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ABSTRACT

We investigate the role of payoff asymmetry in laboratory prisoner's dilemma games. Symmetric and Asymmetric games are examined in simultaneous and sequential settings. In the asymmetric/sequential games, we study the impact of having payoff advantaged players moving either first or second. Asymmetry reduces the rates of cooperation in simultaneous games. In sequential games, asymmetry interacts with order of play such that the rate of cooperation is highest when payoff disadvantaged players move first. The presence of an exit option increases cooperation by the players who choose to play the game when payoffs are symmetric, or when payoffs are asymmetric and the payoff disadvantaged player moves first.


**KEY WORDS** • cooperation • prisoner's dilemma • heterogeneity • exit option

## 1. Introduction

In one-shot prisoner's dilemma games, the predicted outcome is mutual defection if one assumes that players are only concerned about maximizing their own payoffs. This is true whether the game is played simultaneously or sequentially. Contrary to this prediction, experimental studies of one-shot prisoner's dilemma settings generally report a significant proportion of cooperative choices. Several factors have been identified as increasing or decreasing cooperation in one-shot prisoner's dilemma. Examples include: playing the game sequentially results in a higher rate of cooperation than playing the game simultaneously (Ahn, Ostrom, and Walker, 2003; Cho and Choi, 2000; Hayashi et al.1999; Clark and Sefton, 2001); the larger the payoffs from mutual cooperation compared to those from mutual defection, the higher the rates of cooperation (Ahn et al., 2001); the identity of the other player affects a player's likelihood of cooperating (Bohnet and Frey, 1999; Kollock, 1998); pre-play communication raises the rates of cooperation (Andreoni and Varian, 1999); when there is an exit option, the players who choose not to exit tend to cooperate at a higher rate than that in the game without an exit option (Orbell and Dawes, 1993).

The research reported in this paper focuses on whether or not payoff asymmetry affects individual choices in the prisoner's dilemma game, and how choices are related to whether the decision maker is payoff advantaged or disadvantaged. The research is motivated by the fact that, in the naturally occurring world of social dilemma situations, the gains from mutual cooperation are often times not equally distributed. That is, even when both individuals gain by cooperating with each other compared to the case in which both defect, one might gain more than the other. Field researchers have often concluded that heterogeneity is a cause of management failure, or alternatively, ignore within community asymmetries when there are successes (Agrawal and Gibson, 1999). More recently, some have cautioned against making broad claims about the putative negative role of heterogeneity (Baland and Platteau, 1996; Lam, 1998; Ruttan and Borgerhoff Mulder, 1999; Bardhan and Dayton-Johnson, 2001, 2002; Ostrom, 1990, 2001;

Varughese and Ostrom, 2001). For that matter, researchers within the international relations tradition have typically emphasized the beneficial effects of heterogeneity among states (Snidel, 1995), and those studying adaptive resource management institutions stress the positive role of actors with heterogeneous motives. Thus, the field research provides mixed views on the role of payoff asymmetry and at least one of the reasons for this inconclusiveness seems to be the difficulties involved in identifying the payoff structures precisely, even when it is rather clear that the situation under investigation constitute a social dilemma.

Several laboratory social dilemma experiments contribute to a better understanding of the roles of asymmetry by precisely defining the incentive structure. For example, Budescu, Rapoport and Sulieman (1990) report no difference in mean levels of requests to withdraw units in an asymmetrical, 5-person, one-shot, resource dilemma game, as compared to a symmetrical version of the game. However, other research reports heterogeneity to be associated with either diminished payoff efficiencies, or with increasing difficulty in agreeing to resource sharing rules. Hackett, Schlager and Walker (1994) found that in *N*-person commons dilemmas, heterogeneity in endowments reduced earnings relative to the symmetric setting. Furthermore, heterogeneity was associated with a reduced ability of group members to agree on allocation rules.

In this literature, two principal reasons are often discussed for how asymmetry may impact levels of cooperation and the form of cooperative agreements. First, asymmetric incentives for finding a cooperative agreement may alter subjects' perceptions of the likelihood of others' willingness to cooperate and thus impact their choices in anticipation of their partner cooperating/not cooperating. Second, subjects may have preferences for fair outcomes, reflecting more equal payoffs. Van Dijk and Wilke (1995) present evidence that subjects in asymmetrical settings are attending to fairness insofar as they arrive at resource sharing rules that vary with experimental design. Similarly, in an asymmetric resource dilemma game, Budescu, Rapoport and Suleiman (1990), report that a substantial number of subjects make decisions consistent with a preference for equity, or proportionality, in earnings.

This paper revisits the issue of asymmetry in the most basic social dilemma situation of a one-shot prisoner's dilemma game. To make the comparison more valid between symmetric and asymmetric prisoner's dilemmas, we control for the sum of the two players' payoffs for each of the four outcomes of the game between the games structures. In asymmetric games one player is "advantaged'' and the other "disadvantaged." The advantaged player not only receives a larger payoff in the mutual cooperation outcome than the disadvantaged player, he or she also gains more when defecting on a cooperating partner, and loses less when cooperating with a partner that defects.

Given the results from studies in other social dilemmas settings, we expect to observe lower rates of cooperation in asymmetric simultaneous games than in symmetric games, due to the innate violation of the equity norm. For sequential games, however, behavior may vary depending on whether the disadvantaged player moves first or second. One might argue that since the disadvantaged player has more to lose from cooperating with a partner that defects, he or she would be more reluctant as a first mover to trust the second mover. On the other hand, one might argue that an advantaged player is more likely to reciprocate cooperation by a disadvantaged first mover. If this is anticipated by the disadvantaged first mover, cooperation rates may increase for both players. A simple formal game theoretical analysis with two types of players (egoists and conditional cooperators) and incomplete information supports the latter conjecture as do our experimental results. Thus it is shown that institutional rules as rudimentary as the sequence of play, can impact rates of cooperation in asymmetric settings.

