

Evidence on the Equivalence of the Strategic and Extensive Form Representation of Games

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Abstract: This paper reports an experiment testing whether strategically equivalent representations of a social situation produce equivalent behavior when actually played by human subjects. The investigation was limited to representative members of the class of generic 2×2 extensive form games of perfect information, which include widely studied games in the experimental literature, and the resulting class of 2×2 strategic form games. We find a systematic difference between subjects' choices in the strategic and extensive forms of these games. In particular, subjects in the extensive form are consistently more likely to choose a branch that allows the other player to make a meaningful choice. The observed behavioral difference between game forms cannot be attributed to differences in subjects' ability to do backwards induction, differences in expected payoffs between the two game forms, or differences in interpersonal preferences. We hypothesize that the extensive form elicits inclusive behavior.

Introduction

Strategic rationality as developed in the classical game theory literature provides a potentially useful theory of similarity between various social situations. It provides a powerful reduction of complicated situations into a neat specification of players, strategies, and preferences.¹ In particular, the concept of a pure strategy allows one to transform the extensive form representation of a situation into the strategic form representation, which is analytically more tractable. If individuals are strategically rational, they should make identical decisions in an extensive form game and the resulting normal form game.² This paper reports an experiment testing whether strategically equivalent representations of a situation produce equivalent behavior when actually played by human subjects.

While people can be strategically rational in only one way, it has always been recognized that every individual can make mistakes in their own unique way. A key assumption in developing a general model of mistakes is that the probability a player fails to give a best response is inversely related to the optimization premium. The *optimization premium* is the difference between the payoff of the best response to an opponent's behavior and an inferior response. The optimization premium may be irrelevant to strategically rational players, but we expect people to be more likely to play a best response when the optimization premium is large.³ If human errors are sensitive to the optimization premium, then the way a strategic situation is presented will influence their ability to best respond.

The strategic form requires players to make a rational choice at every information set without knowing that the information set will actually be reached. In the extensive form, players only need to make rational choices at information sets along the path of play through the game tree. When an information set may not be reached, the optimization premium for a choice made at that

¹ See von Neumann and Morgenstern (1947) for the seminal derivation and Kuhn (1953) for the reformulation used today.

² A modern statement can be found in Kohlberg and Mertens (1986, p. 1011), "No reasonable definition of rationality could imply a different behavior for the strategist when he has to give instructions to his agents in advance of the play, as compared to the situation where he would have to carry out those instructions himself"

³ See Battalio, Samuelson, and Van Huyck (2001).

information set will be smaller than when making the choice conditional on having reached the information set. Since in general the optimization premium will differ between the strategic and extensive form, behavior will be influenced by the representation of the situation.

While experimenters have previously found evidence against the behavioral equivalence of the strategic and extensive forms,⁴ this evidence is narrow, based on a few cleverly constructed examples. In our experiment, we test the equivalence between the strategic and extensive forms of representative members of the class of generic 2×2 extensive form games of perfect information and the resulting class of 2×2 strategic form games. These include a number of games that have been widely studied in the literature such as Selten's (1978) chain store paradox and Krep's (1990) trust game. For each of these games, subjects are asked to make a choice for each role in both the extensive and strategic form representation of the games. Subjects only make a single choice in each role and each form, and receive no feedback between decisions. We therefore have a clean within subject test of the pure strategy hypothesis. Investigating how people make mistakes in general classes of games will, we hope, contribute towards improving the accuracy of game theoretic predictions and the effectiveness of game theoretic prescriptions.

We find systematic differences between subjects' choices in the strategic and extensive forms of these games. These differences cannot be explained by differences in optimization premiums between the two game forms because Player Two behavior is not influenced significantly by the form of the game. Instead, subjects in the Player One role are more likely to choose a branch that allows the other player to make a choice that influences payoffs in the extensive form than in the normal form.. This bias can not be explained by the greater salience of backwards induction in the extensive game form, by an appeal to other regarding preferences over outcomes, or by models of intentionality. We hypothesize that the extensive form elicits inclusive behavior and suggest directions for future research to investigate this new hypothesis.

⁴Schotter, Weigelt, and Wilson (1994) suggest that the salience of concepts such as backwards induction and removal of dominated strategies may vary with the presentation of the game, see also Deck (2000). Tversky and Kahneman (1981) show that subjects' reported preferences over gambles can be affected by simple changes in wording.

Analytical Framework

To focus our analysis, we examine the class of generic 2×2 extensive form games of perfect information and the resulting class of 2×2 strategic form games (see figure 1). The class contains 36 members, including Selten's (1978) chain store game and Krep's (1990) trust game. It is the simplest class of extensive form games that maintains strategic interdependence between the players.

[Figure one here]

Of these 36 members, half are isomorphic transformations of other members of the class obtained by relabeling actions. We choose to maintain the assumption that behavior will be invariant to a relabeling of actions and eliminate the isomorphic transformations.

In this class of games, the second mover always has a weakly dominant strategy. The first mover has a strictly dominant strategy to pick t in six games and to pick b in six games. In this sense, these games don't involve any meaningful strategic interdependence under the assumed preferences. We select one of each type to include in the experimental design. The remaining six games all require the first mover to forecast what the second mover will do in order to determine a best response. We investigate all six making a total of eight games studied below.

Figure 2 summarizes the eight games. The subgame perfect equilibrium for each game is found by following the doubled line from the root of the tree to a terminal node. Game 1 has not been widely studied. Games 2 and 5 each have an equilibrium in dominant strategies. Game 3 is Krep's (1990) trust the kindness of strangers game. Game 4 is a team game. Like Game 3, Game 5 gives Player Two an opportunity to reciprocate the kindness of strangers. Game 6 is Selten's (1978) chain store game. Game 7 is a strictly competitive game that has not been widely studied to our knowledge. Game 8 is Beard and Beil's (1994) trust the rationality of strangers game. Games 5, 6, and 8 have two Nash equilibria one of which is not subgame perfect.

[Figure 2 here]

Von Neumann and Morgenstern's (1947) concept of a pure strategy allows one to transform the extensive form representation of a social situation into the strategic form. A *pure strategy* assigns an action to every information set controlled by the player. For the class of extensive form games considered here the pure strategy abstraction assumption results in 2×2 bimatrix strategic form

games.⁵

Pure Strategy Hypothesis: Behavior in the strategic and extensive forms will be statistically indistinguishable.

If people are not strategically rational, then there are many ways in which the presentation of a social situation can influence behavior. Schotter, Weigelt, and Wilson (1994) explore the behavioral hypothesis that the presentation of a strategic situation can facilitate the use of alternative solution concepts. For example, backwards induction may be more salient in the extensive form presentation, where the timing is laid out explicitly.

Backwards Induction Hypothesis: Subjects are more likely to make choices consistent with subgame perfection in the extensive form presentation of the social situation.

Probabilistic choice models beginning with Luce (1959) can explain behavior inconsistent with backwards induction. A particularly interesting assumption to make regarding noisy choices is that better responses are more likely than inferior responses, but all responses have positive probability. If choices are sensitive to the optimization premium, then behavior will violate the pure strategy hypothesis. The strategic and extensive forms should not be expected to give equivalent behavior when players give noisy responses to their information.

