Probabilistic Production of a Public Good*

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Abstract: In a laboratory experiment, the voluntary provision of public goods is investigated when there is probabilistic uncertainty about the monetary return from production of the public good. After group members make their provision decisions, the return is drawn from an exogenously determined probability distribution. In a linear decision setting, voluntary provision of the public good is contrasted across three treatments. In the “uncertainA” treatment, the return is randomly drawn from a discrete probability distribution. In the “uncertainB” treatment, the return is drawn from a discrete probability distribution that is a mean-preserving spread of the distribution in the uncertainA treatment, but has larger variance. In the “certain” treatment, the return is known with certainty and equal to the expected value of the return in the uncertainA and uncertainB treatments. The data reveal that average provision of the public good is lower in treatments with uncertainty. However, the negative impact of uncertainty on provision only occurs when subjects experience the certain treatment prior to experiencing an uncertain treatment, suggesting an order effect to uncertainty. Also, there is evidence that subjects in treatments with higher uncertainty (variance of the public-good return) display a version of the “gambler’s fallacy.”

Keywords: public goods · uncertainty · cooperation · laboratory experiments

JEL Classification: D7 · D8 · H4 · C90

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1. INTRODUCTION

Experimental evidence from social-dilemma settings, such as the voluntary provision of public goods, reveals that group members often cooperate despite dominant self-interested strategies to free ride on others’ contributions (Isaac et al. 1994, Ledyard 1995). In many field situations, investments or contributions are made to the production of public goods without the providers knowing with certainty the return they will receive from the public goods. For instance, often the quality of the public good provided by charitable organizations depends on factors that may be uncertain at the time a donation is given. For example, with some probability, the weather conditions will be good and the quality of cleanup and reconstruction after a natural disaster will be high. Otherwise, the quality of the cleanup and reconstruction will be lower. If providers are risk averse, uncertainty regarding the quality of the public good may lead to lower donations. Thus, examining subjects’ provision decisions in experimental settings with uncertainty offers insight into how contribution choices can be influenced by uncertainty.

In this study, empirical evidence is provided that examines the impact of uncertainty regarding the public-good return in an experiment in which subjects make repeated decisions and learn about others’ actions across decision rounds. In a linear decision setting, voluntary provision of a public good is contrasted across three treatments. In the “uncertainA” treatment, the return is randomly drawn from a discrete probability distribution. In the “uncertainB” treatment, the return is drawn from a discrete probability distribution that is a mean-preserving spread of the distribution in the uncertainA treatment, but has larger variance. In the “certain” treatment, the return is known with certainty and equal to the expected value of the return in the uncertainA and uncertainB treatments. The experimental data reveal that in settings where subjects experience the certain treatment condition prior to experiencing an uncertain treatment condition, average provision of the public good is negatively impacted by uncertainty, consistent with risk aversion. However, in settings where subjects experience an uncertain treatment condition first, the negative impact of uncertainty disappears, suggesting an order effect in regard to the impact of uncertainty on behavior. Additionally, in treatments with higher variance of the public-good return, there is evidence that some subjects display a version of the “gambler’s fallacy.”

The experimental studies most directly related to this study are Dickinson (1998) and Gangadharan and Nemes (2009). In Dickinson (1998), hereafter referred to as Dickinson, each session of the experiment consists of three decision sequences. The first sequence is a baseline condition with a certain group-fund return. The second or third sequence, depending on the session, is an uncertain treatment condition. Dickinson finds that public-good provision in the first half of decision rounds in an uncertain treatment is significantly lower than that in a certain treatment. In Gangadharan and Nemes (2009), hereafter referred to as GN, each session of the experiment consists of seven decision sequences. The first sequence is a baseline condition with a certain group-fund return. The second or third sequence, depending on the session, is an uncertain treatment condition. GN find that public-good provision across all decision rounds in an uncertain treatment is significantly lower than in a certain treatment.\(^1\)

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\(^1\) Levati et al. (2009), Levati and Morone (2012), and Potters et al. (2007) also examine experimental settings with uncertainty similar to the settings discussed here. However, these studies differ by, among other things, employing groups of size two and provide complete information regarding the other group member’s provision decision.
This study contributes to the literature in three fundamental ways. The first relates to how the variance of the probability distribution for the public-good return impacts public-good provision. This is examined by comparing public-good provision in two treatments with uncertainty, where the probability distributions have different variances. The second contribution relates to examining order effects as a determinant of the response to uncertainty. The third contribution relates to how subjects in uncertainty treatments respond to previous realizations of the return to the public good. More specifically, the study examines the correlation of individual provision decisions with the one-round lagged group-fund return.²

2. THE DECISION SETTING

The experimental sessions for this study were conducted at Indiana University-Bloomington. Undergraduate subjects from a wide range of disciplines were recruited from classrooms and from an online subject data base. At the beginning of each decision sequence, subjects privately read a set of instructions, which were then summarized publicly.³ After reading the instructions, subjects took a post-instruction quiz and were not allowed to continue until all answers were correct. Subjects made all decisions on computers in private.

In aggregate, data were collected from 136 subjects. All subjects were paid a $5 show-up fee. In all sessions, monetary information was denominated in ECUs (Experimental Currency Units). The conversion rate of ECUs to U.S. dollars was 20 to 1. Earnings averaged $21.74 per subject across all sessions, which each lasted approximately 60 minutes.

Each session consisted of two sequences of 10 rounds, which was public information. Subjects were told that instructions regarding Sequence 2 would be given at the conclusion of Sequence 1. The “certain” treatment condition was used in Sequence 1 of each treatment. In the “certain” condition, subjects knew the value of the group-fund return and also knew that it would not change across decision rounds. As mentioned above, treatments varied by the support of the discrete uniform probability distribution used in Sequence 2 to draw the public-good return. Table I summarizes the design for each treatment.

² There are other less related experimental studies examining uncertainty in social dilemma games. For instance, Stoddard (2014) examines exogenously imposed uncertainty over the value of group-funds in one-shot, payoff-equivalent appropriation and provision games. Blanco et al. (2014) examine probabilistic endogenous degradation of a common-pool resource in one-shot appropriation games. Cox (2014) examines noisy signals regarding common-value public goods. Finally, in Fischbacher et al. (2012) and Stoddard et al. (2014) the production of the group resource is certain, but group members are uncertain about the share of the group resource they will receive.

³ See the Appendix for copies of the instructions. The experiment was programmed using Z-tree (Fischbacher 2007).
Table I-Design Information for Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Support in Sequence 1 (Variance)</th>
<th>Support in Sequence 2 (Variance)</th>
<th>Independent Groups</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain-Certain</td>
<td>[2,4] (σ²=0)</td>
<td>[2,4] (σ²=0)</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>Certain-UncertainA</td>
<td>[2,4] (σ²=0)</td>
<td>[0.4, 2.4, 4.4] (σ²=2.67)</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>Certain-UncertainB</td>
<td>[2,4] (σ²=0)</td>
<td>[0.4, 4.4] (σ²=4)</td>
<td>11</td>
<td>44</td>
</tr>
</tbody>
</table>

2.1 Treatment Conditions

2.1.1 Certain-Certain Treatment

At the beginning of a session, the computer randomly and anonymously assigned subjects to four-person groups. These groups did not change throughout the experimental session. No person could identify his/her group members. In each decision round, each person received an endowment of 10 tokens in his/her individual fund, any number of which could be moved to a group fund. Each person earned 1 ECU for each token placed in his/her individual fund. Each token moved to the group fund produced a return of 2.4 ECUs for the group. The ending value of tokens in the group fund was allocated evenly between group members. Thus, each group member received a Marginal Per Capita Return (MPCR) of 0.6 ECUs (marginal group-fund return / marginal individual-fund return). At the conclusion of each round, each subject was informed of his/her group’s aggregate provision to the group fund and his/her round earnings. Subjects received this information from previous rounds in a history table.

2.1.2 Certain-UncertainA Treatment

Sequence 1 in the certain-uncertainA treatment was identical to that in the certain-certain treatment. Sequence 2 differed from Sequence 1 in that the group-fund return was determined probabilistically. In each round in Sequence 2, the group-fund return was drawn from the discrete uniform probability distribution [0.4 ECUs, 2.4 ECUs, 4.4 ECUs]. Thus, the expected return from each token provided to the group fund was 2.4 ECUs (expected MPCR=0.6 ECUs) and the probability distribution was a mean preserving spread of the return in the certain-certain treatment. The variance of the uncertainA probability distribution is 2.67. Subjects did not learn the value of the group-fund return in a given round until all group members finalized their decisions. In addition to the information provided in Sequence 1, subjects were also informed of the group-fund return for all previous decision rounds.