While our main focus is the role of asymmetry in the simultaneous and sequential prisoner's dilemma, we also examine how the existence of an exit option might interact with payoff asymmetry. Due to the generally high levels of exit choices, we are not able to draw strong conclusions regarding the rates of cooperation among those who choose to play the game. However, there is some evidence that the probability of choosing to play the game is related to the players' expectation about how the game would be played if they chose to play the game. Thus, for example, the disadvantaged first movers are much more likely to choose to play the game than the advantaged first movers.

In Section 2, we report the symmetric and asymmetric prisoner's dilemma payoff matrices that we use in the experiment and discuss the extent to which precise predictions regarding the relative rates of cooperation between symmetric and asymmetric games can be derived from a model that assumes two preferences types of egoists and conditional cooperators. In Section 3, the details of our experimental design and procedure are explained. In Section 4, we present the results of our experiment. In Section 5, we summarize the findings and discuss their implications.

## 2. A Behavioral Model and Conjectures

### 2.1 Symmetric and Asymmetric Prisoner's Dilemma Derived from a Public Good Game

We begin with a discussion of the three payoff matrices utilized in game settings in our experiments. The three games, Symmetric, Asymmetric 1, and Asymmetric 2 are shown in Figure 1 using payoffs in dollars.[1] The games were presented to the subjects as shown, with no discussion of the "logic" behind the payoffs associated with each outcome. However, the payoff matrices were in fact developed to reflect an underlying structure similar to linear public goods settings (e.g. Isaac, Walker, and Williams, 1994).

We imagine each player has an initial endowment of 18 units of a productive resource that can be held (option B) or contributed to a group good (option A). In all games, the value of holding the endowment is $18. If a participant contributes the resource to the group good, he/she incurs a loss of his/her endowment and an additional loss of $6, for a total loss of $24. However, each contribution to the group good yields a payoff benefit to both players.

[ Figure 1 about here]

In the symmetric game, the marginal benefit to each player of a contribution to the group good is $18. Consider the case where player *i* contributes and player *j* does not contribute. Player *i* receives a payoff of $12 (the $18 marginal benefit, plus the $18 endowment, minus the $24 cost of contributing). Player *j* receives a payoff of $36 (the $18 marginal benefit plus the $18 endowment). If both players contribute, they both receive $30 (the $18 marginal benefit from each contribution, plus the $18 endowment, minus the $24 cost of contributing).

In the asymmetric games, the size of the marginal benefit from the group good varies between players. The high marginal benefit player, the "advantaged" player, receives a marginal benefit of $20 for each contribution to the group good, while the low marginal benefit player, the "disadvantaged" player, receives a marginal benefit of $16 for each contribution to the group good. The two asymmetric games differ in whether player 1 or 2 is the advantaged or disadvantaged player. All other aspects of the payoffs are calculated as in the symmetric game. Note that across all three games, the sum of payoffs to the two participants is constant for the outcomes associated with A, B and B, A. In addition, the summed payoff for any particular cell is constant across game designs. For brevity, in the discussions that follow, we will refer to an action of contributing to the group good as cooperation (C) and an action of not contributing to the group good as defection (D).

**2.2 A Model of Heterogeneous Preferences in Prisoner's Dilemma**

We first derive conjectures regarding the effects of payoff asymmetry based on a simplified version of heterogeneous preferences. The model adds a single "guilt" parameter to the monetary payoffs. In recent years there have been a growing number of studies examining the theoretical implications of fairness considerations (Rabin, 1993; Binmore, 1998), as well as experimental demonstrations of its importance in both humans (Ochs and Roth, 1989; Andreoni, Brown and Vesterland, 2002; Fehr and Gachter, 2002; Fehr and Rockenbach, 2003) and non-human primates (Brosnan and DeWaal, 2003). It is reasonable, based on this literature, to assume that many subjects act in a manner that is consistent with decisions based on reciprocal expectations or expectations of trust (Berg, Dickhaut, and McCabe, 1995, Croson, 1998). Several formal models of social preferences (for example, Bolton and Ockenfels 2000; Fehr and Schmidt 1999; Cox and Friedman 2002) attempt to represent the inter-individual heterogeneity in preferences in precise manners. Our model is consistent with all of these models when applied to the prisoner's dilemma game in that it allows for two major preference types: egoists and conditional cooperators. Egoists have strictly self-interested preferences; conditional cooperators prefer to cooperate if the other player also cooperates.

Formally, suppose players experience guilt when defecting on a cooperating counterpart. Let $T_i$,$R_i$,$P_i$, and $S_i$ $(T_i > R_i > P_i > S_i)$ stand for the four objective payoffs for player $i$ of the prisoner's dilemma game as conventionally identified.[2] Let $g_i$ $(0 \leq g_i \leq T_i - P_i)$ denote the magnitude of guilt (loss of utility) a player incurs when the outcome is (D,C) where D stands for defection and C for cooperation. If $g_i$ is greater than $T_i - R_i$, a player prefers the outcome (C,C) to the outcome (D,C) and, thus, is a conditional cooperator as we define the term. Otherwise, the player is an egoist. Egoists have a preference ordering of $u(D,C)>u(C,C)> u(D,D)> u(C,D)$ and the conditional cooperator's preference ordering is either $u(C,C)> u(D,C)> u(D,D)> u(C,D)$ or $u(C,C)> u(D,D)> u(D,C)> u(C,D)$).