It is easiest to see that the pure strategy hypothesis will be violated when the “errors” players

⁵ Specifically, they write, “Imagine now that each player $k = 1, \dots, n$, instead of making each decision as the necessity for it arises, makes up his mind in advance for all possible contingencies; i.e. that the player k begins to play with a complete plan: a plan which specifies what choices he will make in every possible situation, for every possible actual information which he may possess at that moment in conformity with the pattern of information which the rules of the game provide for him for that case. We call such a plan a *strategy*.”

Observe that if we require each player to start the game with a complete plan of this kind, i.e. with a strategy, we by no means restrict his freedom of action. In particular, we do not thereby force him to make decisions on the basis of less information than there would be available for him in each practical instance in an actual play. This is because the strategy is supposed to specify every particular decision only as a function of just that amount of actual information which would be available for this purpose in an actual play. The only extra burden our assumption puts on the player is the intellectual one to be prepared with a rule of behavior for all eventualities, -- although he is to go through one play only. But this is an innocuous assumption within the confines of a mathematical analysis. p. 79”

make are sensitive to the optimization premium if we focus on Player Two: either the column player or second mover. Let p denote player two's assessment of the probability player one will play t . Let $E\pi_2(a, p|f)$ denote the expected payoff from action a , either L or R , against assessment p in game form f , where f is either e for extensive or s for strategic. Let $r_2(p|f)$ denote the optimization premium for player two given assessment p in game form f . Then for the class of games represented in figure 1 the optimization premium for the two forms are

$$r_2(p|s) = E\pi_2(L, p|s) - E\pi_2(R, p|s) = (p \varphi + (1-p) \delta) + (p \psi + (1-p) \delta) = p (\varphi - \psi)$$

and

$$r_2(p|e) = E\pi_2(L, p|e) - E\pi_2(R, p|e) = (\varphi - \psi)$$

respectively. The difference between these two equations occurs because Player 2 has no uncertainty when moving in the extensive form about what Player 1 has done. Notice that since p will be between 0 and 1 in a probabilistic choice framework it follows that $|r_2(p|e)| > |r_2(p|s)|$, where $|\cdot|$ is the absolute value function; that is, the optimization premium is larger in the extensive form representation of the situation. If mistakes are less likely when the optimization premium is larger, then presenting a subject with the subgame resulting from play of t should result in behavior closer to the best response prediction. The second mover in the extensive form does not have any uncertainty about what the first mover did and hence the optimization premium will be larger in the extensive form

Optimization Premium Hypothesis: Subjects are more likely to make choices consistent with subgame perfection in the second mover role of the extensive form representation than in the column role of the strategic form representation of the game.

Given that the second mover makes fewer errors in the extensive form representation, the first mover's optimization premium will also be affected by the game form. The model can be closed by assuming a particular model of errors and imposing a mutual consistency condition on the players' assessments, that is, by computing a Bayes Nash equilibrium of the perturbed game. A modern formulation is contained in McKelvey and Palfrey's (1995) and (1998) solution concepts of quantal response equilibria (QRE) and agent quantal response equilibria (AQRE). We refer to the

Bayes Nash equilibrium of the perturbed strategic form game as the quantal response equilibrium (QRE) and the Bayes Nash equilibrium of the perturbed agent strategic form game as the agent quantal response equilibrium (AQRE).

The logit response function formalizes the perturbations. Let q denote the probability a player two chooses L given an assessment p , then the logit response function is

$$q = \frac{e^{\lambda E\pi(L,p|f)}}{e^{\lambda E\pi(L,p|f)} + e^{\lambda E\pi(R,p|f)}} = \frac{e^{\lambda r_2(p|f)}}{1 + e^{\lambda r_2(p|f)}}$$

The change in Player one behavior predicted by a comparison of the QRE solution applied to the strategic form representation and the AQRE solution applied to the extensive form representation of our games comes solely through anticipated changes in Player two's behavior. It is possible for Player one's predicted behavior to be less consistent with the subgame perfect equilibrium in the extensive form game; see for example Game 2. The AQRE solution of the extensive form representation of game 2 predicts that it is more likely that Player two will choose L than the QRE solution of the strategic form. This decreases Player one's expected payoff from strategy t without affecting the expected payoff from strategy b . Thus, Player one will choose t , the subgame perfect equilibrium strategy, less frequently in the extensive form game. For each of the eight games, we can work out the direction of the predicted change for an AQRE model as Player ones are switched between game forms.

Equilibrium Assessment Hypothesis: Subjects in the player one role are more likely to make choices consistent with subgame perfection in the extensive form games for Games 1,3,4,5,6,7, and 8, but are less likely to make choices consistent with subgame perfection in the extensive form game for Game 2.

Experimental Design

Human subjects made a series of choices using pen and paper. Each subject made decisions for both roles in both the strategic and extensive form representation of all eight games. The subjects made their choices in the row and column role by checking a box and in the first and second mover roles by drawing a line. All of the choices in a single role were presented on one decision page. The page contained eight games plus a ninth game unrelated to the experimental design.⁶ Each decision page was passed out, filed out, and collected before the next decision page was passed out. First the subjects played the player one (row) role in the strategic form, then the player two (column) role in the strategic form, then the player one (first mover) role in the extensive form, and finally, the player two (second mover) role in the extensive form. The paper instrument always used green ink to show the subject's own payoffs and blue ink to show the other participant's payoffs. They received no feedback until the end of the experiment.

Two instruments were used. In the first, the games were always presented in identical order⁷ and only the subgame resulting from the first mover choosing t was shown on the decision page for the second mover. If subjects did not recall the earlier decision pages and did not recognize the pattern in the order of the games, then they did not know what payoffs Player one had foregone in allowing Player two to make a choice.⁸ Since other regarding behavior and intentionality has become an important part of the explanation for anomalous behavior in simple games, we designed a second instrument. The second instrument, scrambled the games making it more difficult to notice the relationship between the roles and game forms and showed the whole extensive form on the decision page for the second mover.

The subjects were explicitly told they were playing against the choices made by the other participants in the session. Their earnings were determined using a mean matching protocol, that is, they received the average payoff determined by the empirical distribution of the other participant's

⁶ Along with the eight strategic form games we were studying, we also included a bargaining game studied in Battalio and Van Huyck (2000) using a computer interface.

⁷ Except that games five and eight were flipped on the extensive form pages.

⁸ The instructions for the Player two forms tell the subjects "your choice will be matched with each of the other first mover choices." This implicitly tells the subjects that the same games are being played on the Player one and Player two forms. But since the Player one forms have already been collected, only subjects with an exceptionally good memory would know what the payoffs were if the Player one picked the branch leading to a terminal node.

choices. The mean matching protocol was explained to the subjects through multiple examples. Subjects were paid in cash for all decisions they made. Their average payoff from these 32 choices was \$12.75. This does not include their earnings from any other games played in the session. Subjects were also given their choice of \$4 cash or a parking pass worth \$4.