2.1.3 Certain-UncertainB Treatment

To examine the effect of variance of the group-fund return on provision behavior, the certain-uncertainB treatment was also conducted. The certain-uncertainB treatment was identical to that of the certain-uncertainA treatment, except for one difference. In each round in
Sequence 2, the group-fund return was drawn from a discrete uniform probability distribution [0.4 ECUs, 4.4 ECUs]. Thus, the expected return from each token provided to the group fund is the same as in the certain-uncertainA treatment (2.4 ECUs with the expected MPCR=0.6 ECUs). However, the variance of the uncertainB probability distribution is larger (σ²=4). Subjects received the same information as in the certain-uncertainA treatment.

2.1.4 Comparison to Related Studies

In Dickinson, the variance of the group-fund return in the uncertain condition is 2.67. In GN, the variance of the group-fund return in the uncertain condition is 2.25. The variance of the group-fund return in the uncertainA treatment is the same as in Dickinson, allowing for a comparison to previous work. The variance of the group-fund return in the uncertainB treatment provides a setting with larger variance than has been previously studied in the prior research in this area.

3. PREDICTIONS

3.1. Sequence 1 Decisions

In Sequence 1, subjects play a finitely repeated game with a known final round. Assuming common knowledge that each group member maximizes his/her own material self-interest, the one-shot theoretical prediction is straightforward. Because the individual marginal benefit from a token in an individual fund is greater than the individual marginal benefit from a token in the group fund, MPCR=0.6 ECUs, the one-shot Nash equilibrium is for each member to provide zero tokens to the group fund. As noted above, during Sequence 1 of all treatments, however, subjects play with incomplete information. Subjects know there will be a second sequence of 10 rounds, but are not given additional information. Game theoretic predictions under incomplete information, in this case, depend on the subjects' beliefs about Sequence 2. Assuming common knowledge that all group members believe that decisions from Sequence 1 will not affect the game in Sequence 2, the material self-interested subgame Nash equilibrium is to provide zero tokens to the group fund in each round in Sequence 1 of each treatment with a certain group-fund return. On the other hand, research on linear public-goods games indicates that aggregate provisions to the group fund are positive and positively correlated with the MPCR (Isaac et al. 1994, Ledyard 1995). These and other “non-classical” experimental results have led to models with alternative preference structures (Fehr and Schmidt 1999, Fischbacher et al. 2001, and Croson 2007). Based on this evidence, aggregate provision of the group fund is predicted to be positive.

3.2. Sequence 2 Decisions

Recall that in Sequence 2, the distributions of group-fund returns in the certain-uncertainA and certain-uncertainB treatments are mean-preserving spreads of the certain group-fund return in the certain-certaint treatment. Assuming group members are risk neutral, the marginal incentives across all treatments are the same as in Sequence 1. Thus, provision of the group fund in Sequence 2 of the certain-uncertainA and certain-uncertainB treatments is predicted to be the same as in the certain-certaint treatment. Alternatively, Dickinson provides a model that predicts, assuming group members are risk averse and make positive provision decisions, provision of the group fund will be larger when the group-fund return is certain than
when the return is a mean preserving spread of the certain return. This implies that, if subjects are risk averse, provision of the group fund will be larger in Sequence 2 of the certain-certain treatment than in the certain-uncertainA and certain-uncertainB treatments.\(^4\) By extension, since the variance is lower in the uncertainA treatment condition compared to the uncertainB treatment condition, Dickinson’s model also predicts that provision of the group-fund will be larger in Sequence 2 of the certain-uncertainA treatment compared to the certain-uncertainB treatment.\(^5\)

4. RESULTS

For brevity in the discussion of results, the certain-certain treatment will be referred to as CC, the certain-uncertainA treatment as CUA, and the certain-uncertainB treatment as CUB.

4.1. Descriptive Overview

Table II presents the means and standard deviations of group provision of the group fund across sequences and treatments. Mean group provision of the group fund by sequence is similar in all treatments, but within each treatment the Sequence 2 average is lower than the Sequence 1 average. Figure 1 shows the path of mean group-fund provision for each treatment condition. Recall, the certain treatment condition is used in all treatments in Sequence 1. The pattern of mean provision of the group fund yields a pattern consistent with similar linear public-goods games (see Sefton, et al. 2007).

Table II-Summary Statistics: Group-Level Data, by Sequence and Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sequence 1</th>
<th>Sequence 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain-Certain</td>
<td>19.36 (7.72), N=12</td>
<td>18.75 (7.51), N=12</td>
</tr>
<tr>
<td>Certain-UncertainA</td>
<td>21.48 (7.60), N=11</td>
<td>17.17 (6.26), N=11</td>
</tr>
<tr>
<td>Certain-UncertainB</td>
<td>20.61 (9.09), N=11</td>
<td>18.05 (8.71), N=11</td>
</tr>
</tbody>
</table>

\(^4\) Using the principle of second-degree stochastic dominance, Dickinson’s prediction holds for any subject with a concave utility function. See Dickinson for a formal proof.

\(^5\) Levati and Morone (2013) hypothesize that risk aversion per se does not cause the significant decline in group-fund provision, but that losses relative to the endowment are the main driving force behind the negative effects of uncertainty. They test this in groups of two by examining a distribution of the group-fund return where the lowest possible value is still “efficiency-enhancing” for the group. This hypothesis is not considered here because in both the uncertainA and uncertainB distributions the lowest possible return is not efficiency-enhancing.
4.2. Group-Level Regression Analysis: Sequence 2 Decisions

Table III reports an estimated pooled OLS model for observations from Sequence 2. To control for any group effects from Sequence 1, the dependent variable is the difference between group-level provision in each decision round in Sequence 2 and mean group-level provision in Sequence 1 for each group. The estimated model comprises treatment and round dummies as independent variables, with the certain-certain treatment serving as the reference treatment condition.

Using a two-tailed test, the coefficients for the CUA and CUB treatment dummies are not significant, \(p=0.139\) and \(p=0.458\), respectively. However, using a one-tailed test, suggested by Dickinson’s model, the difference in group-fund provision is weakly significantly higher in the CC treatment than in the CUA treatment \(p=0.070\).\(^6\) Lastly, a Wald test of regression coefficients for the CUA and CUB treatments fails to reject the pairwise null hypotheses that the coefficients are equal \(p=0.320\). Thus, as in previous studies, uncertainty significantly lowers group-fund provision, after subjects first experience the certain treatment condition. Although, despite the difference in variances in probability distributions, group-fund provision is not statistically different between the CUA and CUB treatments.

\(^6\) Using two-tailed tests, the coefficient for the CUA treatment dummy is significant at the 10% level when data from the last decision round (20) is dropped.
### Table III- Group-Level Provision, Pooled OLS Regression: Pooled Across All Sequence 2 Decisions

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: Difference between Group-Level Provision in Sequence 2 and Mean Group-Level Provision from Sequence 1 for each Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain-UncertainA</td>
<td>-3.70</td>
</tr>
<tr>
<td></td>
<td>(2.44), [p=0.139]</td>
</tr>
<tr>
<td>Certain-UncertainB</td>
<td>-1.96</td>
</tr>
<tr>
<td></td>
<td>(2.61), [p=0.458]</td>
</tr>
<tr>
<td>Constant</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td>(1.31), [p=0.082]</td>
</tr>
</tbody>
</table>

The reference categories are the certain-certain treatment and round 11. Round dummy for rounds 14-20 are negative and significant at least at the 5% level. Figures in parentheses are robust standard errors clustered on 34 independent groups, 10 observations per cluster. R²=0.08; N=340

5. ADDITIONAL TREATMENTS

This section presents additional treatments that check for order effects among treatment conditions with uncertainty. In the two additional settings, subjects experience uncertainty in both sequences. The first additional treatment, uncertainA-uncertainA (or UAUA), is the same as the CUA treatment except that the group-fund return is drawn from the uncertainA probability distribution, [0.4, 2.4, 4.4], in both sequences. The second additional treatment, uncertainB-uncertainB (or UBUB), is the same as the CUB treatment except that the group-fund return is drawn from the uncertainB probability distribution, [0.4, 4.4], in both sequences.⁷

The theoretical predictions of the initial treatments extend to the UAUA and UBUB treatments. That is, provision of the group fund will be larger in the UAUA treatment with lower variance than the UBUB treatment in Sequence 1. Note that comparing decisions made in Sequence 2 between the UAUA and UBUB treatments is not prudent because subjects experienced different treatment conditions in Sequence 1.