[Figure 2 about here]

In our symmetric game, $T_1 = T_2$=36, $R_1 = R_2$=30, $P_1 = P_2$=18, and $S_1 = S_2$= 12. In our asymmetric games $T_i$ = 38, $R_i$ = 34, $P_i$= 18, $S_i$ =14 for the advantaged player, and $T_i$ = 34, $R_i$ = 26, $P_i$= 18, $S_i$ =10 for the disadvantaged player. Note that the payoff parameters ($T_i$,$R_i$,$P_i$, and $S_i$) and a player's intrinsic motivation ($g_i$) jointly determines the player's preferences over possible outcomes of a given prisoner's dilemma game. At the population level, the proportion of conditional cooperators in a population is jointly determined by the payoff parameters of a prisoner's dilemma game and the distribution of $g_i$ in the population. The existence and proportion of conditional cooperators alters the equilibrium prediction of the game as it changes the nature of the decision making problem for players of both types.

**2.3 Theoretical Analysis**

What are the implications of these modeling assumptions, based on a simplified version of the widely shared views on preferences among behavioral game theorists and experimentalists? We find that our model, as well as all of the aforementioned formal models of heterogeneous preferences, provides clear prediction, in terms of the relative rates of cooperation among symmetric and asymmetric prisoner's dilemmas, only among the second movers of the sequential game. Among the players in simultaneous games and among the first movers of the sequential game, the prediction is indeterminate unless one assumes certain distributions of the preference parameter(s).

**Sequential Second Movers**

As mentioned before, sequential play of a prisoner's dilemma generally results in a higher rate of cooperation as compared to simultaneous play. Ahn, Ostrom, and Walker (2003) show that this pattern is consistent with predictions based on formal models of other-regarding preferences such as inequity aversion. The logic of this prediction follows from the notion that some players prefer to cooperate in order to achieve the outcome that maximizes joint payoffs. Yet, they may require sufficient assurance that their partner will also cooperate. A sequential game provides a mechanism for first movers to signal their willingness to trust their partner by cooperating, thus eliminating the uncertainty about the first players' intentions. However, if first movers have reasons for believing their partner will not reciprocate with cooperation, levels of cooperation will be reduced. Asymmetry in payoffs introduces such a reason. If participants consider payoff asymmetries in evaluating whether their partner is likely to reciprocate cooperation, we would expect order of play by payoff advantaged or disadvantaged players to be important.

The clearest prediction is obtained regarding the relative likelihood of cooperation among the second movers responding to first mover's cooperation.

**Proposition 1**. A*mong second movers responding to first movers' cooperation, the rate of cooperation is highest in Asymmetric 2 (in which the disadvantaged player moves first) followed by Symmetric, and lowest in Asymmetric 1 (in which the advantaged player moves first)*.

For a second mover in the Symmetric game responding to first mover's cooperation, $u(D) = 36 - g_i$ and $u(C|C) = 30$. Therefore, $g_i$ must be at least 6 for this player to cooperate. Let $g^*$ denote the critical $g_i$ that separates egoists and reciprocators for a given payoff structure; $g^* = 6$ in the Symmetric game. Similar calculations show that for Asymmetric 1, $g^* = 8$, and for Asymmetric 2, $g^* = 4$. Thus, given that the first mover cooperates, the second mover in Asymmetric 2 has the highest probability of reciprocating. This is also consistent with the temptation parameter argument of Rappoport and Chamma (1965) and the behavioral results of Ahn et al. (2001). Fehr and Schmidt's (1999) somewhat more complicated inequity aversion model with two parameters yields the same predictions. In fact, the predicted behavior for second movers is equivalent for most of the behavioral models.[3]

There is an intuitive explanation for these predictions. Previous studies have shown that the quantities such as *greed* ($T_i - R_i$) and *cooperators' gain* ($R_i - P_i$) are strong predictors of behavior in one-shot prisoner's dilemma games (Ahn et al. 2001). In an asymmetrical payoff structure, the two players face players with levels of *greed* and/or *cooperator's gain that are different from their own.* Thus, depending on relative payoffs, one of the players is more (or less) likely to reciprocate cooperation. The prediction regarding the rates of cooperation among the second movers responding to first mover's cooperation reflects the fact that, in the games we examine, *greed* is the smallest for payoff advantaged players ($4), followed by that for players in the symmetric games ($6), and the largest for the disadvantaged players ($8). On the other hand, *cooperators' gain*, which has shown to be positively related with rates of cooperation, is the largest for the advantaged players ($16), followed by that for players in the symmetric game ($12), and the lowest for the disadvantaged players ($8). Thus, disadvantaged players have greater incentives to defect than do advantaged players.

**Sequential First Movers**

While the predictions are clear with regard to the relative likelihood of cooperative choices among the second movers of the sequential game, this is not the case with regard to the first movers of the sequential game. More specifically, without particular assumptions about the actual distribution of player types, the predicted behavior for the first mover is indeterminate.

Following the notation given above, let, $Prob(g \geq 6)$ =1-$F(6) = p_s$, $Prob(g \geq 8)$ = 1-$F(8) = p_1$, and $Prob(g \geq 4)$ = 1-$F(4) = p_2$, where $F(\cdot)$ is the cumulative distribution function of $g_i$. Then, $p_s$, $p_1$, and $p_2$ are the probabilities that a second mover will cooperate responding to a first mover's cooperation in Symmetric, Asymmetric 1, and Asymmetric 2, respectively. From the analyses above (Proposition 1) we know that $p_2 > p_s > p_1$. Let $r_s$, $r_1$, and $r_2$ denote the probabilities that a first mover of the sequential game will cooperate in Symmetric, Asymmetric 1, and Asymmetric 2, respectively.