Subjects made other decisions not reported in this paper. These decision pages contained variations on the dictator game with differing prices (see Andreoni and Miller, 2001). In some sessions, the 2×2 games were presented first and in some sessions the dictator games were presented first. No feedback was given until the end of the session when earnings were computed. There is no theoretical reason to believe that participating in the dictator experiment would affect play in our experiment, and indeed no statistically significant effect is found in the data.

A total of 187 subjects participated in the experiment. Three sessions with a total of 99 subjects used the first instrument in which the second mover decision page only showed the subgames resulting from a choice of t and the games were not scrambled, and three sessions with a total of 88 subjects used the second instrument in which the second mover decision page showed the entire extensive form and the games were scrambled.⁹

Subjects were recruited from the undergraduate population at Texas A&M University using email solicitations. Prior to the start of the experiment, a set of instructions was read out loud to all subjects. These instructions explained how to fill out the instrument and how to calculate earnings. A copy of the instructions and decision instrument one are attached to this paper as Appendix A.

⁹ Three sessions with 75 subjects participated in the dictator games experiment prior to participating in our experiment and three sessions with 112 subjects played our experiment first.

Experimental Results

Table 1 summarizes the primary empirical results of the paper. The top half of the table shows data for the player one role, and the bottom half shows data for the player two role. Strategic rationality makes a sharp prediction for both roles in all games in both forms: either everyone plays one action or the other. The actual frequency of t ranged from 0.278 in the strategic form of game 5 to 0.909 in the strategic form of game 2. The actual frequency of L ranged from 0.187 in the strategic form of game 7 to 0.920 in both forms of game 4. The largest deviations from predicted behavior occurs in the player one role of the extensive form representation of game 3, Krep's (1990) trust the kindness of strangers game, and in the player one role of the strategic form representation of game 6, Selten's (1978) chain store game. In both of these cases, the majority of subjects did not choose the predicted behavior.

[Table 1 here]

There is a great deal of heterogeneity in the population. For each of the 32 choices in the experiment, we can calculate the percentage of subjects choosing the less frequent of the two possible choices. The minimum for this variable is 8%, and the median is 28%. This is extraordinary given that the column players always have a weakly dominant strategy and the row players have a strictly dominant strategy for Games 2 and 5. Even if we only consider the choices with a (weakly) dominant strategy, the median percentage of subjects choosing the dominated strategy is 19%.

Even at an individual level substantial heterogeneity is observed. The column labeled "fraction switching" in table 1 reports the fraction of subjects who changed their choice in either direction between the strategic and extensive form representation of the games. (Recall that each subject played both roles of both forms of all eight games.) The choices of individual subjects often vary between the strategic and extensive form representations of a game. Looking at the 16 choices that are made in both the strategic and extensive form games, the minimum percentage of subjects switching their choice between the two forms is 10%, and the median percentage is 35%.

The column labeled "difference between forms" in table 1 reports the difference between the actual play of t or L in the strategic and extensive forms. The next three columns of table 1 report the results of tests for statistically significant differences between the two game forms. We use McNemar's test for significance of changes, a form of chi-squared test that accounts for the paired nature of the observations (Siegel and Castellan, 1988, p. 75 – 80). The null hypothesis is that the

proportion of subjects switching from top to bottom (or left to right for column players) between the two game forms is the same as the proportion switching in the opposite direction. In other words, we are testing whether the difference between the forms is significantly different from zero. We report rejections of the null at the 10%, 5%, and 1% levels of significance. Of the 16 possible differences between the two game forms, 7 are at least significant at the 10% level of significance. Naively treating these 16 tests as statistically independent, the likelihood of getting 7 or more false rejections out of 16 at the 10% level is 6.1×10^{-5} .

Conclusion 1: There are significant differences in play between the two game forms. We reject the pure strategy hypothesis.

These economic significance of these differences are modest. The maximum difference observed is only 15% (see the player one role in game 5). The differences between the two game forms are more systematic for player ones than for player twos. The changes are positive in seven of the eight games for the player one role, but are only positive in four of eight games for the player two role. The player one role changes are not only more consistently positive but also larger in absolute value. Looking at the tests of statistical significance for the player ones, there are significant changes in play for five of the eight games. A number of these are quite strong, with the differences for Games 4 and 5 easily significant at the 1% level and the difference for Game 7 barely missing the 1% level. In contrast, there are only significant changes in two of the eight games for the player two role. Neither of the differences is even close to reaching the 1% level of significance.

Conclusion 2: There are much greater differences in play between the two game forms for the player one role than for the player two role.

The penultimate columns of table 1 report whether the difference for the game is in the direction predicted by the backwards induction or AQRE hypotheses. If so, this is indicated by an X. Only 4 of 16 differences are in the direction predicted by the backwards induction hypothesis. The extensive form does not seem much better at inducing strategic rationality than the strategic form.

For three of the eight games, the play of player one role is more consistent with subgame perfection in the extensive form. Looking at only the games in which the change between game forms is significant at the 10% level for player one, four of five have play that is less consistent with subgame perfection in the extensive form. Only 5 of 16 differences are in the direction predicted by the AQRE hypothesis. Only in two cases is there a statistically significant shift in the direction predicted by AQRE. Neither hypothesis gets much support from the difference data.

Conclusion 3: There is little evidence that changes in row players' behavior between the two game forms is organized either by subgame perfection or AQRE. We reject the subgame perfect, optimization premium, and equilibrium assessment hypotheses.

Instead, we discover an unexpected bias in favor of t by subjects in the player one role of the extensive form. For seven of the eight games, the player ones choose "Top" more frequently in the extensive form representation. Moreover, for all five games where there are significant differences between the two game forms, the row players choose "Top" more frequently in the extensive form games. We present more evidence about this bias before attempting to interpret it.

Conclusion 4: Subjects in the player one role show a strong movement towards "Top" in the extensive form representation of the games. In other words, they are more likely to make a choice that leads to a decision node for Player two rather than a terminal node.

One possibility is that this bias in favor of t reflects other-regarding preferences.¹⁰ Emotions as varied as altruism, envy, reciprocity, and spite fall under the umbrella of these models. Rather than focusing on any one model of other-regarding preferences, we instead consider a strong empirical regularity that has been observed in a wide variety of experiments, reciprocity: Do unto others as they have done unto you. In other words, reward those who have treated you well and punish those who have treated you poorly. We examine the data for evidence of more (or less) reciprocity in the

¹⁰ For some leading examples, see Bolton and Ockenfels (2000), Fehr and Schmidt (1999), and Charness and Rabin (2000).

extensive form games.

