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EFFECTS OF MONITORING AND INFORMATION ON PUBLIC GOODS PROVISIONING: EXPERIMENTAL EVIDENCE

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EFFECTS OF MONITORING AND INFORMATION ON PUBLIC GOODS PROVISIONING: EXPERIMENTAL EVIDENCE

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Social dilemmas, n-person prisoner dilemmas, and free-rider/public goods dilemmas share a common set of concerns. They generally point to settings in which markets fail and in which governments play an important role. These variously named "dilemmas" share a common theoretical structure and a common conclusion. At heart such settings are non-cooperative, whereby individuals cannot strike bargains over which binding agreements can be made to resolve conflict. As well, in each setting a strategy exists which is pareto superior to the Nash dominant strategy. Taken in combination, participants in such dilemmas have incentives to select the Nash dominant strategy which results in either the commons being destroyed or the public good not being provided. Such a result variously has been used as a call for a centralized (government) authority to step in and restructure the outcome (see Ostrom, 1986 for a review and critique of this view).

Although many lament the inexorable destruction of the "commons" brought about by the structure of social dilemmas, a growing body of empirical evidence indicates that many "commons" may flourish (Ostrom, 1985). This raises a fundamental question as to how can a "commons" survive or the public good be provided? Obviously, few natural settings mirror the stringent conditions contained in theoretical models of social dilemmas or public goods settings. Instead, a variety of additional components may intrude on such decision processes, leading away from the destruction of the commons. Ostrom catalogues several features which might deflect the destruction of a commons ranging from historical patterns of shared behavior to specific rules defining appropriate strategic behavior to control over the flow of information about the commons.

In this paper we tackle a single attribute, the level of information available to participants in an n-person repeated-play prisoner's dilemma, and speculate whether such a condition is either necessary or sufficient to prevent the destruction of a commons. Our major concern is whether changing the levels of information participants use to monitor the behavior of others in a social dilemma affects their strategic choices. We anticipate that when individuals have full information as to the past behavior of others they chose a strategy that is dominated by a pareto inferior Nash equilibrium. In this paper we discuss several related streams of research that have arisen over the past decade on repeated-play n-person prisoner dilemma games. Next we discuss several conjectures about the role that monitoring plays in non-cooperative repeated-play n-person prisoner dilemma games. Finally we use a laboratory experimental setting to test these conjectures.

Literature

The literature on social dilemmas and public goods problems has not directly addressed the role that information about past contributions plays for enhancing cooperative behavior. Nonetheless, there are three streams of literature that touch on ways in which differences in levels of information **work** to increase contributions to the public good. The first points to face-to-face communication as a device that enhances public good contributions (Isaac et al., 1985; Van de Kragt et al., 1983, Dawes, McTavish and Shaklee, 1977; Brechner, 1977; Edney and Harper, 1978a and 1978b). Exactly **how** communication **works** to induce these changes is not clear. Messick and Brewer, 1983, suggest that communication creates at least four pressures to ensure more cooperation : conformity pressures. pressures, **belief that others are committed to cooperative choice, moral suasion, and** group identity and cohesion. The first two of these pressures are linked with concepts that rely on past behavior in order to predict future interactions. In order to conform or to have beliefs about commitments, one must have in depth information about past behavior and must be able to continually update that information.

A second literature points to the "visibility" of public goods as a means of increasing group contributions. This is done in two ways: first by examining aggregate and second, by investigating information about individual levels of contribution to the public good. Much of this discussion has taken place in the context of replenishable resource traps in which resources (public goods) change with respect to time and to the "harvesting" strategies made by individuals within the group. Examples of such traps include water or energy conservation settings. In this context, visibility means whether or not individuals can see the resource levels after harvesting (Cass and Edney, 1978). Empirically, when individuals see the resource levels they come closer to maintaining an optimal level of the public good than when they cannot monitor those levels. Again, this is related to information about past decisions — at least at an aggregate level. In the public goods literature, this aggregate level of information is routinely incorporated into research designs (See for example, Isaac et al., 1985; Isaac et al, 1984). Individuals are informed about the group's past decisions prior to the present decision. In this decision environment, a characteristic decision or contribution pattern emerges: although contributions contain "pulses", with replication, "the level of public goods provisions falls" (Isaac et al., 1985).

Those examining resource replenishment traps also tackle the concept of "visibility" by focusing on characteristics of individual decision makers. Hessick et al. (1983b) argue that knowledge about other individual member's choices has conflicting effects on decision making. On the one hand, learning that individuals are acting cooperatively may increase conformity pressures; on the other hand, it may diffuse individuals' contributions to the group. Jerdee and Rosen (1974) find that introducing a defector increases defecting strategies by others. Messick et al., 1983a and Samuelson et al., 1984 examine how other group members' past decisions and the homogeneity of group members' harvests affect an individual's strategies. Their results indicate that individuals respond to others' overuse of the resource by harvesting less. Their general findings, however, are culture-bound, since a large variance in harvesting weakens cooperation among United States participants but not for participants in the Netherlands.

A third literature, largely theoretical stemming from n-person repeated-play prisoner dilemma games, focuses on the use of information about the state of a public good in order to signal strategies to others. What stands out in this literature is the possibility of achieving cooperation in a setting in which coordination is not possible. Radner (1981; 1986) contends that participants in such settings can form long-term agreements by signalling their intention to punish others if they defect from the agreement. Likewise Lewis and Cowens (1982) point to the importance of knowing the harvest levels of others in order to know when to abandon a strategy of cooperation. As such, knowing information about other's harvesting levels, allows individuals to signal their intention to overharvest a common resource if there are deviations from established harvesting levels. Much of this literature has focused on the use of information as a threat, while ignoring how variable levels of information may be and what that means for the ability to either monitor other's strategies and to signal one's own strategy.