**Proposition 2.** $p_2 > p_s > p_1$ does not imply $r_2 > r_s > r_1$. *That is, the probabilities of cooperation among first movers in sequential games are not dictated by the ordering of probabilities of cooperation among second movers.*

A first mover's expected utility calculation for the Symmetric game can be calculated as follows: $u(C) = p_s * 30 + (1- p_s) * 12 = 18p_s + 12$, and $u(D) = 18$. Thus, a first mover is expected to cooperates if $p_s \geq 1/3$. Similar calculations show that a first mover in Asymmetric 1 cooperates if $p_1 \geq 1/5$ and a first mover in Asymmetric 2 cooperates if $p_2 \geq 1/2$. This implies that assuming $p_2 > p_s > p_1$ is not sufficient to yield predictions as to which of the three games will have the highest probability of cooperation by the first mover. This prediction depends on the exact distribution of types. For example, suppose for a given $F(g)$, players actual probabilities were $p_2 = 4/7$, $p_s = 2/7$, and $p_1 = 1/7$. Then the first mover cooperates only in the Asymmetric game 2 (in which the second mover is the advantaged player). But if we assumed $p_2 = 5/11$, $p_s = 4/11$, and $p_1 = 3/11$, the first movers cooperate in Symmetric and Asymmetric 1, but not in Asymmetric 2.

**Simultaneous Games**

A Bayesian Nash equilibrium of the simultaneous game, again, does not provide a definite result regarding the relative frequency of cooperation between the symmetric and asymmetric games. This is shown below by focusing on the equilibrium conditions.

In the symmetric game, suppose there is a cut point on the guilt parameter $g^* \geq 6$ such that all types with $g \geq g^*$ cooperate and all other types defect. Let $p^*$ denote the proportion of types that cooperate. Then $p^* = 1 - F(g^*)$. The player type $g^*$ should be indifferent between cooperating and defecting. Thus,

$$u(c \mid g^*) = p^* \times 30 + (1 - p^*) \times 12$$
$$u(d \mid g^*) = p \times (36 - g^*) + (1 - p^*) \times 18$$

The cut points, when they exist, can be obtained by solving the equality $u(c|g^*) = u(d|g^*)$ , which gives $g^*=6/(1-F(g^*))$. This means that the $g^*$ that satisfies the expression $g^* = 6/(1-F(g^*))$ is the cut point of types that cooperate and defect. For a given cumulative distribution $F(g)$, it is possible to calculate the proportion of cooperators as $p^*=1-F(g^*)$.

In the asymmetric game, again assuming that both the advantaged and disadvantaged players are drawn from a common distribution $F(g)$, denote the cut point for the advantaged players $g^a$ and that for the disadvantaged players $g^d$ . Also, let $p^a = 1-F(g^a)$ and $p^d = 1-F(g^d)$. Calculating the cut points ($g^a$ , $g^d$ ) involves solving a simultaneous system of equations

$$\begin{aligned} u(c \mid g^a) &= u(d \mid g^a) \\ u(c \mid g^d) &= u(d \mid g^d) \end{aligned},$$

which simplifies to another simultaneous equation system

$$\begin{aligned} g^a &= 4/(1 - F(g^d)) \\ g^d &= 8/(1 - F(g^a)) \end{aligned}.$$

The two cut points can be solved once the distribution $F(g)$ is specified. The proportions of cooperating types among advantaged and disadvantaged can be calculated thereafter. (If any of the cut points are below 6, or above the upper bound of the distribution, then the distribution does not support an equilibrium in which at least some types cooperate.) The only definite result is that the advantaged player is more likely to cooperate than the disadvantaged player, as long as there exists at least one equilibrium in which some types cooperate – this is independent of the distribution of types. But the analysis does not provide a definite result regarding whether the players in the simultaneous game are more likely to cooperate than those in the asymmetrical game. Unlike the case of the second movers in a sequential game, the ranking in the simultaneous game depends on the exact specification of the distribution of the types. Thus, we must leave this and the behavior of first movers in sequential games as open empirical questions of our study.

## 3. The Experimental Design and Procedure

### 3.1 Procedures

We report observations from experiments conducted at Indiana University-Bloomington, U.S., and Sung Kyun Kwan University, Seoul, Korea. Participants from Indiana University were recruited from introductory economics classes. Participants from Sung Kyun Kwan University were recruited from introductory social science classes.[4] Instructions used in the experiments conducted in Korea were based on a translation of the U.S. experiments. One of the authors participated as an experimenter in all sessions in both the U.S. and Korea, insuring that the same experimental protocols were utilized across sessions.

Subjects were recruited in groups of approximately 20 students for each session. Upon entering the classroom used to conduct the experiments, subjects were seated in a manner that allowed for private decision-making. They were anonymously assigned to a two-person group and randomly selected to be “Participant 1” or “Participant 2.” Participants could not identify the other participant with whom they were matched or which of the other participants were assigned the roles of Participant 1 or Participant 2.