For player twos, it is clear what it means for play to be more (or less) consistent with reciprocity in the extensive form games. In the games where player one can unambiguously help or harm the column player, differences should be observed between the game forms. There are only two games where there are any significant changes between the two game forms for column players. In Game 2, player one takes an action that unambiguously helps the player two when he chooses "Top." Player twos are somewhat less likely to play reciprocally by choosing R in the extensive form. In Game 5, the player one is once again taking an action that unambiguously helps player two when he chooses t . Here, the act of kindness is more obvious since player one is hurting himself by choosing t . Player twos are significantly more likely to play reciprocally by choosing R in the extensive form for Game 5. These results suggest that player twos might be weakly more reciprocal in the extensive form representation of the games. However, other games in which changes in reciprocal behavior might be expected show no change. For example, Games 1 and 6 are obvious candidates for more reciprocity since player one unambiguously harms Player two by choosing t . No difference is seen in player twos' choices for these two games between the two game forms. Overall, there is little evidence that the game form makes player twos either more or less reciprocal.

For player ones, it is less obvious what it means for their behavior to be more consistent with reciprocity since they have no previous action by the player twos to reciprocate. One possibility is the player ones might act more (or less) kindly in the extensive form games anticipating that the player twos will act more (or less) reciprocally in the extensive form games. In Games 2, 5, and 8, player one can unambiguously help the player two. In only one of these games, Game 5, is there a statistically significant difference between player ones' choices in the two game forms. Likewise, in Games 1 and 6, the player one can unambiguously harm the column player. Game 1 has a statistically significant difference between the game forms, but in the direction of being less other-regarding. Overall, there is little reason to believe that other-regarding preferences play any important role in explaining differences between the two game forms.

Conclusion 5: Play in the extensive form by both player ones and player twos is not obviously either more or less consistent with models of other-regarding preferences.

One possible explanation for the tendency of player ones to choose t more frequently in the extensive form games is a bias towards choosing the left branch of a game tree. However, if such a “left branch bias” exists, it doesn’t appear to affect player two behavior. As such, we consider this an unlikely explanation for our results.

Table 2 presents regression analysis of the experimental data. The inclusion of this analysis has two purposes. First, it allows us to aggregate the data across games. This allows us to determine if the results described previously are statistical blips that are confined to a few games or are more general in nature. Second, the regression results let us see whether any of the variations in treatments we used are responsible for the results.

[Table 2 here]

Given the binary nature of subjects’ choices, all of the regressions reported in Table 2 use a logit specification. We include fixed effects to reduce the impact of any individual effects (Chamberlain, 1980). The regressions also include dummies for seven of the eight games (with no dummy for Game 1). While highly significant statistically, these dummies are of little direct interest and hence are suppressed in Table 2. The regressions included all observations from all subjects. Data from player one roles and player two roles are analyzed separately. Thus, each of the regressions includes sixteen observations, two per game, for each of the 187 subjects in the experiment. Standard errors are reported in parentheses below the parameter estimates. Tests of statistical significance for parameter estimates are two-tailed z-tests.

For the player one regressions, the dependent variable equals 1 if player one chose t and 0 if he chose b . Thus, positive coefficients indicate that player one is more likely to chose t all else equal. For player two regressions, the dependent variable equals 1 if player two chose L and 0 if he chose R .¹¹

¹¹ One implication of this choice of dependent variables is that the fixed effects are capturing a subject’s predilection towards using one of the strategies (e.g. t vs. b). It may instead be true that subjects have a greater or lesser predilection towards using the subgame perfect action. We have run regressions using this sort of specification, and get qualitatively identical results. We have also looked at models in which there is correlation between an individual’s switches between game forms. These also yield identical qualitative results.

The independent variables are as follows:

- 1) **Payoff Difference:** This variable is calculated as the difference in expected payoffs between t and b for player ones and the difference in expected payoffs between L and R for player twos. The expected payoffs are based on the empirical frequencies. Payoff differences are calculated separately for each game form. For example, the expected payoff from choosing t in Game 1 in the normal form is equal $.316*60 + .684*20 = 32.64$. The payoff difference for Game 1 in the normal form is then the expected payoff from t minus the expected payoff from b which equals $32.64 - 40 = -7.36$. If subjects' are sensitive to the optimization premium, the coefficient estimate for this variable should be positive.
- 2) **Extensive form:** This variable is coded is a 0 for observations from the strategic form games and 1 for observations from the extensive form games. A positive coefficient for the dummy means that player ones are more likely to choose t in the extensive form or player twos are more likely to choose L in the extensive form.
- 3) **Interaction between extensive form and subgame perfection:** We first create a dummy that is coded as one if the subgame perfect choice is t for a row player or L for a column player and is coded as zero otherwise. This variable is then interacted with the variable for the extensive form. A positive coefficient for this variable means that row players are more likely to choose t in the extensive form game when it is the subgame perfect action and column players are more likely to choose L in the extensive form game if it is the subgame perfect action. Suppose any differences between the game forms were due to greater (lesser) consistency with subgame perfection in the extensive form. We expect the coefficient for the interaction between extensive form and subgame perfection to be positive (negative) and we expect this coefficient to equal negative two times the coefficient for the extensive game form variable.
- 4) **Gender:** The gender variable is coded as a one for male and a zero for female. This is interacted with the extensive form variable. This variable allows us to determine if changes between the game forms are tied to a subject's gender.
- 5) **Treatments:** We create dummy variables for whether a subject saw the Andreoni-Miller instrument prior to playing in our experiment, and whether they played in the treatment

with scrambling and full trees as Player twos in the extensive form games. These variables are interacted with the dummy for the extensive form. These variables allow us to determine if changes between the game forms are linked to the treatment being played.

The top half of Table 2 shows regressions on row player data. Model 1 only includes the payoff difference between t and b . The coefficient estimate is large and statistically significant at the 1% level. Given that the game variables control for any other differences between the games, this suggests that subjects do respond to changes in the optimization premium.

Model 2 only includes an extensive form variable. The parameter estimate on this variable is positive and significant at the 1% level. Thus, we find general support for our conclusion that row players are more likely to choose t in the extensive form.

Model 3 includes both the payoff difference between t and b and the extensive form variable. The coefficient for the extensive form is little changed in magnitude and remains significant at the 1% level. The coefficient for payoff difference is roughly halved and only achieves statistical significance at the 10% level. The results of Model 3 indicate that the impact of the extensive form on player ones' choices cannot be attributed to changes in the optimization premium.

Model 4 modifies Model 3 by adding the interaction between the extensive form and subgame perfection. Subjects are more likely to switch to top in the extensive form when this is the subgame perfect action, but the parameter estimate for this variable is not statistically significant at any standard level. Moreover, the linear restriction that the coefficient for extensive form interacted with subgame perfection equals negative two times the coefficient for the extensive form variable is rejected at the 1 percent level. Therefore, subgame perfection does not help explain the changes in player ones' choices between the two game forms. Addition of the interaction between the extensive form and subgame perfection does somewhat weaken the estimate for the extensive form coefficient.

The final regression, Model 5, modifies Model 3 by adding the interaction between the extensive form and gender and the interactions between the extensive form and the treatment variables. Only the interaction with gender is even weakly significant; the impact of switching to the extensive form game is less for men than for women. Women are almost twice as likely to bias their behavior in the extensive form to allow the other player to have a meaningful choice. There is no evidence that our results are being driven by the differing treatments used.