Conceptual Framework

It has been argued that conflicting research conclusions in the area of public good have resulted from imprecise specification and operationalization of economic theory (see Kim and Walker, 1984). Consequently, we want to clearly specify both the type of public good we consider and the scope conditions involved. The public good investigated is characterized by: 1) nonrivalness of consumption (the consumption of one individual is unaffected by the consumption of another), 2) a constant increase with respect to contributions (for example, no provision point is involved), and 3) divisibility (that is individuals can individually consume their portion of the good, see Alfano and Marwell, 1981). The situation we examine is consistent with a number of repeated-play public goods games: no face to face communication is involved (although individuals know the number of other group members); payment to individuals is private and no sidepayments are possible; and group members know the decision process occurs over a fixed time period with a known end point.

We examine three levels of information regarding other members' contributions: no information; information about the aggregate level of contribution; and full information regarding each individual member's contribution. When group members are given no information about contribution levels, they are unable to monitor any behavior by others. We regard this situation as equivalent to a series of one-shot decisions. In this case, knowing that members face a finite series of repeated plays is of little value since no one can monitor either individual contribution strategies or aggregate group contributions. Neither, of course, can signalling take place. In the absence of information about previous levels of contributions, individuals have no reason to change from whatever contribution was made in the first period. We thus predict little variability in individual's contributions over time. Secondly, if no information is, indeed, simi1ar to one-time decisions, we shouId see relatively high contributions as most such studies report (See Marwell and Ames, 1979; 1980; Alfano and Marwell, 1981; Nallapati et al., 1987).

Where group members *are* given information about aggregate group levels of contributions, they are able to incompletely monitor the behavior of others. While aggregated information allows some measure of past contributions, it is, at best a sluggish indicator of individual strategies. Since any member's contribution constitutes only a small portion of the public good, it is difficult to gauge the effect of any single individual's change in contribution behavior. If members rely on monitoring to make adjustments to their contribution decisions, collective contributions to the public good should slowly change. Extreme shifts in contributions by a single individual should have little effect on signa11ing to others. However, participants will respond to those signa1s and as a consequence the variation in period-to-period contributions will be greater than where individuals have no information about contribution levels. Since such a setting is identical to that investigated by Isaac et al., 1984; Isaac et al., 1985 and Isaac and Walker, 1988, we have strong expectations as to group contributions—they begin at a fairly high rate and decay over time.

Where group members are given fu11 information about each others' past contributions, members are able to monitor everyone's behavior and to signal their own intentions. Following Radner's (1986) formal argument concerning partnership games and monitoring, we expect that individuals are provided the "opportunity to use self-enforcing rules of behaviour that sustain efficient decision rules," (Radner, 1986:43). If this is the case, individuals will gradually contribute at higher levels than under the other two cases. However, this also implies a high amount of variance across periods in individual contributions. This variance results from the very process of signalling. According to Radner, for example, of one individual's contributions drop, others will drop as well. In this way, members inform each other about the consequences of a particular decision and it remains a threat against decreasing contributions. Thus, patterns of contributions under full information should resemble those that emerge in the 'tit for tat' strategies of simple prisoner dilemma games.

Experimenta1 Design

The experiments reported here are based on the experimental design contained in Isaac, Walker and Thomas (1984). Three distinct experimental conditions were investigated which focused on different amounts of information given to participants about the past contribution levels of others. These conditions mirror the three cases of information discussed above — no information; moderate (aggregate) information; and full information. The moderate information experimenta1 condition rep1icates the inexperienced four-person, high marginal per capita return condition reported in Isaac, Walker and Thomas (1984). All experimental conditions reported here had inexperienced four-person groups operating under high marginal per capita return parameters. While the Isaac, Walker and Thomas experiments were run using the PLATO system, all experiments run here were conducted on a Macintosh Local Area Network developed by the second author.

Before beginning an experiment, participants were given a set of instructions outlining the mechanics behind the experiment. These instructions were administered over each individual's computer terminal and were self-paced. At points throughout the instructions participants were required to answer questions and were corrected if their answer was wrong. The instructions were short and participants ordinarily took only eight minutes to read through them (a copy of these instructions is in Appendix A). Once participants completed the instruction set they were informed as to the parameters of the experiment. At this point all participants were told the number of periods in which they could invest tokens, how many tokens they could invest in each period, and how much information they would have about the investments of others. Before beginning the experiment, participants were quizzed about each of the salient parameters and were not allowed to proceed until they understood those features. In all experiments participants faced 10 distinct investment periods and were allotted 30 tokens per period. Moreover, their identities were randomized before beginning the experiment, so they would not be able to associate the position of the terminals with particular individuals. Participants were identified simply by letter over the computer nodes.

A participant's task was relatively simple — to decide how many tokens to place in a group investment pool and how many to keep in a private investment pool. Private investments yielded a return of one cent per token. On the other hand, group investments had a return of 3.0 cents per token invested. However, the group investment represented a public good whereby all four participants shared equally in the return on investment, no matter what their level of investment in the group pool. This meant that an individual's effective marginal return for tokens put into the group investment pool was .75 cents per invested token. These parameters are consistent with those used by Isaac, Walker and Thomas (1984) for their four-person groups with high returns. In all of the experiments participants were only told their own valuation for public and private goods.