5.1. Results

5.1.1 Descriptive Overview

Table IV presents the means and standard deviations of group provision of the group fund across sequences and treatments. Mean group provision of the group fund by sequence is similar in both treatments, but within each treatment the Sequence 2 average is lower than the Sequence 1 average. Figure 2 reports the path of the mean group-fund provision for the UAUA and UBUB treatments, as well as the CC treatment for a visual control. The primary observation is that the paths of mean provision of the group fund for the additional treatments and the CC treatment are very similar in Sequence 1.

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⁷ Recruiting and experimental protocols in the additional treatments were the same as with the initial three treatments. Data was collected from 108 subjects. Earnings averaged $21.72 per subject across all sessions.
### Table IV-Summary Statistics: Group-Level Data, by Sequence and Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sequence 1</th>
<th>Sequence 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>UncertainA-UncertainA</td>
<td>19.39 (7.92), N=14</td>
<td>18.19 (9.79), N=14</td>
</tr>
<tr>
<td>UncertainB-UncertainB</td>
<td>20.43 (6.56), N=13</td>
<td>20.02 (7.58), N=13</td>
</tr>
</tbody>
</table>

### Figure 2-Mean Group-Fund Provision, by Treatment

![Mean Group-Fund Provision](image)

### 5.1.2 Group-Level Regression Analysis: Sequence 1

Table V reports a regression analysis that pools group-level observations in Sequence 1 of all five treatments. The dependent variable is group provision of the group fund in each round. The independent variables are treatment and round dummies. The treatment dummy
serving as the reference category is a dummy that equals 1 for observations from treatments with the certain treatment condition in Sequence 1.

The coefficients for the treatment dummies are negative and highly insignificant when using one-tailed and two-tailed tests. A Wald test of regression coefficients for the UAUA and UBUB treatments fails to reject the pairwise null hypotheses that the coefficients are equal \([p=0.903]\). Recall, Table III reports similar regression analysis of group-fund provision between the initial three treatments in Sequence 2. The coefficient for the CUA treatment in Table III was significant at the 10% level using a one-tailed test. Thus, combining the results of Table V to those of Table III, there is evidence of a weak order effect with the uncertainA treatment condition.\(^8\)

**Table V- Group-Level Provision, Pooled OLS Regression: Pooled Across All Sequence 1 Decisions**

<table>
<thead>
<tr>
<th>Dependent Variable: Group-Level Provision Sequence 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UncertainA-UncertainA</td>
<td>-1.06 (2.49), ([p=0.670])</td>
</tr>
<tr>
<td>UncertainB-UncertainB</td>
<td>-0.02 (2.24), ([p=0.993])</td>
</tr>
<tr>
<td>Constant</td>
<td>21.61 (1.11), ([p=0.000])</td>
</tr>
</tbody>
</table>

The reference categories are the pooled Sequence 1 certain treatments and round 1. Round dummy for round 2 is positive and significant at the 5% level. Round dummies for rounds 8-10 are negative and significant at least at the 5% level. Figures in parentheses are robust standard errors clustered on 61 independent groups, 10 observations per cluster.

R\(^2\)=0.03; N=610

**6. INDIVIDUAL-LEVEL REGRESSION ANALYSIS**

**6.1 Sequence 1: Three Initial Treatments**

Recall subjects in the CC, CUA, and CUB treatments experience the certain treatment condition during Sequence 1. The purpose of this section is to confirm that group-fund provision decisions were not significantly different from each other across treatment conditions, making them appropriate for comparisons with decisions made in Sequence 2. Table VI reports random-effects models for each of the initial treatments using only observations from Sequence 1. The dependent variable in each regression is the change in an individual’s provision decision in round \((t)\) minus the provision decision in round \((t-1)\). The random-effects models control for the

\(^{8}\) To further investigate the carryover effect from subjects experiencing the certain condition in Sequence 1 as a potential drive for the lower group-fund provision in Sequence 2 with uncertainty, additional regression analysis comparing Sequence 2 group-fund provision between the CUA and UAUA treatments, as well as CUB and UBUB treatments, is reported in the appendix. In both comparisons, group-fund provision in Sequence 2 is higher in the treatment where subjects experience uncertainty in Sequence 1, but the difference is not significant.
subject-specific effect in addition to the idiosyncratic error. The independent variables are rounds dummies and the one-round lagged deviation of person $i$ from the mean provision decision of his/her other three group members.

Consistent with previous linear public-good studies (Chaudhuri and Paichayontvijit 2006, Ashley et al. 2010, Ferraro and Vossler 2010, and Smith 2013), the coefficient for the lagged deviation from other group members is significant and negative in all treatment models. This indicates the presence of reciprocal norms in decision strategies used by group members. Wald tests of regression homogeneity reveal that the Sequence 1 data for pairwise subsamples are not significantly different. The joint null hypothesis of homogeneous coefficients are rejected across pairwise Sequence 1 subsamples ($p>0.10$) for CC=CUA, CC=CUB, and CUA=CUB.$^9$

Table VI- 1-Round Change in Individual Provision Decisions, Random-effects Panel Regression: Sequence 1 Decisions, by Treatment

<table>
<thead>
<tr>
<th>Dependent Variable: 1-Round Change in Individual Provision Decisions in Sequence 1</th>
<th>Certain-Certain</th>
<th>Certain-UncertainA</th>
<th>Certain-UncertainB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lagged Deviation from Mean Provision Decision of Other Members</td>
<td>-0.35 (0.04), [p=0.000]</td>
<td>-0.32 (0.07), [p=0.000]</td>
<td>-0.51 (0.09), [p=0.000]</td>
</tr>
<tr>
<td>Constant</td>
<td>0.38 (0.32), [p=0.236]</td>
<td>0.41 (0.32), [p=0.207]</td>
<td>0.41 (0.25), [p=0.103]</td>
</tr>
</tbody>
</table>

Data from round 1 were dropped because there are no lagged comparisons. The reference category is round 2.

**Certain-Certain:**
- Dummy variables for rounds 4 and 10 are negative and significant at least at the 10% level.
- Figures in parentheses are robust standard errors clustered on 12 independent groups,
- 36 observations per cluster. $R^2=0.22$; N=432

**Certain-UncertainA:**
- Dummy variables for rounds 3 and 8 are negative and significant at least at the 5% level.
- Figures in parentheses are robust standard errors clustered on 11 independent groups,
- 36 observations per cluster. $R^2=0.17$; N=396

**Certain-UncertainB:**
- Dummy variables for rounds 3, 4, and 9 are negative and significant at the 1% level.
- Figures in parentheses are robust standard errors clustered on 11 independent groups,
- 36 observations per cluster. $R^2=0.29$; N=396

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$^9$ The Wald test used here is conducted by pooling data across subsamples and then including subsample dummy and interaction terms. The null hypothesis is that the dummy and interaction coefficients are jointly zero. Unlike the traditional Chow test of regression homogeneity, the Wald test utilizes the estimated variance-covariance matrix from the regression, which incorporates the robust variance estimates with clustering.
6.2 Sequence 2: Three Initial Treatments

Table VII reports random-effects models for each of the initial treatments using only observations from Sequence 2. The dependent and independent variables are the same as those utilized in models in Table VI. Additionally, in models of the CUA and CUB treatments with uncertainty in Sequence 2, the one-round lagged group-fund return is included as an independent variable to control for the effect an uncertain group-fund return has on provision decisions.

Consistent with the results from Table VI, the coefficient for the lagged deviation from other group members is significant and negative in all treatment models. This indicates the presence of reciprocal norms in decision strategies used by group members is unaffected by the uncertainty condition.