Three game designs were used: Symmetric, Asymmetric 1, and Asymmetric 2. While only one design was utilized in each experimental session, subjects faced four decision situations within each session. Participants were presented with instructions that summarized the experimental procedures and were given a detailed description of each of the four decision situations. Instructions were read by each participant in private and reviewed publicly by the experimenter using an overhead projector. Upon reviewing the instructions for a situation, participants were asked to make their decision for that situation. After all four situations had been presented, participants were given an opportunity to review all their decisions and make any changes they desired.[5]

As was explained in the instructions to participants, after decisions were collected the experimenters randomly chose one of the four decision situations for determining experimental earnings. The choice was made by blindly choosing one of four color-coded chips from a cup. Participants' earnings for the experiment were then calculated based on the game situation chosen. Each participant also received a participation fee, which was $5 in U.S. and W5,000 in Korea, and completed a questionnaire before leaving the experiment.[6]

The four decision situations were presented to the participants as: the first decision situation, the second decision situation, the third decision situation, and the fourth decision situation. As was the case in the instructions, the descriptions presented below are from the perspective of a particular decision situation being randomly chosen to be the one on which experimental earnings would be based.

**3.2 The Decision Settings**

The four decision settings that each subject faced are the following. In the **first** decision setting participants made decisions simultaneously. Each participant chose "A" or "B". In the **second** decision setting, Participant 1 chose "A" or "B", while Participant 2 made two choices. Without knowing the choice of Participant 1, Participant 2 made one choice of "A" or "B" under the condition that Participant 1 chose "A." Participant 2 made another choice of "A" or "B" under the condition that Participant 1 chose "B." Participant 2 made one choice of "A" or "B" under the condition that Participant 1 chose "A", and another choice of "A" or "B" under the condition that

Participant 1 chose "B". In neither case, did participant 2 know the choice of participant 1 before making their decision. The **third** decision setting parallels the first decision setting, except that each participant was given the choice of playing the game or not (the exit option). If a participant chose to play the game, he/she chose option "A" or "B." If a participant chose not to play the game, he/she received a known monetary payoff ($24 for Participants 1 and 2 in the Symmetric game, $26 for Participant 1 and $22 for Participant 2 in Asymmetric 1, and $22 for Participant 1 and $26 for Participant 2 in Asymmetric 2.) Note that if either participant chose not to play the game in this decision situation, and if this decision situation was randomly chosen at the end of the experiment for payoff purposes, then both participants received the payoff associated with not playing the game. The **fourth** decision setting parallels the second decision setting, except that each participant is given the choice of playing the game or not.

## 4. Experimental Results

Observations are reported on decisions of 80 subjects in the Symmetric game, 48 subjects in Asymmetric 1 and 42 subjects in Asymmetric 2. As noted above, for purposes of presentation we refer to the choice of "A" as the cooperative choice and "B" as defection. Similarly, with respect to the asymmetric games, the participants are referred to as "advantaged" or "disadvantaged" and games are described as ones where participant 1 (or 2) has payoff advantages or disadvantages. The presentation of results is organized around examining the influence of payoff asymmetry in (1) simultaneous decision making with no exit option, (2) sequential decision making with no exit option, (3) simultaneous and sequential decision making with an exit option. Results are pooled across sessions using the same game design. In addition, for the simultaneous setting the observations are pooled across the two asymmetric designs, the justification being that subjects make decisions simultaneously and hence there is no logical difference between them. For brevity, we do not separately analyze the data of the U.S. and Korean subjects. The patterns of results we report are not dependent on such an analysis.

Statistics reported are from two-sample Wilcoxon rank-sum tests. For tests of statistical significance we adopt an $\alpha$ equal to 0.10.

**4.1 Symmetric vs. Asymmetric Simultaneous PD**

Table 1 displays the frequencies of cooperation for both simultaneous and sequential settings without an exit option and test statistics for treatment comparisons. In the simultaneous setting 32% of subjects cooperate in the Symmetric game, whereas only 13% of subjects cooperate in the pooled Asymmetric games. The difference is statistically significant ($p$ = 0.003). Of the 12 subjects who cooperate in the latter condition, 8 are advantaged and 4 disadvantaged. Comparing decisions made by these two groups with decisions made in the symmetric game, the rate of cooperation among players in the Symmetric game is significantly higher in comparison to the advantaged players ($p$ = 0.08) and the disadvantaged players ($p$ = 0.003) in the Asymmetric games.

[Table 1 about here]

Based on prior empirical results and the payoff parameters for *greed* and *cooperators' gain* in our game designs, one might expect to observe higher rates of cooperation for advantaged players relative to their counterparts in the Symmetric games. However, just like the advantaged first movers in the sequential game with asymmetric payoffs, the advantaged player in the simultaneous game faces a counterpart whose incentive to cooperate is very low. Thus, if the advantaged players take into account the incentives of their counterparts, it is quite possible that their rates of cooperation will be lower than those observed for players in the symmetric game. Indeed, the results reported in Table 1 confirm this conjecture. This finding suggests that players, instead of responding solely to their own payoff structure, take into account the incentives of other players with whom they are matched. Therefore, it can be concluded that the results that payoff parameters of *greed* and *fear* are powerful predictors of the probability of cooperation in the symmetric prisoner's dilemma (Ahn et al., 2001) must be qualified when applied to games in which payoffs are asymmetric.

**4.2 Symmetric vs. Asymmetric Sequential PD**

We next examine the results from games where decisions were made sequentially without an exit option.

**Sequential Second Movers**: Consistent with the results from other studies, cooperation is very low among second movers responding to a first mover's defection, regardless of the game design. The behavior of second movers responding to cooperation is very different. The game theoretic model predicts that the rate of cooperation should be highest in Asymmetric 2 (where the disadvantaged player is moving first), followed by the Symmetric game, and lowest in Asymmetric 1 (where the disadvantaged player is moving second). The ranking we observe is consistent with this prediction (43% > 35% > 21%). The differences, however, are not significant; in the case of Asymmetric 1 versus Asymmetric 2, $p = 0.1154$.