Before making an investment decision, participants were required to wait two minutes. This rule was imposed so as to force participants to think about their decision and to ensure they did not rush through the experiment. AH participants faced a screen similar to that shown on Figure 1. Before deciding how to invest tokens, participants were able to examine the effect of different mixtures of group and individual investments for their payoff. Rather than providing a limited subset of examples about mixes of payoffs, participants were able to study the entire range of payoffs. The experiments were conducted using Macintosh microcomputers and this tremendously decreased task complexity for participants. In order to change mixes of group and individual investments participants only had to use a mouse to point to a box on the screen and increase or decrease the number of tokens. The payoffs associated with any change were then displayed with all bookkeeping taken care of by the computer. Therefore, in this experimental setting participants never had to use the keyboard.

<Figure 1 About Here>

Once the two minute interval ended between periods, participants were required to allocate tokens between the group investment and their own private investment. Once a division was arrived at, participants were double checked as to whether this was what they wished to do. If so, their allocation was recorded on the local area network. Depending on which experimental treatment, participants were given information as to that period's outcome. At the conclusion of the experiment, participants were paid, in private, their total earnings for the experiment.

Experimental Treatments.

In line with the conceptual discussion above, we are concerned with three distinct treatments. Our aim in these experiments is to deliberately constrain the information available for monitoring the behavior of others in an n-person prisoner's dilemma situation. On the one hand we aim at limiting the amount of information available by ensuring that all communication is mediated through a computer system. This means that we are able to highly constrain the amount of information individuals have available to them. By physically separating participants we have minimized effects that are due to face-to-face discussion and personality differences. On the other hand, we also intend to limit information in very distinct ways.

The first treatment is the simplest. In this experimental series we did not give any information to participants from one period to another. At the outset of the experiment participants are informed that they will not know how many tokens are contributed to the group, nor will they know how much they earn following each period. Only at the conclusion of the experiment are they informed as to their earnings. This treatment represents a minimal floor of information. Here no participant can monitor the activities of any other participant or the group as a whole.

The second treatment replicates those experiments reported by Isaac, Walker and Thomas (1984). Under this treatment, at the end of each investment period, participants are informed as to the group investment total and their earnings. In this sense they know only their own contribution and the joint contributions of the remaining three players. The level of information here is moderate since the information is aggregated by all individuals. Variation in contributions by others is buried in the aggregated figure and so the ability to monitor individual contributions is quite low, since individual behavior can only be inferred from aggregate changes. Throughout the experiment participants have access to the past history of group investment figures and a record of their own earnings.

The third treatment provides information concerning each individual's contribution at the end of each investment period. Here each individual is given information about the contributions that all others made to the group, information about the total number of tokens invested in the group pool, and information about current earnings. Also, during each investment period participants have access to information about the past investments of all participants and their own earning history. In this sense participants can closely monitor the behavior of others and adjust their own investment behavior to the individual strategies of others. In the settings we use here, this third treatment provides the richest amount of information about the behavior of others. As with the other treatments, at the conclusion of the experiment, participants are told their own earnings and are paid in private.

Predictions.

Given this conceptual framework and experimental design, we can now translate our theoretical predictions to specific hypotheses. These hypotheses address two dependent variables, the overall level of contributions and the variance of those contributions. We have argued that because signalling and monitoring are critical, greater amounts of contribution should occur when they are present than when they are absent. Thus we should see high amounts of contribution in the Full Information conditions. In the situation where only aggregate data of contribution is available (Moderate Information), signalling and monitoring are impeded and as a result overall contributions should be less in the Moderate

Information condition than in the Full Information condition. Based on past research, we can further expect that contributions in Moderate Information will decay over time. It is this decay that leads us to predict that contribution in the No Information condition will be higher than that in Moderate Information. Because all decisions are made on the same basis, contributions in the No Information condition should not display a decay; in fact contributions should start at about the same level as those in the other conditions and stay at that relatively high level. Thus:

Hypothesis 1: The ordering of overall contributions, from smallest to largest, will be: Moderate Information, No Information, Full Information.

As previously stated, we expect little variation in contribution levels by individuals faced with no information because all decisions are made with the same lack of information. With Moderate Information, variability should increase since there is the possibility (although limited) of signalling and monitoring. Finally, if the contribution levels of individual group members are known (Full Information), signalling and monitoring procedures should create high degrees of contribution variability. Thus:

Hypothesis 2: The ordering of variances by conditions, from smallest to largest, will be: No Information, Moderate Information, Full Information.

Analysis

A total of 24 experiments were conducted using student participants responding to advertisements at Rice University. Eight experiments were run under each of the three information conditions and each experiment involved four participants, none of whom had ever participated in a dilemma experiment. While participants volunteered for particular days and times in which to be in the experiment, experimental conditions were randomly ordered. In addition, participants were asked to remain quiet about the nature of the experiment and experiments were conducted within a two week period in order to avoid external contaminating effects due to discussions as to differences in the experimental conditions.

Group Contribution Hypothesis.