The bottom half of Table 2 shows regressions on player two data. These specifications are analogous to those run for player ones. In none of these regression is there any significant difference between the two game forms. Thus, the small number of differences found for the individual games do not appear to reflect a general pattern. None of the interaction terms are statistically significant either.¹²

¹² The regressions in Table 2 do not test whether the use of full game trees and scrambling affects the behavior of player twos in general. We therefore ran chi-squared tests separately for each of the eight games to see to see if the use of full game trees and scrambling affected the choices of player twos in the extensive form games. The null hypothesis being tested is that the likelihood of choosing L is equal between the treatment with partial trees and the treatment with full trees and scrambling. For none of the eight games could we reject the null at even the 10% level. Changing how the game trees were presented does not appear to have any impact on player two decisions.

Conclusions

We find significant differences in behavior between the extensive and strategic form representation of social situations. However, these were not the differences in player two behavior predicted by a theory of noisy best responses. We find little difference in the behavior of subjects in the player two role. For our simple class of games, sharpening the optimization premium by removing the uncertainty about player one's choice doesn't significantly influence behavior.

Instead, the observed bias appears in the player one role of the extensive form representation of the games. Our subjects tend to choose the path that allows the second mover to influence the outcome of the game more frequently than they do in the strategic representation of the situation. We hypothesize that this bias results from a norm in favor of allowing other people to influence the outcome of social situations. To the best of our knowledge, this systematic bias in subjects' behavior has not been identified in any previous studies. We hypothesize that subjects have a preference for inclusion – all individuals affected by the outcome should be involved in selecting it – and that the extensive form representation makes this inclusion preference more salient.

It is worth noting that the existing results between game forms are consistent with the inclusion preference we identify in our data. Both Schotter *et al* and Deck study games that fall within the class of 2 x 2 games we study. While they give their results quite different interpretations, both of them actually find that Player 1 is more likely to give Player 2 a meaningful choice in the extensive form game. Thus, our results unify the results found by earlier experimenters.

Further experimental work is needed to determine the causes underlying the bias we observe in extensive form games. If our hypothesis that subjects have preferences for procedural fairness turns out to be correct, this gives us insight into a wide variety of puzzling phenomena. For example, this bias in favor of including others may be responsible for some of the results reported in the literature on the trust game. In the trust game including the other may be misinterpreted as “trust.” Also, it is a common place occurrence that organizations facing a major decision will devote a large amount of time considering how to go about making the decision and assuring that all stakeholders within the organization have input on the decision. Often these activities seem unnecessary, having little impact on the decisions actually reached. However, if individuals indeed have preferences over how decisions get made, then these apparently wasteful activities are rationalizable.

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Table 1: Results Summary

Player 1 Role

Game	Predicted Play of t	Actual Play of t		Difference Between Forms	Statistical Significance			Movement Towards...		Fraction Switching
		Strategic	Extensive		10%	5%	1%	SGPE	AQRE	
1	0.000	0.316	0.412	0.096	X					0.385
2	1.000	0.909	0.866	-0.043					X	0.182
3	0.000	0.583	0.674	0.091	X					0.401
4	1.000	0.578	0.722	0.144	X	X	X	X	X	0.401
5	0.000	0.278	0.428	0.150	X	X	X			0.396
6	1.000	0.380	0.439	0.059				X	X	0.455
7	0.000	0.374	0.492	0.118	X	X				0.406
8	1.000	0.733	0.791	0.059				X	X	0.262

Player 2 Role

Game	Predicted Play of L	Actual Play of L		Difference Between Forms	Statistical Significance			Movement Towards...		Fraction Switching
		Strategic	Extensive		10%	5%	1%	SGPE	AQRE	
1	0.000	0.283	0.294	0.011						0.342
2	1.000	0.738	0.818	0.080	X			X	X	0.316
3	0.000	0.401	0.460	0.059						0.380
4	1.000	0.920	0.920	0.000						0.096
5	1.000	0.674	0.572	-0.102	X	X				0.348
6	1.000	0.893	0.872	-0.021						0.150
7	0.000	0.187	0.193	0.005						0.273
8	1.000	0.861	0.840	-0.021						0.171

Notes: All tests of statistical significance are from McNemar's test for significance of changes (Siegel and Castellan, p. 75-80). Movement indicates the direction of change in the extensive form using the normal form as a base. The data set includes all observations from all 187 subjects.

Table 2
Fixed Effects Logits

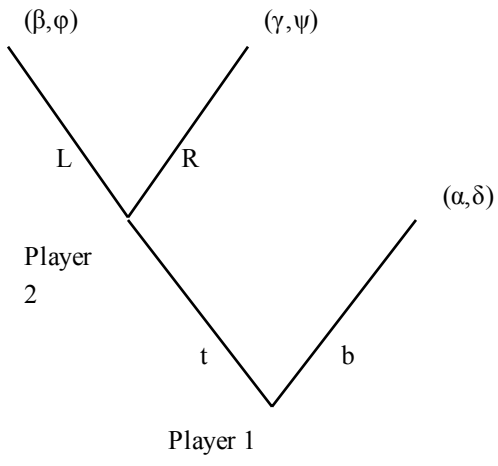
Row Players
Dependent Variable: Choice of Top = 1, Bottom = 0

Variable Name	Model 1	Model 2	Model 3	Model 4	Model 5
Payoff Difference	0.214** (0.064)		0.126+ (0.068)	0.153 (0.107)	0.125+ (0.068)
Extensive Form		0.437** (0.084)	0.388** (0.088)	0.340+ (0.174)	0.598** (0.186)
Extensive * Subgame Perfect				0.086 (0.267)	
Extensive * Gender 0 = Female, 1 = Male					-0.296+ (0.174)
Extensive * Andreoni-Miller First					-0.189 (0.173)
Extensive * Scrambling					0.086 (0.170)
Log-Likelihood	-1325.02	-1316.89	-1315.15	-1315.09	-1312.96

Column Players
Dependent Variable: Choice of Left = 1, Right = 0

Variable Name	Model 1	Model 2	Model 3	Model 4	Model 5
Payoff Difference	0.058+ (0.033)		0.059+ (0.034)	0.070 (0.054)	0.059+ (0.034)
Extensive Form		0.008 (0.091)	-0.010 (0.092)	-0.057 (0.192)	-0.123 (0.201)
Extensive * Subgame Perfect				0.081 (0.292)	
Extensive * Gender 0 = Female, 1 = Male					0.214 (0.188)
Extensive * Andreoni-Miller First					-0.015 (0.188)
Extensive * Scrambling					-0.010 (0.186)
Log-Likelihood	-1122.68	-1124.21	-1122.67	-1122.63	-1121.98