**Sequential first Movers:** Now, consider the decisions made by first movers. Cooperation rates are highest for players in the Symmetric design, followed by first movers in Asymmetric 2 (who are disadvantaged), and lowest for first movers in Asymmetric 1 (who are advantaged), 30%>14%>0%. The differences in rates of cooperation are not significant between Symmetric and Asymmetric 2, but both of these designs yield rates that are significantly different than Asymmetric 1. Further, in Asymmetric 1, first movers cooperate at lower rates than players in the corresponding simultaneous setting ($p = 0.0597$). None of the twenty-four advantaged first movers cooperated in Asymmetric 1, despite the fact that the *fear* parameter ($P$ - $S$) is the smallest for these players. Consistent with the behavior of the advantaged players in the simultaneous game, the advantaged first movers in the sequential game seem to respond more to their expectation of the second movers' behavior than to their own incentives characterized by the parameters *fear* and *greed*.

### 4.3 The Exit Choice

How does asymmetry affect player's likelihood of choosing to play the game? Table 2 displays the percentages of players choosing to play for each decision situation, the rates of cooperation among this subset of subjects, and test statistics for treatment comparisons.

[Table 2 about here]

In the simultaneous setting with an exit option, the likelihood of choosing to play the game is not significantly different between symmetric and asymmetric games, but the likelihood of cooperation conditional on choosing to play is. As shown, 45% of the subjects choosing to play in the Symmetric game also cooperate, whereas in the Asymmetric games only 12% of those choosing to play cooperate. The difference is statistically significant at $p = 0.005$.

Among the first movers choosing to play in the sequential setting, those in the Symmetric game are significantly more likely to cooperate than those movers in either the Asymmetric 1 game ($p = 0.083$) or the Asymmetric 2 game ($p = 0.06$). However, there are no significant differences in the rate of cooperation by second movers among any of the three games.

A choice to play appears to reflect players' beliefs about whether or not their matched counterparts will cooperate. That is, in the sequential setting, the order of the rates of choosing to play among first movers corresponds to the order of the rates of cooperation among second movers responding to first mover's cooperation: Asymmetric 2 > Symmetric > Asymmetric 1. Further, in the simultaneous games, the rates at which players choose to play the game corresponds to the rates of cooperation among those who choose to play the game; more subjects choose to play in the Symmetric game than in the Asymmetric games, and more subjects who choose to play cooperate in the Symmetric game than those in the Asymmetric game. Thus, players seem to form relatively accurate predictions about the expected behavior of other players' behavior conditional on others' choosing to play the game and then respond to this expectation when they decide whether to play the game or not. This again suggests that players evaluate other player's motivations and not solely their own.

**4. Discussion**

All of the games studied here have a payoff structure in which mutual defection is the only equilibrium if players make decisions based only on their own monetary returns. Yet most researchers, working with a wide range of settings, find that a significant proportion of subjects cooperate in PD games and other similar social dilemma games (see Ahn, Ostrom, Walker, 2003 and the citations therein). Typically, however, these experiments utilize a symmetric payoff structure. This study broadens the scope of these previous studies. Our results suggest that asymmetry in payoffs, sequential play, and having an exit option interact in their impact on behavior. Below we discuss how these factors interact with subjects' strategic choices.

Three principal findings emerge from this research. First, asymmetry has a clear negative effect on cooperation in simultaneous decision settings. This finding is true for games with and without an exit option. We hypothesize that asymmetric payoffs may increase uncertainty about the intentions of one's partner, leading to reduced cooperation. Previous research indicates that focal points may organize cooperative behavior with the most important focal point being equality of payoffs. In the asymmetric games examined here, there is no obvious focal point for cooperation, and in fact, the only outcome in which partners receive equal payoffs is joint defection. Further, the asymmetric game yields unequal payoff incentives in regard to gains from cooperation, the cost of cooperating when one's partner defects, and the temptation to defect. It is likely that players observe that a disadvantaged player has a larger monetary incentive to defect and a greater loss from cooperating if her/his partner defects. Thus subjects, who might otherwise prefer an outcome of mutual cooperation, may be reluctant to cooperate in anticipation of defection by their counterpart. Finally, both aspects of the decision situation, the lack of a focal point and the differing pecuniary incentives to cooperate, may lead subjects to perceive the outcome of cooperation as "unfair".

Second, asymmetry interacts with order of play in sequential settings. In games with and without an exit option, first movers in the Asymmetric 1 sequential game (the advantaged players) are significantly less likely to cooperate than participants in the Asymmetric/simultaneous setting. In contrast, second movers in the Asymmetric 2 sequential game (the advantaged players) are more likely to cooperate (conditional on cooperation by the first mover) than are participants in the Asymmetric/simultaneous setting. These results are consistent with the theoretical prediction proposed above. If subjects are concerned about fairness, in the sense of equality of payoffs, and have a preference for mutual cooperation, the differences in incentives of advantaged and disadvantaged players will interact with order of play. Survey results suggest that there exists a class of subjects who are willing to cooperate if they have a reasonable assurance that their counterpart will cooperate (Ahn, Ostrom, and Walker, 2004). In the Asymmetric 1 sequential game, the disadvantaged player has the strategic advantage, in the sense of moving second, and also has a large incentive to defect ($8). Player 1, the advantaged player, may anticipate this and not cooperate as a first mover. In contrast, in the Asymmetric 2 sequential game, the advantaged player has the strategic advantage of moving second, but has a smaller incentive to defect ($4). Here player 1, the disadvantaged player, may be less fearful of defection by player 2 and thus choose to cooperate. Thus, when the advantaged player moves second, we would expect more cooperation by first movers and by second movers responding to their cooperation.