The negative coefficients for the lagged group-fund return indicate that some subjects decreased (increased) their provision when they received a high (low) group-fund return in the previous round. To the extent that the lagged group-fund return significantly affected provision behavior across rounds, some subjects may have exhibited a version of the “gambler’s fallacy.” That is, a subject believes that the probability of drawing a particular return has decreased because it recently occurred, even though subjects were informed that the probability of drawing each possible return was independent of the returns drawn in previous rounds.10 The small and insignificant coefficient in the CUA model indicates some subjects exhibited a weak version of the “gambler’s fallacy.” The large and significant coefficient in the CUB model indicates some subjects exhibited a strong version of the “gambler’s fallacy.” Although, a Wald test of the homogeneity of regression coefficients across the CUA and CUB models does not indicate a significant treatment effect on the change in individual provision decisions (fail to reject CUA=CUB, \( p > 0.10 \)).11

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10 The standard version of the gambler’s fallacy occurs in individual decision making (see Ayton and Fischer 2004 and Oskarsson et al. 2009). In the public-goods games studied here, an individual’s provision decision has implications on other group members’ earnings. For instance, there may be an interaction between a mistaken belief of the probability of drawing a possible return and other-regarding preferences for other group members.

11 Individual-level regression analysis for the additional treatments is reported in the appendix. Evidence of a strong version of the “gambler’s fallacy” is also found in the UBUB treatment, but only in the Sequence 2 decision data.
Table VII- 1-Round Change in Individual Provision Decisions, Random-effects Panel Regression: Sequence 2 Decisions, by Treatment

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Certain-Certain</th>
<th>Certain-UncertainA</th>
<th>Certain-UncertainB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Deviation from Mean Provision Decision of Other Members</td>
<td>-0.33 (0.06), [p=0.000]</td>
<td>-0.24 (0.05), [p=0.000]</td>
<td>-0.31 (0.05), [p=0.000]</td>
</tr>
<tr>
<td>Lagged Group-Fund Return</td>
<td>----</td>
<td>-0.06 (0.12), [p=0.616]</td>
<td>-0.41 (0.15), [p=0.007]</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.56 (0.33), [p=0.093]</td>
<td>-0.55 (0.39), [p=0.159]</td>
<td>1.18 (0.31), [p=0.000]</td>
</tr>
</tbody>
</table>

Data from round 11 were dropped because there are no lagged comparisons. The reference category is round 12.

**Certain-Certain:**
Dummy variable for round 16 is positive and significant at the 10% level. Figures in parentheses are robust standard errors clustered on 12 independent groups, 36 observations per cluster. $R^2=0.20$; N=432

**Certain-UncertainA:**
Dummy variable for round 17 is negative and significant at the 10% level. Figures in parentheses are robust standard errors clustered on 11 independent groups, 36 observations per cluster. $R^2=0.13$; N=396

**Certain-UncertainB:**
Dummy variables for rounds 14 and 17 are negative and significant at least at the 10% level. Dummy variable for round 19 is positive and significant at the 10% level. Figures in parentheses are robust standard errors clustered on 11 independent groups, 36 observations per cluster. $R^2=0.20$; N=396

7. CONCLUSION

This study examines uncertain group-fund returns in voluntary-provision public-goods games. As found in related studies, uncertainty reduces public-good provision compared to settings without uncertainty. This study contributes to the literature in three fundamental ways. The first relates to how the variance of the probability distribution for the public-good return impacts public-good provision. This is examined by comparing public-good provision in two treatments with uncertainty, where the probability distributions have different variances. The second contribution relates to examining order effects as a determinant of the response to uncertainty. The third contribution relates to how subjects in treatments with uncertainty respond to previous realizations of the return to the public good. More specifically, the study examines the correlation of individual provision decisions with the one-round lagged group-fund return.

Theoretical predictions assuming risk-averse subjects predict that the negative impact of uncertainty on group-fund provision would be stronger in the treatment with greater variance. However, the data supports the opposite conclusion. The treatment with the lower variance,
certain-uncertainA, had the stronger negative impact on group-fund provision. At the group level, this suggests that the variance of an uncertain return from a public good may not be an important determinant in public-good provision. The data from the additional treatments, where subjects experienced uncertainty in both sequences, support an order effect to uncertainty. Group-fund provision in Sequence 1 is not significantly different between the certain and uncertain treatments. This result suggests that subjects are sensitive to when they are exposed to uncertainty.

At the individual level, at least some individuals increase (decrease) their provision after observing a low (high) group-fund return in the previous period. This result suggests that subjects may have exhibited a version of the “gambler’s fallacy.” An alternative explanation may be that subjects expected the group-fund return to revert towards the mean in the next round. Evidence of such behavior is stronger in the treatment with greater variance, certain-uncertainB.

The results from this study offer insights to organizations that produce public goods with voluntary contributions. Variation in the productivity (or quality) of a public good may have a negative effect on contributions, if preceded by time intervals with no or little variation in productivity or quality in producing the public good. However, if the variation in productivity is large, individual contributions across time intervals may increase (decrease) after a time interval of randomly relatively poor (strong) productivity.
REFERENCES


APPENDIX: Additional Regression Analysis

A.1 Group-Level Regression Analysis: Sequence 2 of Treatments with Uncertainty

To further investigate the impact of subjects experiencing the certain condition prior to an uncertain condition, Table A.I reports two estimated pooled OLS models for observations from Sequence 2. Each model compares group-fund provision from treatments that experience different conditions in Sequence 1, but the same uncertain condition in Sequence 2. These comparisons yield information regarding the carryover effect from subjects’ experiencing the certain condition in Sequence 1 as a potential driver for the reduced provision observed in Sequence 2 with uncertainty. The first model compares decisions in the CUA and UAUA treatments. The second model compares decisions in the CUB and UBUB treatments. To control for any group effects from Sequence 1, the dependent variable in each model is the difference between group-level provision in each decision round in Sequence 2 and mean group-level provision in Sequence 1 for each group. The estimated model comprises treatment and round dummies as independent variables, with the CUA treatment and CUB treatment serving as the reference treatment condition in models 1 and 2, respectively.

In model 1 reported in Table A.I, using a two-tailed test, the coefficient for the UAUA treatment dummy is positive, but not significant ($p=0.168$). In model 2 reported in Table A.I, using a two-tailed test, the coefficient for the UBUB treatment is positive, but not significant ($p=0.360$). Thus, it appears that there is a weak (insignificant) carryover effect from subjects experiencing the certain condition in Sequence 1 that lowers group-fund provision in Sequence 2 with uncertainty.

Table A.I- Group-Level Provision, Pooled OLS Regression: Pooled Across Sequence 2 Decisions

<table>
<thead>
<tr>
<th>Dependent Variable: Difference between Group-Level Provision in Sequence 2 and Mean Group-Level Provision from Sequence 1 for each Group</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>UncertainA-UncertainA</td>
<td>3.11 (2.19), [p=0.168]</td>
<td>UncertainB-UncertainB</td>
</tr>
<tr>
<td>Constant</td>
<td>-2.09 (1.68), [p=0.227]</td>
<td>Constant</td>
</tr>
</tbody>
</table>

Model 1:
The reference categories are the certain-uncertainA treatment and round 11. Round dummy for rounds 12, 13, and 16-20 are negative and significant at least at the 10% level. Figures in parentheses are robust standard errors clustered on 25 independent groups, 10 observations per cluster. R²=0.07; N=250

Model 2:
The reference categories are the certain-uncertainB treatment and round 11. Round dummy for rounds 15 and 17-19 are negative and significant at least at the 10% level. Figures in parentheses are robust standard errors clustered on 24 independent groups, 10 observations per cluster. R²=0.07; N=240
**A.2 Individual-Level Regression Analysis: Sequence 1 of the Two Additional Treatments**

Recall, subjects in the UAUA and UBUB treatments experience the uncertain treatment conditions during Sequence 1. Table A.II reports a random-effects model similar to those in Table VI in the study for each additional treatment using only observations from Sequence 1.

As in the previous Tables V and VI, the significance and negative signs of the coefficients for lagged deviation from other group members in the UAUA and UBUB models suggest the presence of reciprocal norms in decision strategies used by group members. The negative and insignificant coefficient of the lagged group-fund return in the UAUA model is some evidence of a weak version of the “gambler’s fallacy.” However, the coefficient of the lagged group-fund return is positive and insignificant in the UBUB model. A Wald test of the homogeneity of regression coefficients across the UAUA and UBUB models does not indicate a significant treatment effect in Sequence 1 (fail to reject UAUA=UBUB, \( p>0.10 \)).