FIGURE 1

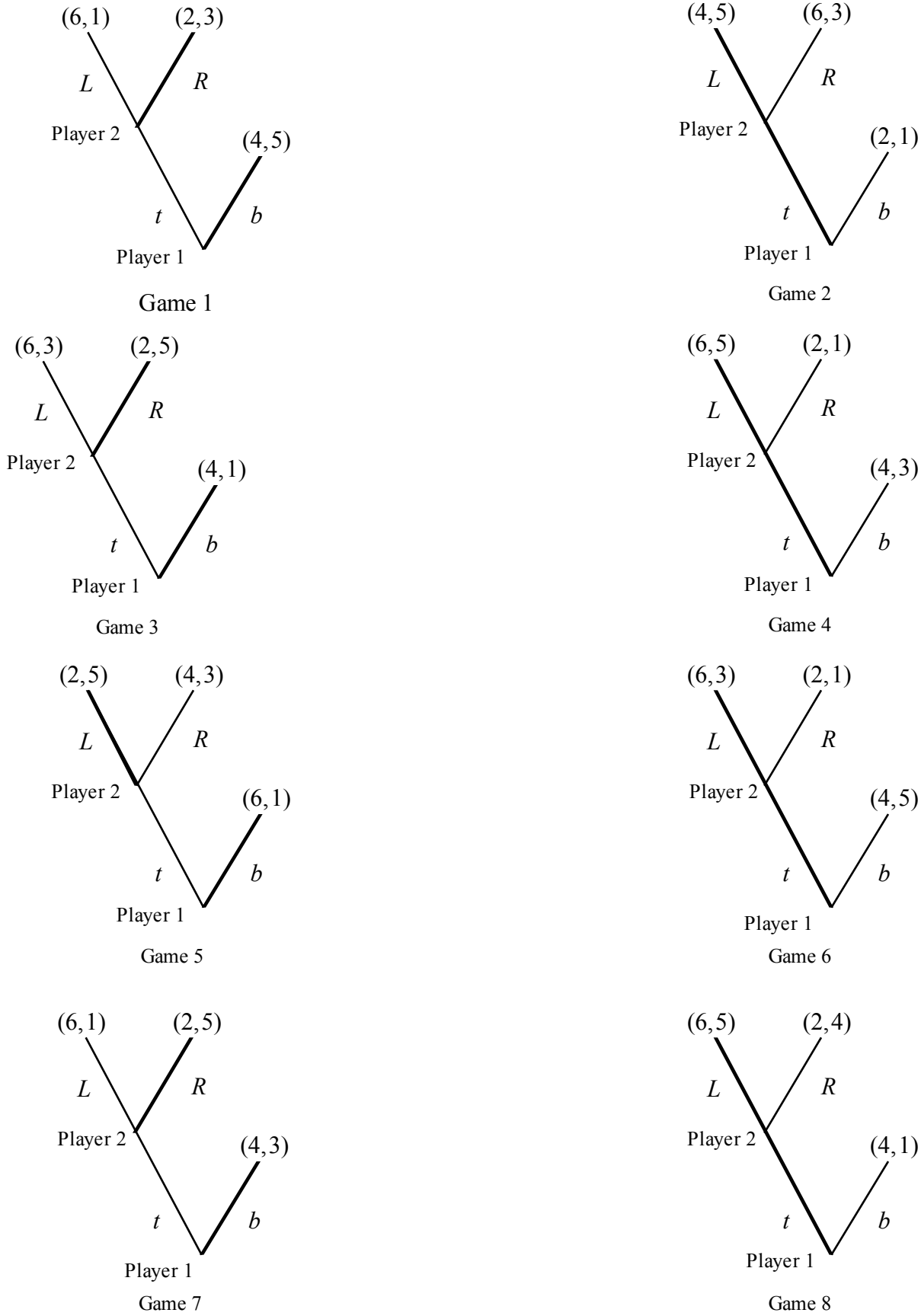


Extensive Form

	L	R	
t	β φ	γ ψ	p
b	α δ	α δ	(1-p)
	q	(1-q)	

Strategic Form

FIGURE 2



Appendix A: Instrument One

Welcome

This is an experiment about decision making. If you have any questions during this experiment, please raise your hand and an experimenter will come to you. You will be paid for participating, and the amount of money you will earn depends on the decisions that you and the other participants make. Research grants have provided the funds for this experiment. At the end of the experiment you will be paid privately and in cash for your decisions.

Session ID Number

At the top of this page is a number on an index card. This is your participant number. Each participant has a different number. You will want to verify that the number on this card is the same as the number on the top of each decision form. You will use this number to collect your cash payment. Please remove your index card now and place it face up on the desk.

Choices

You will be asked to make nine choices about your choice of t or b in an earnings table. You make choices on the row form by checking a box for one of two rows labeled “t” and “b” respectively.

The choices that you make and the choices that all of the other participants in this room make will determine your earnings. The next page provides an example of how your earnings are calculated.

Earnings

Your payoffs will always be indicated by green. Units are cents. You will be paid for all of your choices. Your earnings for each choice is going to be determined based on the choices of everyone else in the room. Your row choice will be matched against all of the column choices and you will receive the average of these earnings. For example, suppose there are 101 people including yourself and suppose that of the 100 other people in the room 75 choose column L and 25 choose column R for the example earnings table.

		L	R	
t		30	10	⋮
	40	60		
b		50	70	~
	80	20		

Example Choice of “t”

		L	R	
t		30	10	~
	40	60		
b		50	70	⋮
	80	20		

Example Choice of “b”

$$\text{Earnings for example choice of “t”} : \frac{75}{100} 40 \% \frac{25}{100} 60 \cdot \frac{120}{4} \% \frac{60}{4} \cdot \frac{180}{4} \cdot 45 \text{ cents}$$

$$\text{Earnings for example choice of “b”} : \frac{75}{100} 80 \% \frac{25}{100} 20 \cdot \frac{240}{4} \% \frac{20}{4} \cdot \frac{260}{4} \cdot 65 \text{ cents}$$

Now suppose 25 choose column L and 75 choose column R:

$$\text{Earnings for example choice of “t”} : \frac{25}{100} 40 \% \frac{75}{100} 60 \cdot \frac{40}{4} \% \frac{180}{4} \cdot \frac{220}{4} \cdot 55 \text{ cents}$$

$$\text{Earnings for example choice of “b”} : \frac{25}{100} 80 \% \frac{75}{100} 20 \cdot \frac{80}{4} \% \frac{60}{4} \cdot \frac{140}{4} \cdot 35 \text{ cents}$$

Please fill out the row choice form, taking the time you need to be accurate. When all participants are done and have turned their Instruction sheet and their row choice form face down on their desk we will collect the forms.

Check the box at the end of a row to indicate your choice. Your payoffs are in green. The blue payoffs are for column participants. Units are cents. Your choice will be matched with each of the other column participant choices (but not your own). Your earnings for each choice will be determined by summing up your payoff for each match and dividing by the number of matches. Please make nine choices now.

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Choice 1

Choice 2

Choice 3

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Choice 7

Choice 8

Choice 9

Check the box at the bottom of a column to indicate your choice. **Your payoffs are in green.** The blue payoffs are for row participants. Units are cents. Your choice will be matched with each of the other row participant choices (but not your own). Your earnings for each choice will be determined by summing up your payoff for each match and dividing by the number of matches. Please make nine choices now.