The average levels of group contributions in each period under each information condition is given in Figure 2 (and the raw data for each experiment is given in Table 1). The data plotted in Figure 2 are normalized to represent contributions as a percentage of the Lindahl optimum. The data plotted on this Figure do not fully support our prediction that contributions to the public good will differ by treatment. We see little difference between the no information and moderate information conditions. Average contributions in each condition track almost identically. However, in the later periods, differences are quite apparent between the full information condition and the no and moderate information conditions. These observations are partly borne out by statistical analysis using a MANOVA design. In Table 2 multivariate F-tests are reported for two estimated parameters (a constant and a categorical measure representing the three different information conditions) across all periods. For the overall model, in which all periods are considered, we cannot reject the null hypothesis that levels of group investment are equivalent across periods and within information conditions. Taking into account all three of the principal MANOVA F-tests, none fall below a .05 level of statistical significance for our experimental condition, the level of information available to participants.

<Figure 1 About Here> <Tables 1 & 2 About Here>

If we use a set of post hoc tests across levels of information, we can examine pairs of differences between information levels. In particular, we examine two relationships. First, to see if there is any statistical difference between the no information and moderate information conditions and second, to test for differences between moderate and high information conditions. The post hoc paired test between no and moderate information again do not permit us to reject the null hypothesis that levels of group investment are equivalent across. These multivariate F-statisties are given in Table 2. This finding is consistent with what is displayed on Figure 2. The second post hoc comparison across periods between the moderate and high information conditions approaches our statistical level of .05. These multivariate F-statisties point to what we observe in Figure 2, that contributions to the public good occur at their highest rates in the no information condition. However, using a strict statistical significance level, we are unable to reject the null hypothesis that the moderate and full information conditions have equivalent contribution rates across all periods.

In repeated-play public goods games, participants may take time to learn, signal and adjust their strategies. Consequently we separately analyze the last five investment periods. It is apparent from Figure 2 that there is some sorting of strategies that begins after the first few trials. Looking at only the final five trials, we are again unable to reject the principal null hypothesis that group investment levels differ across periods by treatment (see Table 3). However, the effects here approach our .05 level of statistical significance. Examining paired effects across experimental conditions we again find that we cannot reject the null hypothesis that group contributions are the same under no and moderate information conditions. On the other hand we can reject the null hypothesis that public good contribution levels are the same for moderate and full information conditions. This finding supports our prediction that full information about individuals' past contribution levels enhances public goods contributions. This is due to the fact that full information allows participants in a repeated-play public goods environment to fully monitor others' levels of commitment to a pareto superior cooperation strategy. Higher levels of group contribution, then, are sustainable over time with full information about past behavior.

<Table 3 About Here>

Variation in Contribution Hypothesis.

The second hypothesis predicts that the variation in group contributions differs by information conditions. This variation is a function of the ability of members to monitor the behavior of others and to adjust their own strategies accordingly. To test this prediction we calculated the variance of group contributions for each experiment. An ANOVA model was used, in which the calculated variance for experiment contributions was the dependent variable and the experimental condition the independent variable. This analysis is presented in Table 4. Based on these results we can reject the null hypothesis that all experimental conditions have similar levels of variation in group contributions. This supports our hypothesis that behavioral strategies vary between information conditions.

In addition, our predictions have a specific ordering to them. We predict that the no information condition has the least variance, since members of the group adopt investment strategies and do not update them in the absence of information about what others' within the contribute. The highest variance in contributions should be found with the full information condition, since in this instance members have the richest information about others' behavior and can adjust their own contributions accordingly. To test these differences between groups, we used a series of post hoc paired tests. These results are reported in Table 4. From these results, we cannot reject the null hypothesis that the no and moderate information conditions have similar levels of variation. We can reject the null hypothesis comparing moderate and full information conditions. These findings, while not fully supportive of our predictions are consistent with the other findings presented above. These results show that having full information about members' past contributions leads to much greater fluctuation in group contributions than under the moderate or no information conditions. This fluctuation favors enhancing the public good rather than resulting in its decay.

<Table 4 About Here>

While investigating levels of contributions we also had some concerns with the behavioral strategies that participants used in making their investment decisions. We used a measure similar to that discussed in Isaac, Walker and Thomas (1984) to examine participant's behavioral strategies. For empirical purposes Isaac, Walker and Thomas characterize five distinct investment strategies, ranging from a "complete strong free-rider" to a "complete Lindahl" investor. Each strategy is operationalized according to the percentage of total tokens invested in group fund. Our operationalization is given on Table 5. Extending from our discussion above, we expect that information conditions will have an effect on individual strategic choices. With no information, participants have no knowledge about the choices of others or any feedback from period to period, and consequently are more likely to adopt free-rider strategies.

Under the moderate information condition participants have aggregate information about the choices of others. That information can be put to use in deciding when to contribute and when to free ride. If such information allows members to incompletely monitor one another's contributions, then free riding is less likely to be chosen as a strategy. Finally, under the full information condition, free riding should be selected as a strategy less often than with under the moderate or low information conditions. This is due to the ability of members to fully monitor the past contributions of others, previous empirical observations that participants begin with reasonably high levels of contributions to the public good, and the importance of "trigger strategies" for an individual's choice calculus when participating in a repeated game. Consequently we have comparative expectations about the strategies will select under different information conditions.

<Table 5 About Here>

Strategic choices are given in Table 5 and are broken out by type of information condition. One point which immediately stands out is how seldom individuals chose to completely free ride or to completely provide the public good. A second point is that there appears to be some support for our conjecture that there are differences across treatments as to the choice of strategies. The greatest proportion of incomplete strong free riders are found under experiments with no information and the greatest proportion of those using an incomplete Lindahl strategy are found under experiments with fu11 information. Appearances can be deceiving, however, since using a Chi-square test we can not reject the null hypothesis that there is no difference in choice of strategy across experimental conditions. Because only two individuals *are* complete strong free riders or used a complete Lindahl strategy, these two strategies were excluded from this analysis. In this case x^2 = 8.85 and p = .065.