**Table A.II- (Additional Treatments) 1-Round Change in Individual Provision Decisions, Random-effects Panel Regression: Sequence 1 Decisions, by Treatment**

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>UncertainA-UncertainA</th>
<th>UncertainB-UncertainB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Deviation from Mean Provision Decision of Other Members</td>
<td>-0.32 (0.08), ([p=0.000])</td>
<td>-0.27 (0.05), ([p=0.000])</td>
</tr>
<tr>
<td>Lagged Group-Fund Return</td>
<td>-0.13 (0.09), ([p=0.166])</td>
<td>0.02 (0.07), ([p=0.719])</td>
</tr>
<tr>
<td>Constant</td>
<td>0.61 (0.29), ([p=0.034])</td>
<td>-0.15 (0.30), ([p=0.628])</td>
</tr>
</tbody>
</table>

Data from round 1 were dropped because there are no lagged comparisons. The reference category is round 2.

**UncertainA-UncertainA:**
- Dummy variable for round 8 is negative and significant at the 1% level.
- Figures in parentheses are robust standard errors clustered on 14 independent groups, 36 observations per cluster. \( R^2=0.20; N=504 \)

**UncertainB-UncertainB:**
- Dummy variable for round 10 is positive and significant at the 1% level.
- Figures in parentheses are robust standard errors clustered on 13 independent groups, 36 observations per cluster. \( R^2=0.17; N=468 \)
A.3 Individual-Level Regression Analysis: Sequence 2 of the Two Additional Treatments

Recall, subjects in the UAUA and UBUB treatments experienced different treatment conditions during Sequence 1. For this reason, analysis between these treatments in Sequence 2 is not prudent. Table A.III reports random-effects model similar to those in Table A.I of the study for each additional treatment using only observations from Sequence 2.

A.2.1 UncertainA-UncertainA Treatment: Sequence 2

In the UAUA model in Table A.III, the significant and negative sign of the coefficient for lagged deviation from other group members suggests the presence of reciprocal norms in decision strategies used by group members. The coefficient of the lagged group-fund return is negative and insignificant. This suggests some evidence of a weak version of the “gambler’s fallacy.”

A.2.2 UncertainB-UncertainB Treatment: Sequence 2

In the UBUB model in Table A.III, the significant and negative sign of the coefficient for lagged deviation from other group members suggests the presence of reciprocal norms in decision strategies used by group members. The coefficient of the lagged group-fund return is negative and significant at the 5% level. This is some evidence of a strong version of the “gambler’s fallacy.”

Comparing results in Tables VI, A.II, and A.III there appears to be an order effect within the uncertainB treatment condition because the lagged group-fund return impacts provision behavior only in Sequence 2 of the CUB and UBUB treatments, regardless of whether the Sequence 1 treatment condition was certain or uncertain.

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12 To verify that the lagged group-fund return did not significantly affect provision decisions in the latter decision rounds in Sequence 1 in the UBUB treatment, a model similar to that in Table VII was examined using only observations from rounds 6-10. The coefficient of the lagged group-fund return from the UBUB model using data from rounds 6-10 is positive and insignificant, similar to the coefficient reported in Table A.I.
Table A.III- (Additional Treatments) 1-Round Change in Individual Provision Decisions, Random-effects Panel Regression: Sequence 2 Decisions, by Treatment

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>UncertainA-UncertainA</th>
<th>UncertainB-UncertainB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Deviation from Mean</td>
<td>-0.30 (0.05), [p=0.000]</td>
<td>-0.31 (0.06), [p=0.000]</td>
</tr>
<tr>
<td>Provision Decision of Other Members</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lagged Group-Fund Return</td>
<td>-0.12 (0.09), [p=0.157]</td>
<td>-0.15 (0.07), [p=0.049]</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.01 (0.44), [p=0.977]</td>
<td>0.25 (0.43), [p=0.560]</td>
</tr>
</tbody>
</table>

Data from round 11 were dropped because there are no lagged comparisons. The reference category is round 12.

UncertainA-UncertainA:
Dummy variables are not significant.
Figures in parentheses are robust standard errors clustered on 14 independent groups, 36 observations per cluster. $R^2=0.16; N=504$

UncertainB-UncertainB:
Dummy variable for round 20 is positive and significant at the 5% level.
Figures in parentheses are robust standard errors clustered on 13 independent groups, 36 observations per cluster. $R^2=0.18; N=468$
APPENDIX: Instructions

Certain-Certain Treatment

Welcome

No Talking Allowed
Now that the experiment has begun, we ask that you do not talk. If you have a question after we finish reading the instructions, please raise your hand and the experimenter will approach you and answer your question in private.

This Experiment
This experiment consists of TWO SEQUENCES of decision rounds. Each sequence contains TEN decision rounds. This set of instructions details Sequence 1. An additional set of instructions detailing Sequence 2 will be provided after Sequence 1 is completed.

Random Matching and Anonymity
Each person will be randomly matched with 3 other people to form a group. Thus, each group will contain 4 individuals. YOU WILL REMAIN IN THIS GROUP FOR THE REST OF THIS EXPERIMENT.

For cash payment purposes, you will enter your name into the computer when the experiment is finished. You and the experimenter are the only people who will know your decisions and earnings.

Cash Payment
Your earnings in this experiment are expressed in EXPERIMENTAL CURRENCY UNITS, which we will refer to as ECUs. At the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

Sequence 1 (decision rounds 1-10)

Multiple Rounds
In each round, you will face the same decision task. The decision task in each round is described below.

Starting Balances
Each individual begins EACH ROUND with an endowment of 10 tokens worth 1 ECU each, yielding an Individual Fund of 10 ECUs. Each four person group begins EACH ROUND with a Group Fund of 0 ECUs.

DECISION TASK IN EACH ROUND
Each person will decide independently and privately whether or not to move any of his/her tokens from his/her own Individual Fund into the Group Fund. Each person can move up to a maximum of 10 tokens to the Group Fund. Each token that a person adds to the Group Fund reduces the value of his/her Individual Fund by 1 ECU. However, each token added to the Group Fund by a group member increases the value of the Group Fund by 2.4 ECUs.

Each decision must be in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund.
After all individuals have made their decisions for the round, the computer will tabulate the results. You will be informed of the total number of tokens in the Group Fund and the total value of the Group Fund, in ECUs.

Earnings

**Earnings in EACH round:** After all persons in the group make their decisions, the Group Fund will be divided equally among all individuals in the group. That is, all individuals in the group will receive 25% of the Group Fund. For each individual in the group, those earnings will be combined with the amount that the individual has remaining in his/her own Individual Fund.

A person’s earnings in a round will equal the ending value of tokens (in ECUs) in his/her own Individual Fund plus one-fourth of the ending value of tokens in the Group Fund (in ECUs).

**Three examples** illustrate how the tokens moved to the Group Fund are related to the values of the Individual and Group Funds.

- If a person adds 0 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 0 ECUs and adds 0 ECUs to the value of the Group Fund.
- If a person adds 5 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 5 ECUs and adds 12 ECUs to the value of the Group Fund.
- If a person adds 10 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 10 ECUs and adds 24 ECUs to the value of the Group Fund.

Information and History

At the end of each round, you will receive information on your Group Fund earnings and your total earnings for that round. While making your decision in each round a history table of decisions and results, shown below, will be on the bottom of the screen. The history table displays a past summary of the group’s decisions to move tokens to the Group Fund, your decisions to move tokens to the Group Fund, your Group Fund earnings, and your total earnings for each completed decision round. The uncompleted round will be the last row in the history table and will have zeros in each entry. In the history table shown in the handout, round 4 is the uncompleted round.

<table>
<thead>
<tr>
<th>Round</th>
<th>Tokens you moved to the Group Fund</th>
<th>Total amount of tokens moved to the Group Fund by the group</th>
<th>Earnings from the Group Fund, in ECUs</th>
<th>Earn total earnings, in ECUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>8.40</td>
<td>8.40</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>10.60</td>
<td>10.60</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**TOTAL Earnings:** Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. Recall, at the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

This completes the instructions for Sequence 1.

Next, to ensure you understand the basic procedures and calculations in Sequence 1 you will complete 4 review questions. After you answer each question, press the Continue button. If you answer a question correctly, you will move on to the next question. If you answer a question incorrectly, the computer will give you a message stating you answered incorrectly. Questions answered incorrectly will be attempted again until answered correctly.