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Choice 1

Choice 2

Choice 3

<table border="1" style="margin: auto;"> <tr> <td></td> <td style="text-align: center;">L</td> <td style="text-align: center;">R</td> </tr> <tr> <td style="text-align: center;">t</td> <td style="text-align: center;">50</td> <td style="text-align: center;">10</td> </tr> <tr> <td></td> <td style="text-align: center;">60</td> <td style="text-align: center;">20</td> </tr> <tr> <td style="text-align: center;">b</td> <td style="text-align: center;">30</td> <td style="text-align: center;">30</td> </tr> <tr> <td></td> <td style="text-align: center;">40</td> <td style="text-align: center;">40</td> </tr> </table> <p style="text-align: center;">~ ~</p>		L	R	t	50	10		60	20	b	30	30		40	40	<table border="1" style="margin: auto;"> <tr> <td></td> <td style="text-align: center;">L</td> <td style="text-align: center;">R</td> </tr> <tr> <td style="text-align: center;">t</td> <td style="text-align: center;">50</td> <td style="text-align: center;">30</td> </tr> <tr> <td></td> <td style="text-align: center;">20</td> <td style="text-align: center;">40</td> </tr> <tr> <td style="text-align: center;">b</td> <td style="text-align: center;">10</td> <td style="text-align: center;">10</td> </tr> <tr> <td></td> <td style="text-align: center;">60</td> <td style="text-align: center;">60</td> </tr> </table> <p style="text-align: center;">~ ~</p>		L	R	t	50	30		20	40	b	10	10		60	60	<table border="1" style="margin: auto;"> <tr> <td></td> <td style="text-align: center;">L</td> <td style="text-align: center;">R</td> </tr> <tr> <td style="text-align: center;">t</td> <td style="text-align: center;">30</td> <td style="text-align: center;">10</td> </tr> <tr> <td></td> <td style="text-align: center;">60</td> <td style="text-align: center;">20</td> </tr> <tr> <td style="text-align: center;">b</td> <td style="text-align: center;">50</td> <td style="text-align: center;">50</td> </tr> <tr> <td></td> <td style="text-align: center;">40</td> <td style="text-align: center;">40</td> </tr> </table> <p style="text-align: center;">~ ~</p>		L	R	t	30	10		60	20	b	50	50		40	40
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Choice 4

Choice 5

Choice 6

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Choice 7

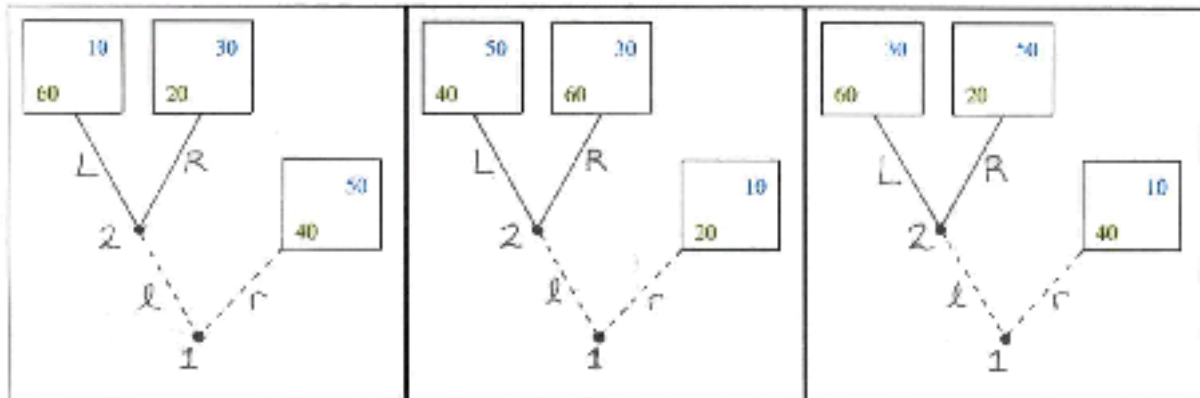
Choice 8

Choice 9

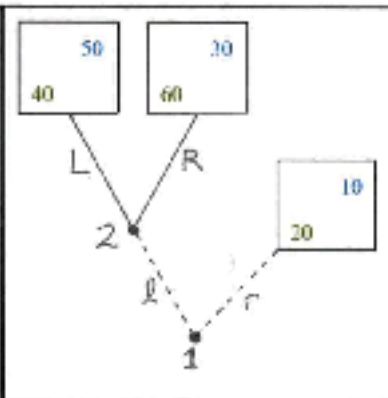
First Mover Form

Participant # _____

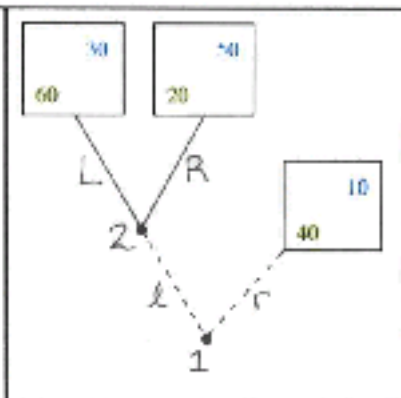
Draw a line along one of the two dashed lines to indicate your choice of the left or right branch. **Your payoffs are in green.** The blue payoffs are for the second mover. Units are cents. Your choice will be matched with each of the other second mover participant choices (but not your own). Your earnings for each choice will be determined by summing up your payoff for each match and dividing by the number of matches. Please make nine choices now.