Summary

Our results are somewhat puzzling. On the one hand we observe some differences due to our experimental conditions. That is, we find a tendency by participants to contribute to the public good at higher rates when they have full information as to other member's past contributions. This is consistent with conjectures we derive from models of resource depletion and principa1/agent relationships. From both sets of literature we expect that individuals acting in non-cooperative repeated n-person prisoner dilemma games use such information to monitor the past behavior of others. From this information they can finely adjust their own behavior, sustaining a high level of cooperation among members of the group.

On the other hand, the lack of difference that we observe between settings with no and moderate information are baffling. In each setting participant contributions to the public good track almost precisely. Unlike the full information condition, those in the moderate information condition do not appear to use the information available to them to focus their contribution strategies. Equally puzzling is the variation observed in group contributions under the no information condition. There we expected there would be little variation in individual's choices. Since they did not know anything about group contributions at any period, we expected they would select and stick with a particular strategy. This we did not observe.

These experimental results are not too distorted, since the patterns we observe here are consistent with other experiments (c.f. Isaac, Walker & Thomas, 1984 and Isaac and Walker, 1988) As with those experiments we observe high levels of group contributions in the initial investment period. Likewise we observe "crashes" at the final period (in fact 36.5 percent of the participants contribute nothing to the public good in this final period). We conclude that our results *are* not an artifact of our experimental design. Instead these results provide additional grist for the theoretical mill, simultaneously playing up and playing down the variable effect of information for resolving a repeated play n-person prisoners dilemma.

Conclusions

Our research has several important theoretical implications. The first relates to the lack difference between individuals' behavior with no information and an aggregate level information. Our No Information condition represents a baseline. There is a pattern of decay in this baseline and it is somewhat mysterious since conditions for the first decision in the sequence are identical to conditions for all other decisions (except for the last decision since it is the endpoint). Thus, the changes we observe probably represent a consistent set of reflective strategies used by individuals. More importantly, the similarity between the no information and aggregate information results suggests that, from the individuals' point view, aggregate level information is roughly equivalent to no information at all. If this Is the case, it has important implications for public goods contributions. It suggests that signalling and monitoring do not occur with aggregate information.

On the other hand, signalling and monitoring processes occur when individuals have information about individual contributions—even when the identities of the particular individuals are unknown. And through these processes, contributions to the public good are increased. This lends support to the literature on monitoring, n-person prisoner dilemmas (for example Radner, 1986 and Lewis and Cowens, 1982). Additionally, this adds to the social psychological literature concerning the effects of communication in public good provisioning by demonstrating that signal Ing and monitoring are analytically distinct and important aspects of the communication process.

The problem of provisioning public goods is not solved of course. Even when individuals have information about other group members' contributions, the Lindahl optimum is not reached. Such information is not sufficient to solve the social dilemma and, based upon our results, we can only speculate that such information is necessary for resolving social dilemmas. At best we show that information about individuals' past contributions increases the overall supply of the public good and this is consistent with what we expect if individuals use such information to monitor implicit agreements to cooperate in provisioning the public good.

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Table 1
Period-by-Period Group Contributions

No Information
Experimental Condition

Exper.	Period 1	2	3	4	5	6	7	8	9	10
1	47	54	39	55	59	45	39	37	40	20
2	38	24	24	22	34	24	37	22	36	37
3	57	60	90	90	90	90	90	90	90	60
4	35	52	58	57	40	50	74	57	49	38
5	71	80	70	43	65	66	62	90	60	60
6	52	60	20	37	45	49	32	65	15	16
7	56	55	45	56	10	57	58	49	59	49
8	55	75	52	66	67	57	50	60	47	80

Moderate Information
Experimental Condition

Exper.	Period 1	2	3	4	5	6	7	8	9	10
1	50	105	85	100	100	65	95	100	75	35
2	75	62	62	47	71	71	52	49	57	44
3	38	33	34	36	40	27	27	21	34	34
4	54	58	70	73	70	80	80	78	74	50
5	57	68	38	56	72	68	70	71	75	56
6	65	75	46	34	36	61	53	63	51	30
7	63	45	18	36	33	41	44	19	15	51
8	28	35	40	44	22	24	40	21	15	4

Full Information
Experimental Condition

Exper.	Period 1	2	3	4	5	6	7	8	9	10
1	66	87	84	88	113	113	118	116	119	120
2	45	55	65	55	55	59	44	61	69	31
3	13	28	48	39	45	8	20	47	45	5
4	29	12	18	18	30	15	40	65	79	75
5	65	62	57	41	18	56	71	85	54	35
6	40	62	75	86	90	100	100	100	100	90
7	56	50	63	66	48	41	55	65	83	62
8	56	45	65	85	86	98	100	111	111	72

[Maximum total group tokens per period: 120]

Table 2

Analysis of all Period-by-Period Group Contributions

Main Effect: CONSTANT

WILKS' LAMBDA =	0.038			
F-STATISTIC =	29.990	DF = 10, 12	PROB =	0.000
PILLAI TRACE =	0.962			
F-STATISTIC =	29.990	DF = 10, 12	PROB =	0.000
HOTELLING-LAWLEY TRACE =	24.992			
F-STATISTIC =	29.990	DF = 10, 12	PROB =	0.000

