.), *Handbook of experimental economics* (pp. 111–194). Princeton, NJ: Princeton University Press.

Liebrand, W. B. G. (1984). The effect of social motives, communication, and group size on behavior in an n-person multi-staged mixed-motive game. *European Journal of Social Psychology*, *14*, 239–264.

Liebrand, W. B. G. (1997). *Social dilemmas*. New York: Pergamon Press.

Liebrand, W. B. G., & Messick, M. D. (1996). *Frontiers in social dilemmas research*. New York: Springer Verlag.

Liebrand, W. B. G., Wilke, H. A. M., Vogel, R., & Wolters, F. J. M. (1986). Value orientation and conformity in three types of social dilemma games. *Journal of Conflict Resolution*, *30*, 77–97. DOI: 10.1177/0022002786030001006

Lomborg, B. (1996). Nucleus and shield: The evolution of social structure in the iterated prisoner's dilemma. *American Sociological Review*, *61*, 278–307.

Maynard Smith, J. (1982). *Evolution and the theory of games*. Cambridge: Cambridge University Press.

McClintock, C. G., & Liebrand, W. B. G. (1988). Role of interdependence structure, individual value orientation, and another's strategy in social decision making: A transformational analysis. *Journal of Personality and Social Psychology*, *55*, 396–409.

Messick, D. M., & Brewer, M. B. (1983). Solving social dilemmas. *Review of Personality and Social Psychology*, *4*, 11–44.

Messick, D. M., & McClintock, C. G. (1968). Motivational bases of choice in experimental games. *Journal of Experimental Social Psychology*, *4*, 1–25. DOI: 10.1016/0022-1031(68)90046-2

Messick, D. M., Wilke, H., Brewer, M. B., Kramer, R. M., Zemke, P. E., & Lui, L. (1983). Individual adaptations and structural change as solutions to social dilemmas. *Journal of Personality and Social Psychology*, *44*, 294–309.

Orbell, J. M., van de Kragt, A. J. C., & Dawes, R. (1988). Explaining discussion-induced cooperation. *Journal of Personality and Social Psychology*, *54*, 811–819.

Parks, C. D. (1994). The predictive ability of social values in resource dilemmas and public goods games. *Personality and Social Psychology Bulletin*, *20*, 431–438. DOI: 10.1177/0146167294204010

Parks, C. D., & Komorita, S. S. (1997). Reciprocal strategies for large groups. *Personality and Social Psychology Review*, *1*, 314–322. DOI: 10.1207/s15327957pspr0104_3

Parks, C. D., & Rumble, A. C. (2001). Elements of reciprocity and social value orientation. *Personality and Social Psychology Bulletin*, *27*, 1301–1309. DOI: 10.1177/01461672012710006

Parks, C. D., Sanna, L. J., & Berel, S. R. (2001). Actions of similar others as inducements to cooperate in social dilemmas. *Personality and Social Psychology Bulletin*, *27*, 345–354. DOI: 10.1177/0146167201273008

Pruitt, D. G., & Kimmel, M. J. (1977). Twenty years of experimental gaming: Critique, synthesis, and suggestions for the future. *Annual Review of Psychology*, *28*, 363–392. DOI: 10.1146/annurev.ps.28.020177.002051

Shang, J., & Croson, R. (2006). The impact of social comparisons on nonprofit fundraising. In R. Mark Isaac & D. D. Davis (Eds.), *Experiments investigating fundraising and charitable contributions. Research in experimental economics* (Vol. 11, pp. 143–156). Amsterdam, The Netherlands: Elsevier.

Sugden, R. (1984). Reciprocity: The supply of public goods through voluntary contributions. *Economic Journal*, *94*, 772–787.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology*, *46*, 35–57.

Van den Bergh, B., Dewitte, S., & De Cremer, D. (2006). Are prosocials unique in their egalitarianism? The pursuit of equality in outcomes among individualists. *Personality and Social Psychology Bulletin*, *32*, 1219–1231. DOI: 10.1177/014616720689346

Van Dijk, E., Wit, A., Wilke, H., & Budescu, D. V. (2004). What we know (and do not know) about the effects of uncertainty on behavior in social dilemmas. In R. Suleiman, D. V. Budescu, I. Fischer, & D. M. Messick (Eds.), *Contemporary psychological research on social dilemmas* (pp. 315–331). New York, NY, US: Cambridge University Press.

Van Lange, P. A. M. (1999). The pursuit of joint outcomes and equality in outcomes: An integrative model of social value orientation. *Journal of Personality and Social Psychology*, *77*, 337–349.

Van Lange, P. A. M., & Kuhlman, D. M. (1994). Social value orientations and impressions of a partner's honesty and intelligence: A test of the might versus morality effect. *Journal of Personality and Social Psychology*, *67*, 126–141.

Van Lange, P. A. M., & Visser, K. (1999). Locomotion in social dilemmas: How people adapt to cooperative, tit-for-tat, and noncooperative partners. *Journal of Personality and Social Psychology*, *77*, 762–773.

Van Vugt, M., Meertens, R. M., & Van Lange, P. A. M. (1995). Car versus public transportation? The role of social value orientations in a real-life social dilemma. *Journal of Applied Social Psychology*, *25*, 258–278.

Walster, E., Walster, W., & Berscheid, E. (1978). *Equity theory and research*. Boston: Allyn & Bacon.

Wilson, R. K., & Sell, J. (1997). 'Liar, liar . . .' Cheap talk and reputation in repeated public goods settings. *Journal of Conflict Resolution*, *41*, 695–717. DOI: 10.1177/0022002797041005005

Wit, A. P., & Wilke, H. A. M. (1992). The effect of social categorization on cooperation in three types of social dilemmas. *Journal of Economic Psychology*, *13*, 135–151. DOI: 10.1016/0167-4870(92)90056-D

Wit, A., & Wilke, H. (1998). Public good provision under environmental and social uncertainty. *European Journal of Social Psychology*, *28*, 249–256. DOI: 10.1002/(SICI)1099-0992(199803/04)28:2<AID-EJSP868> 3.0.CO;2-J

Yamagishi, T. (1986). The provision of a sanctioning system as a public good. *Journal of Personality and Social Psychology*, *51*, 110–116.

Yamagishi, T., & Sato, K. (1986). Motivational bases of the public goods problem. *Journal of Personality and Social Psychology*, *50*, 67–73.