Finally, the presence of an exit option increases the overall rate of cooperation by players who choose to play. In addition, the likelihood of players choosing to play the game is tied to their relatively accurate predictions regarding how the game would be played if they chose to play. Thus, the relative rates of cooperation in games without an exit option predict the likelihood of players choosing to play the game when there is an exit option.

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**Figure 1. Experimental Payoff Matrices**

*Design:* *Symmetric*
*Game Parameters:* *E=18, B=$18, C=$24*
*Exit Option:* *$24*

| | | IF PARTICIPANT 2 CHOOSES | |
|---|---|---|---|
| | | **A** | **B** |
| **IF PARTICIPANT 1 CHOOSES** | **A** | Participant 1 gets $30<br>Participant 2 gets $30 | Participant 1 gets $12<br>Participant 2 gets $36 |
| | **B** | Participant 1 gets $36<br>Participant 2 gets $12 | Participant 1 gets $18<br>Participant 2 gets $18 |

*Design:* *Asymmetric 1*
*Game Parameters:* $E_1 = 18, B_1 = \$20, C = \$24, E_2 = 18, B_2 = \$16, C = \$24$
*Exit Option:* *Participant 1 = $26, Participant 2 = $22*

| | | IF PARTICIPANT 2 CHOOSES | |
|---|---|---|---|
| | | **A** | **B** |
| **IF PARTICIPANT 1 CHOOSES** | **A** | Participant 1 gets $34<br>Participant 2 gets $26 | Participant 1 gets $14<br>Participant 2 gets $34 |
| | **B** | Participant 1 gets $38<br>Participant 2 gets $10 | Participant 1 gets $18<br>Participant 2 gets $18 |

*Design:* *Asymmetric 2*
*Game Parameters:* $E_1 = 18, B_1 = \$16, C = \$24, E_2 = 18, B_2 = \$20, C = \$24$
*Exit Option:* *Participant 1 = $22, Participant 2 = $26*

| | | IF PARTICIPANT 2 CHOOSES | |
|---|---|---|---|
| | | **A** | **B** |
| **IF PARTICIPANT 1 CHOOSES** | **A** | Participant 1 gets $26<br>Participant 2 gets $34 | Participant 1 gets $10<br>Participant 2 gets $38 |
| | **B** | Participant 1 gets $34<br>Participant 2 gets $14 | Participant 1 gets $18<br>Participant 2 gets $18 |

**Figure 2. Prisoner's Dilemma with Two preference types**

| | | **Player 2** | |
|---|---|---|---|
| | | **Cooperate** | **Defect** |
| **Player 1** | **Cooperate** | $R_1$ , $R_2$ | $S_1$ , $T_2$- $g_2$ |
| | **Defect** | $T_1$- $g_1$, $S_2$ | $P_1$ , $P_2$ |

**Table 1. Frequency of Cooperation and Test Statistics: No Exit Option.** Entries in the upper table are the percentage of cooperation with absolute number of cooperative choices or number of observations in parentheses. In the lower table, p-values are from two-sample Wilcoxon rank-sum tests.

| SIMULTANEOUS GAME | Symmetric | Asymmetric 1 & 2 Pooled | |
|---|---|---|---|
| | 32% (26/80) | 13% (12/90) | |
| SEQUENTIAL GAME | Symmetric | Asymmetric 1 | Asymmetric 2 |
| SEQUENTIAL PLAYER 1 | 30% (12/40) | 0% (0/24) | 14% (3/21) |
| SEQUENTIAL PLAYER 2: CONDITIONAL ON PLAYER 1 COOPERATING | 35% (14/40) | 21% (5/24) | 43% (9/21) |
| SEQUENTIAL PLAYER 2: CONDITIONAL ON PLAYER 1 DEFECTING | 5% (2/40) | 4% (1/24) | 9.5% (2/21) |

| SIMULTANEOUS GAME | Symmetric vs. Asymmetric: p=0.003 | | |
|---|---|---|---|
| SEQUENTIAL GAME | Symmetric vs. Asymmetric 1 | Symmetric vs. Asymmetric 2 | Asymmetric 1 vs. Asymmetric 2 |
| SEQUENTIAL PLAYER 1 | p=0.003 | p=0.179 | p=0.058 |
| SEQUENTIAL PLAYER 2: CONDITIONAL ON PLAYER 1 COOPERATING | p=0.234 | p=0.551 | p=0.115 |
| PLAYER 2: COOPERATION CONDITIONAL ON PLAYER 1 DEFECTING | p=0.880 | p=0.501 | p=0.477 |

**Table 2. Frequency of Play, Frequency of Cooperation, and Test Statistics: Exit Option.** Entries in the upper table are the percentage of cooperation with absolute number of cooperative choices or number of observations in parentheses. In the lower table, p-values are from two-sample Wilcoxon rank-sum tests.

| | Symmetric | Asymmetric 1 & 2 Pooled | |
|---|---|---|---|
| SIMULTANEOUS GAME | 41% (33/80) | 29% (26/ 90) | |
| SEQUENTIAL GAME | Symmetric | Asymmetric 1 | Asymmetric 2 |
| SEQUENTIAL GAME PLAYER 1 | 18% (7/40) | 4% (1/24) | 38% (8/21) |
| SEQUENTIAL GAME PLAYER 2 | 52% (21/40) | 71% (17/ 24) | 62% (13/21) |

| | Symmetric | Asymmetric 1 & 2 Pooled | |
|---|---|---|---|
| SIMULTANEOUS GAME | 45% (15/33) | 12% (3/26) | |
| SEQUENTIAL GAME | Symmetric | Asymmetric 1 | Asymmetric 2 |
| SEQUENTIAL PLAYER 1 | 86% (6/7) | 0% (0/1) | 38% (3/8) |
| SEQUENTIAL PLAYER 2: CONDITIONAL ON PLAYER 1 COOPERATING | 43% (9/21) | 18 % (3/17) | 62% (8/13) |
| SEQUENTIAL PLAYER 2: CONDITIONAL ON PLAYER 1 DEFECTING | 0% (0/21) | 6% (1/17) | 8% (1/13) |

**Appendix1: Game Instructions and a Sample Decision Sheet Used in the U.S.**

**Initial Instructions**

In this experiment, you will make choices in four different decision situations. After the experiment is over, we will randomly pick one of the four decision situations for computing earnings.