Each question screen will have "Important Information" from the instructions specific to that question. Also, the Sequence 1 handout has tables and “important aspects of Sequence 1” that will help you answer the questions. After five minutes an answer key will be provided to help you correct any remaining errors.
After you finish the review questions, please wait patiently for the other participants to finish. Sequence 1 will begin when all participants have finished the review questions.

**Sequence 2 (decision rounds 11-20)**
Sequence 2 will consist of 10 additional decision rounds. In Sequence 2 you will remain in the same group as in Sequence 1 and also face the same decision task as in Sequence 1.

*Certain-UncertainA Treatment*

Sequence 1 instructions are the same as instructions for the certain-certain Sequence 1 instructions.

**Sequence 2 (decision rounds 11-20)**
Random Matching and Anonymity

Your group in Sequence 1 will also be your group in Sequence 2. For cash payment purposes, you will enter your name into the computer when Sequence 2 is finished. You and the experimenter are the only people who will know your decisions and earnings.

Multiple Rounds
In each round, you will face the same decision task. The decision task in each round is described below.

Starting Balances
Each individual begins EACH ROUND with an endowment of 10 tokens worth 1 ECU each, yielding an Individual Fund of 10 ECUs. Each four person group begins EACH ROUND with a Group Fund of 0 ECUs.

DECISION TASK IN EACH ROUND
Each person will perform the same task as in Sequence 1. That is, each person will decide independently and privately whether or not to move any of his/her tokens from his/her own Individual Fund into the Group Fund. Each person can move up to a maximum of 10 tokens to the Group Fund. Each token that a person adds to the Group Fund reduces the value of his/her Individual Fund by 1 ECU. However, each token added to the Group Fund by a group member increases the value of the Group Fund by one of three Group Fund rates, listed below. The computer will randomly choose the Group Fund rate. Each rate has an equal probability of being chosen.

- Group Fund Rate 1: Each token added to the Group Fund by a group member increases the value of the Group Fund by 0.4 ECUs.
- Group Fund Rate 2: Each token added to the Group Fund by a group member increases the value of the Group Fund by 2.4 ECUs.
- Group Fund Rate 3: Each token added to the Group Fund by a group member increases the value of the Group Fund by 4.4 ECUs.

Each decision must be in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund.

After all individuals have made their decisions for the round, the computer will tabulate the results. You will be informed of the total number of tokens in the Group Fund and the total value of the Group Fund, in ECUs.

Earnings
Earnings in EACH round: After all persons in the group make their decisions, the Group Fund will be divided equally among all individuals in the group. That is, all individuals in the group will receive 25% of the Group Fund.

A person’s earnings in a round will equal the ending value of tokens (in ECUs) in his/her own Individual Fund plus one-fourth of the ending value of tokens in the Group Fund (in ECUs).

Three examples illustrate how the tokens moved to the Group Fund and the Group Fund rate are related to the values of the Individual and Group Funds.

- Assume a person adds 0 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 0 ECUs.
  i. If the computer randomly chooses Group Fund rate 1, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund rate 2, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
  iii. If the computer randomly chooses Group Fund rate 3, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
• Assume a person adds 5 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 5 ECUs.
  i. If the computer randomly chooses Group Fund rate 1, the 5 tokens added to the Group Fund add 2 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund rate 2, the 5 tokens added to the Group Fund add 12 ECUs to the value of the Group Fund.
  iii. If the computer randomly chooses Group Fund rate 3, the 5 tokens added to the Group Fund add 22 ECUs to the value of the Group Fund.

• Assume a person adds 10 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 10 ECUs.
  i. If the computer randomly chooses Group Fund rate 1, the 10 tokens added to the Group Fund add 4 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund rate 2, the 10 tokens added to the Group Fund add 24 ECUs to the value of the Group Fund.
  iii. If the computer randomly chooses Group Fund rate 3, the 10 tokens added to the Group Fund add 44 ECUs to the value of the Group Fund.

The following example illustrates how a person’s earnings from the Group Fund in a round are related to value of the Group Fund.

• Suppose the four persons add a total of 20 tokens to the Group Fund.
  i. If the computer randomly chose Group Fund rate 1, this would result in a Group Fund with a total value of 8 ECUs. In this case, each person would receive 25% of the Group Fund worth 2 ECUs.
  ii. If the computer randomly chose Group Fund rate 2, this would result in a Group Fund with a total value of 48 ECUs. In this case, each person would receive 25% of the Group Fund worth 12 ECUs.
  iii. If the computer randomly chose Group Fund rate 3, this would result in a Group Fund with a total value of 88 ECUs. In this case, each person would receive 25% of the Group Fund worth 22 ECUs.

Information and History

At the end of each round, you will receive information on your earnings related to the Group Fund and your total earnings for that round.

While making your decision in each round a history table will be shown at the bottom of the screen. The last row in the table will be the last completed decision round. The history table will display entries for up to 12 decision rounds. As the experiment progresses, you will be able to change which 12 rounds are displayed by scrolling a bar up or down on the right side of the history table.

The history table will display a summary of decisions and earnings, in ECUs, from Sequence 1. For each completed decision round of Sequence 2, the history table will display a summary of decisions and earnings, in ECUs. The history table will also display the Group Fund rate chosen for the group for each completed round.

See the illustration history table in your Sequence 2 handout. Note that in the illustration history table “Sequence 2” refers to decisions and earnings that will be made in Sequence 2.
<table>
<thead>
<tr>
<th>Round</th>
<th>Tokens you chose to move to the Group Fund</th>
<th>Total amount of tokens moved to the Group Fund</th>
<th>Group Fund Rate (in ECUs)</th>
<th>Your earnings from the Group Fund</th>
<th>Your total earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
<td>29</td>
<td>2.4</td>
<td>17.40</td>
<td>19.40</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>35</td>
<td>2.4</td>
<td>21.00</td>
<td>22.00</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>18</td>
<td>2.4</td>
<td>10.80</td>
<td>13.80</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>26</td>
<td>2.4</td>
<td>15.60</td>
<td>20.60</td>
</tr>
<tr>
<td>11</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
<tr>
<td>12</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
<tr>
<td>13</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
<tr>
<td>14</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
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</tr>
<tr>
<td>15</td>
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<tr>
<td>16</td>
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<tr>
<td>17</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
<tr>
<td>18</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
</tbody>
</table>

**TOTAL Earnings:** Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. Recall, at the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

This completes the instructions for Sequence 2.

**REVIEW QUESTIONS**

Next, to ensure you understand the basic procedures and calculations in Sequence 2 you will complete 4 review questions. After you answer each question, press the Continue button. If you answer a question correctly, you will move on to the next question. If you answer a question incorrectly, the computer will give you a message stating you answered incorrectly. Questions answered incorrectly will be attempted again until answered correctly.

Each question screen will have "Important Information" from the instructions specific to that question. Also, the Sequence 2 handout has tables and "important aspects of Sequence 2" that will help you answer the questions. After five minutes an answer key will be provided to help you correct any remaining errors.

After you finish the review questions, please wait patiently for the other participants to finish. Sequence 2 will begin when all participants have finished the review questions.
**Certain-UncertainB Treatment**

Sequence 1 instructions are the same as instructions for the certain-certain Sequence 1 instructions.

**Sequence 2 (decision rounds 11-20)**

**Random Matching and Anonymity**

Your group in Sequence 1 will also be your group in Sequence 2. For cash payment purposes, you will enter your name into the computer when Sequence 2 is finished. You and the experimenter are the only people who will know your decisions and earnings.

**Multiple Rounds**

In each round, you will face the same decision task. The decision task in each round is described below.

**Starting Balances**

Each individual begins EACH ROUND with an endowment of 10 tokens worth 1 ECU each, yielding an Individual Fund of 10 ECUs. Each four person group begins EACH ROUND with a Group Fund of 0 ECUs.

**DECISION TASK IN EACH ROUND**

Each person will perform the same task as in Sequence 1. That is, each person will decide independently and privately whether or not to move any of his/her tokens from his/her own Individual Fund into the Group Fund. Each person can move up to a maximum of 10 tokens to the Group Fund. Each token that a person adds to the Group Fund reduces the value of his/her Individual Fund by 1 ECU. However, each token added to the Group Fund by a group member increases the value of the Group Fund by one of two Group Fund Rates, listed below. The computer will randomly choose the Group Fund Rate. Each rate has an equal probability of being chosen.