Main Effect: EXPERIMENTAL CONDITION

WILKS' LAMBDA =	0.249			
F-STATISTIC =	1.204	DF = 20, 24	PROB =	0.329
PILLAI TRACE =	0.884			
F-STATISTIC =	1.031	DF = 20, 26	PROB =	0.465
HOTELLING-LAWLEY TRACE =	2.476			
F-STATISTIC =	1.362	DF = 20, 22	PROB =	0.240
THETA =	0.691	S = 2, M = 3.5, N = 5.0	PROB =	0.154

Post Hoc Test: No and Moderate Information Conditions

WILKS' LAMBDA =	0.685			
F-STATISTIC =	0.552	DF = 10, 12	PROB =	0.823
PILLAI TRACE =	0.315			
F-STATISTIC =	0.552	DF = 10, 12	PROB =	0.823
HOTELLING-LAWLEY TRACE =	0.460			
F-STATISTIC =	0.552	DF = 10, 12	PROB =	0.823

Post Hoc Test: Moderate and Full Information Conditions

WILKS' LAMBDA =	0.316			
F-STATISTIC =	2.602	DF = 10, 12	PROB =	0.060
PILLAI TRACE =	0.684			
F-STATISTIC =	2.602	DF = 10, 12	PROB =	0.060
HOTELLING-LAWLEY TRACE =	2.168			
F-STATISTIC =	2.602	DF = 10, 12	PROB =	0.060

Table 3

Analysis of Last Five Period-by-Period Group Contributions

Main Effect: CONSTANT

WILKS' LAMBDA =	0.114			
F-STATISTIC =	26.364	DF = 5, 17	PROB =	0.000
PILLAI TRACE =	0.886			
F-STATISTIC =	26.364	DF = 5, 17	PROB =	0.000
HOTELLING-LAWLEY TRACE =	7.754			
F-STATISTIC =	26.364	DF = 5, 17	PROB =	0.000

Main Effect: EXPERIMENTAL CONDITION

WILKS' LAMBDA =	0.414			
F-STATISTIC =	1.887	DF = 10, 34	PROB =	0.082
PILLAI TRACE =	0.638			
F-STATISTIC =	1.686	DF = 10, 36	PROB =	0.122
HOTELLING-LAWLEY TRACE =	1.293			
F-STATISTIC =	2.069	DF = 10, 32	PROB =	0.058
THETA =	0.543	S = 2, M = 1.0, N = 7.5	PROB =	0.046

Post Hoc Test: No and Moderate Information Conditions

WILKS' LAMBDA =	0.889			
F-STATISTIC =	0.426	DF = 5, 17	PROB =	0.824
PILLAI TRACE =	0.111			
F-STATISTIC =	0.426	DF = 5, 17	PROB =	0.824
HOTELLING-LAWLEY TRACE =	0.125			
F-STATISTIC =	0.426	DF = 5, 17	PROB =	0.824

Post Hoc Test: Moderate and Full Information Conditions

WILKS' LAMBDA =	0.491			
F-STATISTIC =	3.520	DF = 5, 17	PROB =	0.023
PILLAI TRACE =	0.509			
F-STATISTIC =	3.520	DF = 5, 17	PROB =	0.023
HOTELLING-LAWLEY TRACE =	1.035			
F-STATISTIC =	3.520	DF = 5, 17	PROB =	0.023

Table 4

Analysis of Group Contribution Variances by Experimental Condition

Main Effects:

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
TREATMENT	134851.187	2	67425.594	3.699	0.042
ERROR	382754.758	21	18226.417		

Post Hoc Test: Low and Moderate Information Conditions

TEST OF HYPOTHESIS

SOURCE	SS	DF	MS	F	P
HYPOTHESIS	3271.554	1	3271.554	0.179	0.676
ERROR	382754.758	21	18226.417		

Post Hoc Test: Moderate and Full Information Conditions

TEST OF HYPOTHESIS

SOURCE	SS	DF	MS	F	P
HYPOTHESIS	81534.519	1	81534.519	4.473	0.047
ERROR	382754.758	21	18226.417		

Table 5

Overall Contribution Strategies for Participants

	Experimental Condition		
	No Information	Moderate Information	High Information
Complete Strong Free Rider	0 (0%)	0 (0%)	1 (3.1%)
Incomplete Strong Free Rider	13 (40.6%)	11 (34.4%)	7 (21.9%)
Weak Free Rider	13 (40.6%)	17 (53.1%)	12 (37.5%)
Incomplete Lindahl	6 (18.8%)	3 (9.4%)	12 (37.5%)
Complete Lindahl	0 (0%)	1 (3.1%)	0 (0%)
	32 (100%)	32 (100%)	32 (100%)

Excluding the Complete Strong Free Rider and Complete Lindahl strategies, $X^2 = 8.5$ and $p = .065$.

Note: The following coding rules were used for an individual's group contribution given by x.