You have been randomly matched with one other participant. Further, you will be randomly selected to be Participant 1 or Participant 2. Your earnings will depend upon your decisions and the decisions of the participant with whom you are matched.

All decisions will be anonymous. You will never know the identity of the other participant with whom you are matched. Do not talk with other participants and do not look on others' decision sheets. Below we describe the ten steps for the experiment.

1. You will receive instructions for the first decision situation that will explain the type of decision you will make. Then, you will be given time to make your decision in that situation.

2. We will then proceed to the instructions for the second decision situation, and you will again be given time to make your decision for that situation.

3. We will then proceed to the instructions for the third decision situation, and you will again be given time to make your decision for that situation.

4. Finally, we will proceed to the fourth decision situation, where you will be given instructions and time to make your decision for that situation.

5. Before we collect your decisions, you will be given time to go back and change any of your decisions in the four decision situations.

6. After all participants have had time to finalize their decisions, we will collect the decisions.

7. We will randomly pick one of the four decision situations for computing earnings.

8. Your earnings will depend on your decisions and the decisions of the participant with whom you are matched.

9. While we are calculating your earnings, you will be asked to complete a short, one page questionnaire.

10. At the end of the experiment, you will receive your $5 show-up fee, plus your earnings from the decision situation that was selected.

You are participant _____ in pair ____ for all four decision situations. Your subject number is: ______

**Instructions for Second Decision Situation**

The instructions below describe the second decision situation you face and the way earnings will be determined if this decision situation is the one that is randomly selected.

**You are "Participant 1"** and the other decision maker is "Participant 2".

Each Participant will choose between option "A" and option "B".

The information below describes the earnings you and the other participant will receive, depending upon which option you each choose.

| | | IF PARTICIPANT 2 CHOOSES | |
|---|---|---|---|
| | | **A** | **B** |
| **IF PARTICIPANT 1 CHOOSES** | **A** | Participant 1 gets $30<br>Participant 2 gets $30 | Participant 1 gets $12<br>Participant 2 gets $36 |
| | **B** | Participant 1 gets $36<br>Participant 2 gets $12 | Participant 1 gets $18<br>Participant 2 gets $18 |

In this decision situation, Participant 1 must make one decision and Participant 2 must make two decisions that depend upon the choices that could be made by Participant 1. Payoffs will be based only on the relevant one of Participant 2's decisions. In other words, if Participant 1 chooses option "A" then only the first decision made by Participant 2 will be counted. If Participant 1 chooses option "B" then only the second decision made by Participant 2 will be counted.

**The box below shows the decision options for Participant 1 and Participant 2.**

**Please mark your decision in the un-shaded box below.**

| Participant 1 | Participant 2 |
|---|---|
| I choose: A _______ B _______ | If Participant 1 chooses A, I choose: A _______ B _______<br><br>If Participant 1 chooses B, I choose: A _______ B _______ |

You are participant 1 in pair ____ for all four decision situations. Your subject number is: ______

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[1] The experiments were conducted in Korea and in the U.S. The payoffs for Korea were identical except for using an exchange rate of $1 = W1,111.

[2] *T* stands for temptation to defect and is the payoff to an individual defecting on a cooperator. *R* is the reward gained by one of a pair of cooperators. *P* is for punishment, the payment received by one of a pair of defectors. *S* is the sucker's payoff received by a cooperator paired with a defector.

[3] The linear altruism models are one exception (Cain, 1998), however, these are among the weakest of the preference models (see Ahn, Ostrom, and Walker, 2003).

[4] IU Students in introductory economics classes have majors in a wide variety of areas, including economics, business, political sciences, journalism, etc. A large percentage is pre-business. SKKU students in introductory social science classes also have majors in a wide variety of areas, such as political sciences, public administration, journalism, social work, economics, etc. The main reason for conducting the experiment in two countries was to widen the subject pool. Brandts et al. (2002) show that cultural difference is small across four countries in a public goods provision game. Also Cho and Choi (2000) show the rates of cooperation in symmetric PD are strikingly similar between Korea and the U.S. Some studies do identify significant behavioral difference across different societies (Henrich et al. 2001). But the 15 small scale communities studies by Henrich et al. differ from one another in their primary modes of production, while the countries compared in Brandt et al. and this paper can be all characterized as market economies.

[5] Appendix 1 contains a copy of the game instructions and a sample decision sheet used in the US. Note that this is one of 48 different decisions sheets corresponding to the four different decisions situations, the three game designs, the two player positions (first mover or second mover) and the two nations. The one included here is the decision sheet for a US first mover in the sequential setting with no exit option and with symmetric payoffs.

[6] In this paper we pool the observations from the two countries and do not report the subjects' answers to the questionnaire. Lee, Ostrom, and Walker (2004) report results from a part of this data set, comparing the results from the U.S. and Korea, in games without an exit option.