- Group Fund Rate 1: Each token added to the Group Fund by a group member increases the value of the Group Fund by 0.4 ECUs.
- Group Fund Rate 2: Each token added to the Group Fund by a group member increases the value of the Group Fund by 4.4 ECUs.

Each decision must be in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund.

After all individuals have made their decisions for the round, the computer will tabulate the results. You will be informed of the total number of tokens in the Group Fund and the total value of the Group Fund, in ECUs.

**Earnings**

*Earnings in EACH round:* After all persons in the group make their decisions, the Group Fund will be divided equally among all individuals in the group. That is, all individuals in the group will receive 25% of the Group Fund.

*A person’s earnings in a round will equal the ending value of tokens (in ECUs) in his/her own Individual Fund plus one-fourth of the ending value of tokens in the Group Fund (in ECUs).*

**Three examples** illustrate how the tokens moved to the Group Fund and the Group Fund Rate are related to the values of the Individual and Group Funds.
• Assume a person adds 0 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 0 ECUs.
  i. If the computer randomly chooses Group Fund Rate 1, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund Rate 2, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.

• Assume a person adds 5 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 5 ECUs.
  i. If the computer randomly chooses Group Fund Rate 1, the 5 tokens added to the Group Fund add 2 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund Rate 2, the 5 tokens added to the Group Fund add 22 ECUs to the value of the Group Fund.

• Assume a person adds 10 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 10 ECUs.
  i. If the computer randomly chooses Group Fund Rate 1, the 10 tokens added to the Group Fund add 4 ECUs to the value of the Group Fund.
  ii. If the computer randomly chooses Group Fund Rate 2, the 10 tokens added to the Group Fund add 44 ECUs to the value of the Group Fund.

The following example illustrates how a person’s earnings from the Group Fund in a round are related to value of the Group Fund.

• Suppose the four persons add a total of 20 tokens to the Group Fund.
  iv. If the computer randomly chose Group Fund Rate 1, this would result in a Group Fund with a total value of 8 ECUs. In this case, each person would receive 25% of the Group Fund worth 2 ECUs.
  v. If the computer randomly chose Group Fund Rate 2, this would result in a Group Fund with a total value of 88 ECUs. In this case, each person would receive 25% of the Group Fund worth 22 ECUs.

Information and History

At the end of each round, you will receive information on your earnings related to the Group Fund and your total earnings for that round.

While making your decision in each round a history table will be shown at the bottom of the screen. The last row in the table will be the last completed decision round. The history table will display entries for up to 12 decision rounds. As the experiment progresses, you will be able to change which 12 rounds are displayed by scrolling a bar up or down on the right side of the history table.

The history table will display a summary of decisions and earnings, in ECUs, from Sequence 1. For each completed decision round of Sequence 2, the history table will display a summary of decisions and earnings, in ECUs. The history table will also display the Group Fund Rate chosen for the group for each completed round.
See the illustration history table in your **Sequence 2 handout**. Note that in the illustration history table “Sequence 2” refers to decisions and earnings that will be made in Sequence 2.

<table>
<thead>
<tr>
<th>Round</th>
<th>Tokens you chose to move to the Group Fund</th>
<th>Total amount of tokens moved to the Group Fund</th>
<th>Group Fund Rate (in ECUs)</th>
<th>Your earnings from the Group Fund</th>
<th>Your total earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
<td>29</td>
<td>2.4</td>
<td>17.40</td>
<td>19.40</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>35</td>
<td>2.4</td>
<td>21.00</td>
<td>22.00</td>
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<tr>
<td>10</td>
<td>5</td>
<td>26</td>
<td>2.4</td>
<td>15.60</td>
<td>20.60</td>
</tr>
<tr>
<td>11</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
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<td>Sequence 2</td>
<td>Sequence 2</td>
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<tr>
<td>18</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
<td>Sequence 2</td>
</tr>
</tbody>
</table>

**TOTAL Earnings:** Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. Recall, at the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

This completes the instructions for Sequence 2.

**REVIEW QUESTIONS**

Next, to ensure you understand the basic procedures and calculations in Sequence 2 you will complete 4 review questions. After you answer each question, press the Continue button. If you answer a question correctly, you will move on to the next question. If you answer a question incorrectly, the computer will give you a message stating you answered incorrectly. Questions answered incorrectly will be attempted again until answered correctly.

Each question screen will have "Important Information" from the instructions specific to that question. Also, the Sequence 2 handout has tables and "important aspects of Sequence 2" that will help you answer the questions. After five minutes an answer key will be provided to help you correct any remaining errors.

After you finish the review questions, please wait patiently for the other participants to finish. Sequence 2 will begin when all participants have finished the review questions.
Welcome

No Talking Allowed
Now that the experiment has begun, we ask that you do not talk. If you have a question after we finish reading the instructions, please raise your hand and the experimenter will approach you and answer your question in private.

This Experiment
This experiment consists of TWO SEQUENCES of decision rounds. Each sequence contains TEN decision rounds. This set of instructions details Sequence 1. An additional set of instructions detailing Sequence 2 will be provided after Sequence 1 is completed.

Random Matching and Anonymity
Each person will be randomly matched with 3 other people to form a group. Thus, each group will contain 4 individuals. YOU WILL REMAIN IN THIS GROUP FOR THE REST OF THIS EXPERIMENT.

For cash payment purposes, you will enter your name into the computer when the experiment is finished. You and the experimenter are the only people who will know your decisions and earnings.

Cash Payment
Your earnings in this experiment are expressed in EXPERIMENTAL CURRENCY UNITS, which we will refer to as ECUs. At the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 10 ECUs of earnings from the experiment.

Sequence 1 (decision rounds 1-10)

Multiple Rounds
In each round, you will face the same decision task. The decision task in each round is described below.

Starting Balances
Each individual begins EACH ROUND with an endowment of 10 tokens worth 1 ECU each, yielding an Individual Fund of 10 ECUs. Each four person group begins EACH ROUND with a Group Fund of 0 ECUs.

DECISION TASK IN EACH ROUND
Each person will perform the same task as in Sequence 1. That is, each person will decide independently and privately whether or not to move any of his/her tokens from his/her own Individual Fund into the Group Fund. Each person can move up to a maximum of 10 tokens to the Group Fund. Each token that a person adds to the Group Fund reduces the value of his/her Individual Fund by 1 ECU. However, each token added to the Group Fund by a group member increases the value of the Group Fund by one of three Group Fund rates, listed below. The computer will randomly choose the Group Fund rate. Each rate has an equal probability of being chosen.

- Group Fund Rate 1: Each token added to the Group Fund by a group member increases the value of the Group Fund by 0.4 ECUs.
- Group Fund Rate 2: Each token added to the Group Fund by a group member increases the value of the Group Fund by 2.4 ECUs.
- Group Fund Rate 3: Each token added to the Group Fund by a group member increases the value of the Group Fund by 4.4 ECUs.
Each decision must be in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund. After all individuals have made their decisions for the round, the computer will tabulate the results. You will be informed of the total number of tokens in the Group Fund and the total value of the Group Fund, in ECUs.

**Earnings**

*Earnings in EACH round:* After all persons in the group make their decisions, the Group Fund will be divided equally among all individuals in the group. That is, all individuals in the group will receive 25% of the Group Fund.

*A person’s earnings in a round will equal the ending value of tokens (in ECUs) in his/her own Individual Fund plus one-fourth of the ending value of tokens in the Group Fund (in ECUs).*

**Three examples** illustrate how the tokens moved to the Group Fund and the Group Fund rate are related to the values of the Individual and Group Funds.

- Assume a person adds 0 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 0 ECUs.
  - i. If the computer randomly chooses Group Fund rate 1, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
  - ii. If the computer randomly chooses Group Fund rate 2, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.
  - iii. If the computer randomly chooses Group Fund rate 3, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.

- Assume a person adds 5 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 5 ECUs.
  - i. If the computer randomly chooses Group Fund rate 1, the 5 tokens added to the Group Fund add 2 ECUs to the value of the Group Fund.
  - ii. If the computer randomly chooses Group Fund rate 2, the 5 tokens added to the Group Fund add 12 ECUs to the value of the Group Fund.
  - iii. If the computer randomly chooses Group Fund rate 3, the 5 tokens added to the Group Fund add 22 ECUs to the value of the Group Fund.