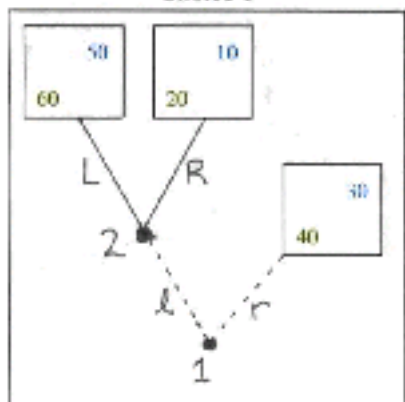
Choice 1



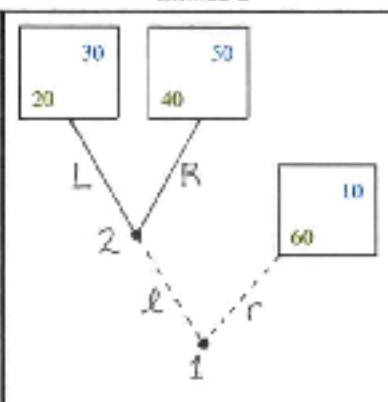
Choice 2



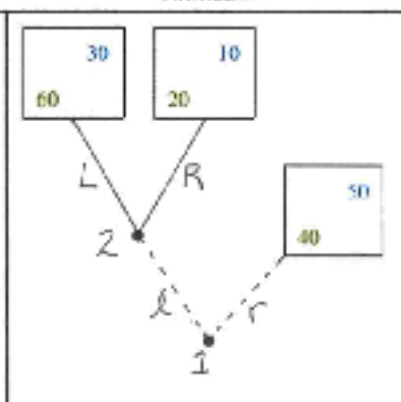
Choice 3



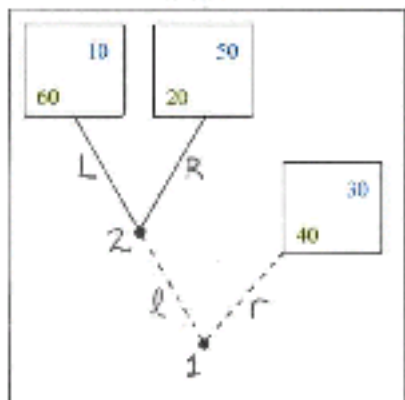
Choice 4



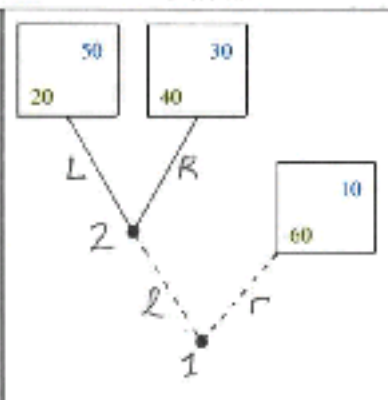
Choice 5



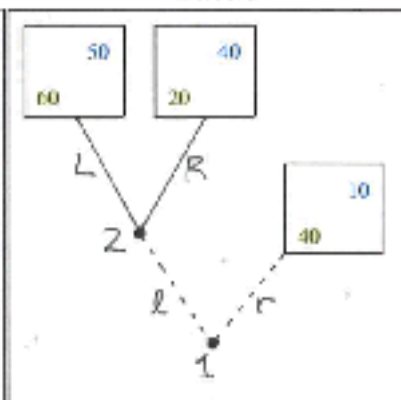
Choice 6



Choice 7



Choice 8

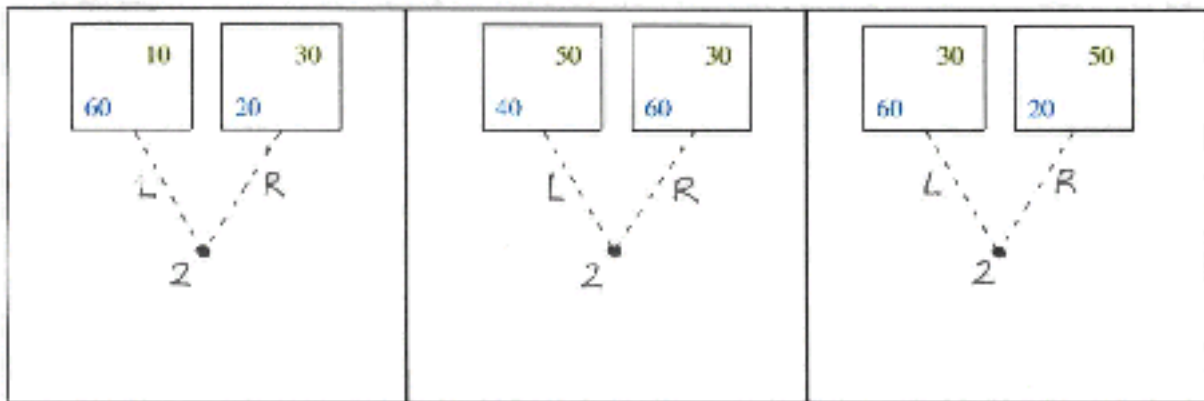


Choice 9

Second Mover Form

Participant # _____

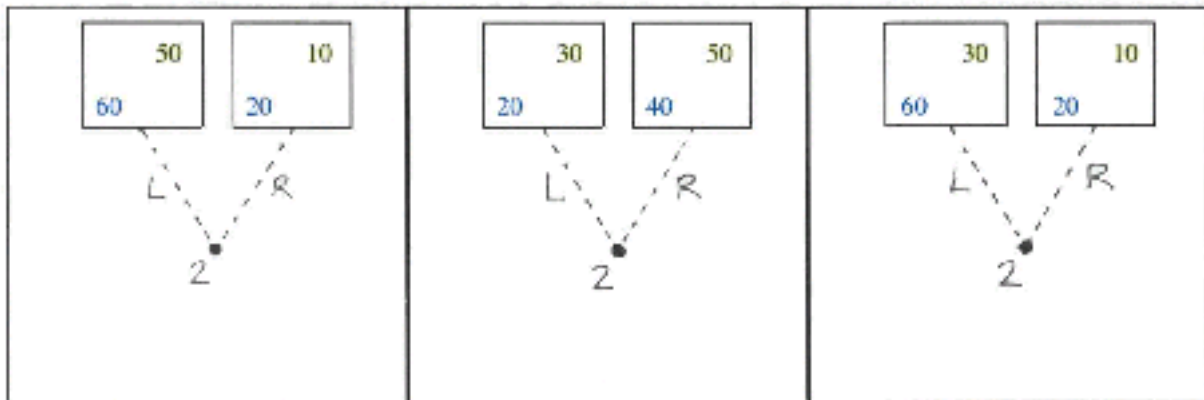
Draw a line along one of the two dashed lines to indicate your choice of the left or right branch. Your payoffs are in green. The blue payoffs are for the first mover. Units are cents. Your choice will be matched with each of the other first mover choices (but not your own). Your earnings for each choice will be determined by summing up your payoff for each match and dividing by the number of matches. Please make nine choices now.



Choice 1

Choice 2

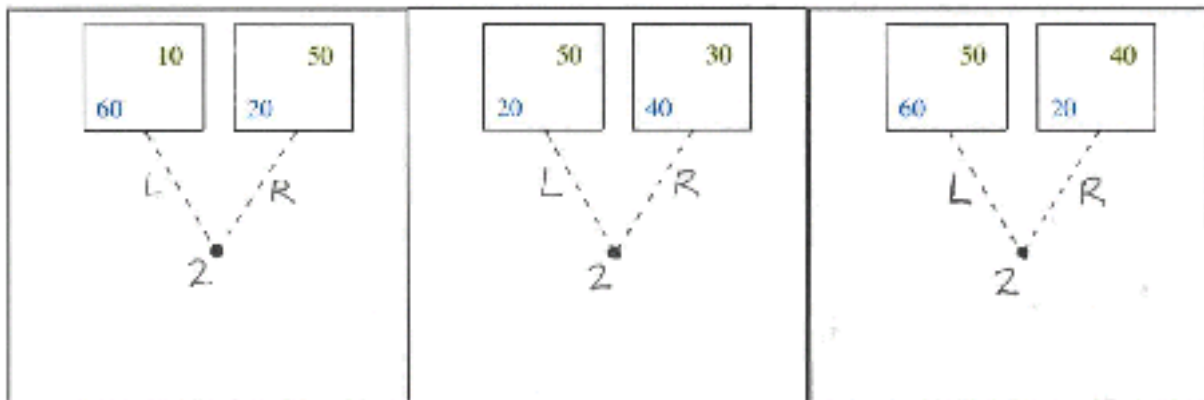
Choice 3



Choice 4

Choice 5

Choice 6



Choice 7

Choice 8

Choice 9