Complete Strong Free Rider: $x = 0\%$

Incomplete Strong Free Rider: $0\% < x \leq 33.33\%$

Weak Free Rider: $33.33\% < x \leq 66.66\%$

Incomplete Lindahl: $66.66\% < x \leq 100\%$

Complete Lindahl: $x = 100\%$

Figure 1

Main Screen for Individual Participants

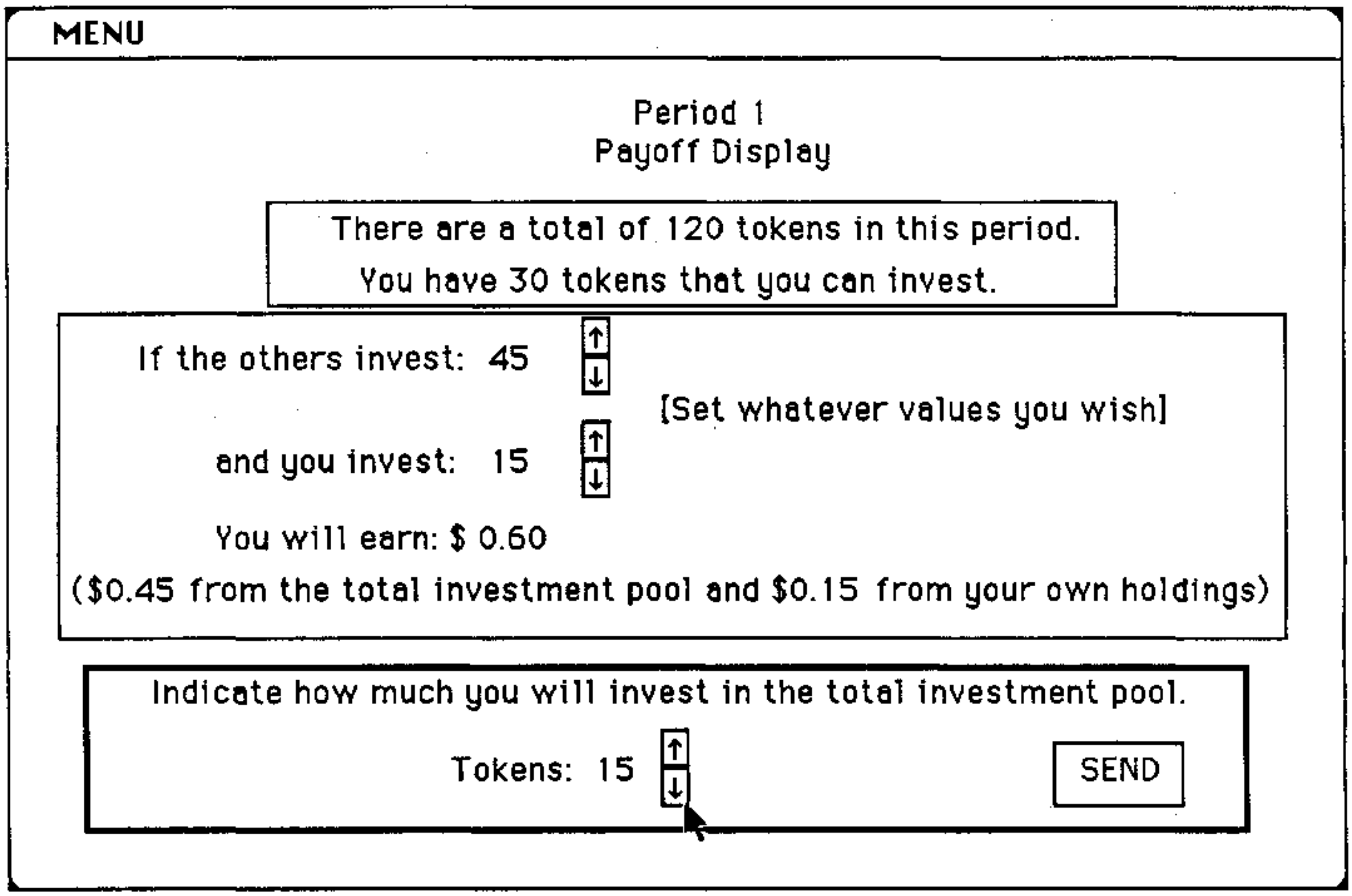
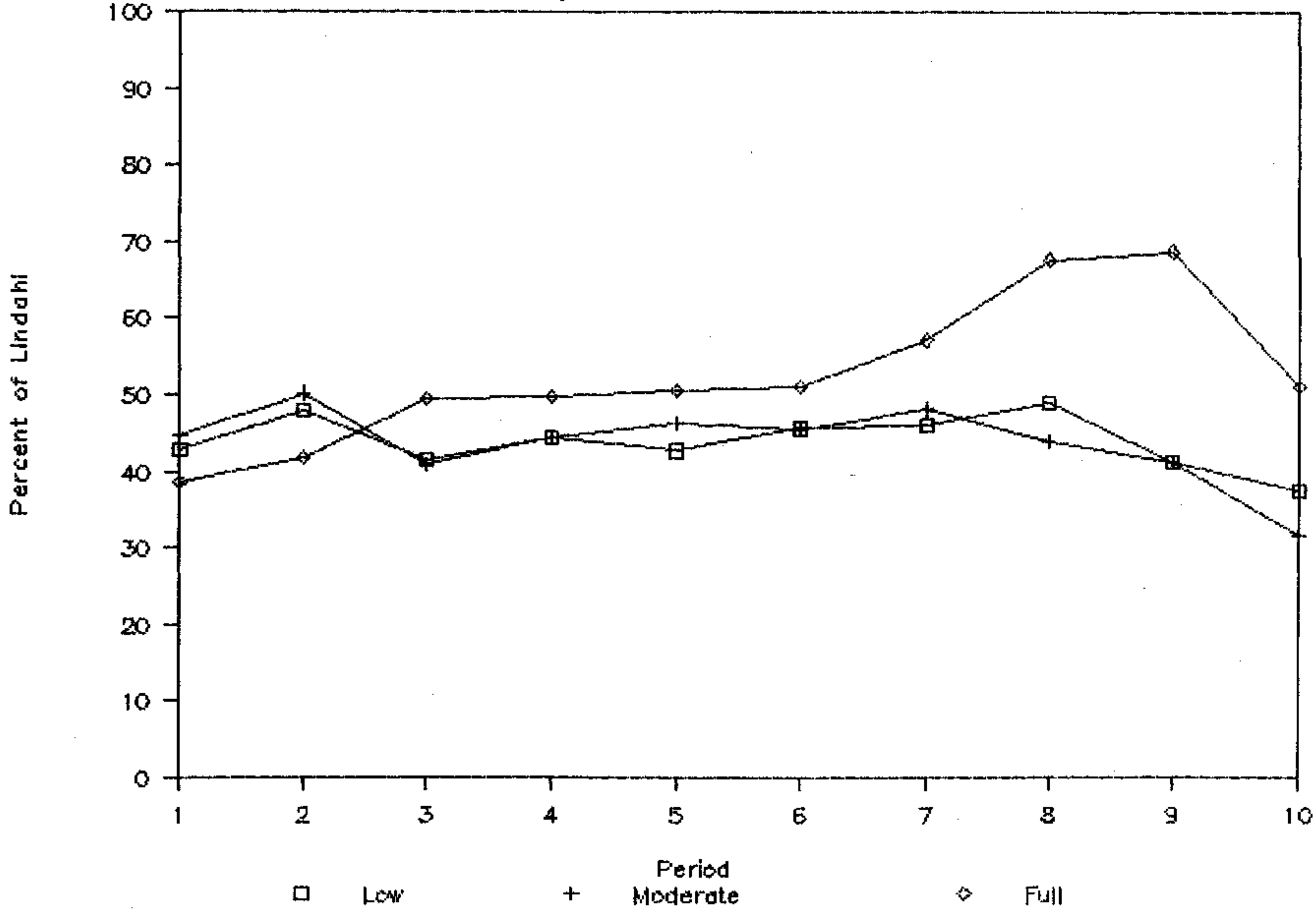