- Assume a person adds 10 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 10 ECUs.
  - i. If the computer randomly chooses Group Fund rate 1, the 10 tokens added to the Group Fund add 4 ECUs to the value of the Group Fund.
  - ii. If the computer randomly chooses Group Fund rate 2, the 10 tokens added to the Group Fund add 24 ECUs to the value of the Group Fund.
  - iii. If the computer randomly chooses Group Fund rate 3, the 10 tokens added to the Group Fund add 44 ECUs to the value of the Group Fund.

**The following example** illustrates how a person’s earnings from the Group Fund in a round are related to value of the Group Fund.

- Suppose the four persons add a total of 20 tokens to the Group Fund.
  - vi. If the computer randomly chose Group Fund rate 1, this would result in a Group Fund with a total value of 8 ECUs. In this case, each person would receive 25% of the Group Fund worth 2 ECUs.
  - vii. If the computer randomly chose Group Fund rate 2, this would result in a Group Fund with a total value of 48 ECUs. In this case, each person would receive 25% of the Group Fund worth 12 ECUs.
If the computer randomly chose Group Fund rate 3, this would result in a Group Fund with a total value of 88 ECUs. In this case, each person would receive 25% of the Group Fund worth 22 ECUs.

Information and History

At the end of each round, you will receive information on your earnings related to the Group Fund and your total earnings for that round.

While making your decision in each round a history table will be shown at the bottom of the screen. The last row in the table will be the last completed decision round. The history table will display entries for up to 12 decision rounds. As the experiment progresses, you will be able to change which 12 rounds are displayed by scrolling a bar up or down on the right side of the history table. The history table will display a summary of decisions and earnings, in ECUs, from Sequence 1. For each completed decision round of Sequence 1, the history table will display a summary of decisions and earnings, in ECUs. The history table will also display the Group Fund rate chosen for the group for each completed round.

See the illustration history table in your Sequence 1 handout. Note that in the illustration history table “Sequence 1” refers to decisions and earnings that will be made in Sequence 1.

<table>
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<td>1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
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<tr>
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<td>Sequence 1</td>
<td>Sequence 1</td>
</tr>
<tr>
<td>3</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
</tr>
</tbody>
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TOTAL Earnings: Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. Recall, at the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

This completes the instructions for Sequence 1.

REVIEW QUESTIONS

Next, to ensure you understand the basic procedures and calculations in Sequence 1 you will complete 5 review questions. After you answer each question, press the Continue button. If you answer a question correctly, you will move on to the next question. If you answer a question incorrectly, the computer will give you a message stating you answered incorrectly. Questions answered incorrectly will be attempted again until answered correctly.

Each question screen will have "Important Information" from the instructions specific to that question. Also, the Sequence 1 handout has tables and "important aspects of Sequence 1" that will help you answer the questions. After five minutes an answer key will be provided to help you correct any remaining errors.

After you finish the review questions, please wait patiently for the other participants to finish. Sequence 1 will begin when all participants have finished the review questions.

Sequence 2 (decision rounds 11-20)

Sequence 2 will consist of 10 additional decision rounds. In Sequence 2 you will remain in the same group as in Sequence 1 and also face the same decision task as in Sequence 1.
UncertainB-UncertainB Treatment

Welcome

No Talking Allowed
Now that the experiment has begun, we ask that you do not talk. If you have a question after we finish reading the instructions, please raise your hand and the experimenter will approach you and answer your question in private.

This Experiment
This experiment consists of TWO SEQUENCES of decision rounds. Each sequence contains TEN decision rounds. This set of instructions details Sequence 1. An additional set of instructions detailing Sequence 2 will be provided after Sequence 1 is completed.

Random Matching and Anonymity
Each person will be randomly matched with 3 other people to form a group. Thus, each group will contain 4 individuals. YOU WILL REMAIN IN THIS GROUP FOR THE REST OF THIS EXPERIMENT.

For cash payment purposes, you will enter your name into the computer when the experiment is finished. You and the experimenter are the only people who will know your decisions and earnings.

Cash Payment
Your earnings in this experiment are expressed in EXPERIMENTAL CURRENCY UNITS, which we will refer to as ECUs. At the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 10 ECUs of earnings from the experiment.

Sequence 1 (decision rounds 1-10)

Multiple Rounds
In each round, you will face the same decision task. The decision task in each round is described below.

Starting Balances
Each individual begins EACH ROUND with an endowment of 10 tokens worth 1 ECU each, yielding an Individual Fund of 10 ECUs. Each four person group begins EACH ROUND with a Group Fund of 0 ECUs.

DECISION TASK IN EACH ROUND
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- Group Fund Rate 1: Each token added to the Group Fund by a group member increases the value of the Group Fund by 0.4 ECUs.
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Each decision must be in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund. After all individuals have made their decisions for the round, the computer will tabulate the results. You will be informed of the total number of tokens in the Group Fund and the total value of the Group Fund, in ECUs.

**Earnings**

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  - ii. If the computer randomly chooses Group Fund Rate 2, the 0 tokens added to the Group Fund add 0 ECUs to the value of the Group Fund.

- Assume a person adds 5 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 5 ECUs.
  - i. If the computer randomly chooses Group Fund Rate 1, the 5 tokens added to the Group Fund add 2 ECUs to the value of the Group Fund.
  - ii. If the computer randomly chooses Group Fund Rate 2, the 5 tokens added to the Group Fund add 22 ECUs to the value of the Group Fund.

- Assume a person adds 10 tokens to the Group Fund, that reduces the value of his/her Individual Fund by 10 ECUs.
  - i. If the computer randomly chooses Group Fund Rate 1, the 10 tokens added to the Group Fund add 4 ECUs to the value of the Group Fund.
  - ii. If the computer randomly chooses Group Fund Rate 2, the 10 tokens added to the Group Fund add 44 ECUs to the value of the Group Fund.

**The following example** illustrates how a person’s earnings from the Group Fund in a round are related to value of the Group Fund.

- Suppose the four persons add a total of 20 tokens to the Group Fund.
  - ix. If the computer randomly chose Group Fund Rate 1, this would result in a Group Fund with a total value of 8 ECUs. In this case, each person would receive 25% of the Group Fund worth 2 ECUs.
  - x. If the computer randomly chose Group Fund Rate 2, this would result in a Group Fund with a total value of 88 ECUs. In this case, each person would receive 25% of the Group Fund worth 22 ECUs.

**Information and History**

At the end of each round, you will receive information on your earnings related to the Group Fund and your total earnings for that round.

While making your decision in each round a history table will be shown at the bottom of the screen. The last row in the table will be the last completed decision round. The history table will display entries for
up to 12 decision rounds. As the experiment progresses, you will be able to change which 12 rounds are displayed by scrolling a bar up or down on the right side of the history table.

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See the illustration history table in your **Sequence 1 handout**. Note that in the illustration history table “Sequence 1” refers to decisions and earnings that will be made in Sequence 1.

<table>
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<tr>
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<tbody>
<tr>
<td>1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
</tr>
<tr>
<td>2</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
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<td>Sequence 1</td>
<td>Sequence 1</td>
</tr>
<tr>
<td>3</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
<td>Sequence 1</td>
</tr>
</tbody>
</table>

**TOTAL Earnings:** Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. Recall, at the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 20 ECUs of earnings from the experiment.

This completes the instructions for Sequence 1.

**REVIEW QUESTIONS**

Next, to ensure you understand the basic procedures and calculations in Sequence 1 you will complete 5 review questions. After you answer each question, press the Continue button. If you answer a question correctly, you will move on to the next question. If you answer a question incorrectly, the computer will give you a message stating you answered incorrectly. Questions answered incorrectly will be attempted again until answered correctly.

Each question screen will have "Important Information" from the instructions specific to that question. Also, the Sequence 1 handout has tables and "important aspects of Sequence 1" that will help you answer the questions. After five minutes an answer key will be provided to help you correct any remaining errors.

After you finish the review questions, please wait patiently for the other participants to finish. Sequence 1 will begin when all participants have finished the review questions.
Sequence 2 (decision rounds 11-20)

Sequence 2 will consist of 10 additional decision rounds.

In Sequence 2 you will remain in the same group as in Sequence 1 and also face the same decision task as in Sequence 1.