Figure 2

Average Public Good Contributions



This experiment is concerned with how people make decisions about investments. You are one member of a group. Everyone in the group will be making similar types of investment decisions. No one in the group will be able to speak to one another or interact during the experiment. Each group member will make a number of investment decisions over computer terminals. At the conclusion of the experiment you will be paid in private the amount you have earned.

At the beginning of each investment period you are given a fixed number of tokens which you will invest.

You have two choices.

The first choice involves putting tokens into the group investment pool. Every token placed in the investment pool is worth 3 cents. The total worth of the investment pool is evenly divided among all members of the group – no matter how much they put into the group pool. You always receive a 1/4 share of the investment pool.

The second choice involves putting tokens into a private fund. Every token put into your private fund is worth 1 cent. This money is added directly to your earnings and it is shared with no one.

You may mix up your investment of tokens any way you wish.

As an example, suppose you begin with 60 tokens. Suppose you put no tokens in the investment pool and instead put all 60 into your private fund. Suppose the remaining three group members put a total of 100 tokens in the investment pool. How much would you earn?

- ☐ $0.75
- ■ $1.35
- ☐ $1.95

That is Correct.

You would earn 60 <tokens> * $.01 for your private fund, which is $.60

Also you would earn a 1/4 share of the investment pool or
(100 <tokens> * $.03) divided by 4, which is $.75.

Your total earnings in this example would be $1.35.

CONTINUE

As a second example suppose you put 30 tokens into the group investment pool and the remaining 30 tokens into your private fund. Also suppose that a total of 200 tokens are put into the group investment pool. How much would you earn?

☐ $1.80

☐ $2.40

■ $3.00

That is Incorrect.

You would earn 30 <tokens> * $.01 for your private fund, which is $.30.

Also you would earn a 1/4 share of the investment pool or (200 <tokens> * $.03) divided by 4, which is $1.50.

Your total earnings in this example would be $1.80.

CONTINUE

At any time during the experiment you will be able to easily calculate how much you will earn from different combinations of investment choices.

You and the others will make a number of investment choices. You will have to wait two minutes before you make each investment decision.

Once you have made your choice the computer will total your share of the investment pool, total your private fund, and keep track of your overall earnings.

When the experiment is completed, your earnings will be paid to you in private.

CONTINUE

This concludes your introduction to the experiment. If you have any questions, please raise your hand and ask the experimenter.

During the experiment you may not speak with any of the other participants. If you do so, the experiment will be stopped. If you need help during the experiment, ask the experimenter.

Keep in mind that: THE ONLY MONEY YOU MAKE FOR THIS EXPERIMENT STEMS FROM YOUR INVESTMENT DECISIONS.

Good luck. You may begin the experiment if you have no questions.

CONTINUE

During this Experiment:

You are player d – one of 4 members of this group.
There are 1 separate investment periods in this experiment.
A total of 120 tokens can be invested by the group.
Of this total, you have 30 tokens that you can invest.

For every 10 tokens ANYONE invests in the group pool, your share is $0.07.
For every 10 tokens put into your private fund, you earn $0.10.

In this experiment you will be told how many tokens each individual invests after each period. After each period you will be told how much you earned. You can also use the MENU to find out how much each individual invested in previous periods.

CONTINUE

How many tokens are there in the group?

80	120	160	200

How many tokens do you have to invest?

10	20	30	40	50

YOU MAY NOW BEGIN THE EXPERIMENT.

CONTINUE