Forward Induction Works!
An Experimental Study to Test the Robustness and the Power *

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Abstract

Cooper et al. (1993) found support for forward induction but its true predictive power was less than the apparent level due to a confounding focal point; an outside-option asymmetry generated the focal point. We test for the robustness and the true and independent predictive power of forward induction by changing the asymmetry type and constructing a symmetric game (i.e. no focal point). Our results, for the first time, confirm that forward induction functions (1) in games with different types of asymmetry, and (2) as an independent selection criterion in the absence of a confounding factor. We also find that controlling for social preferences provides some additional support to forward induction.

JEL Codes: C72, C91, C92.

Key Words: Coordination Game, Battle-of-the-sex Game, Focal Point, Forward Induction, Social Preference.

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I. Introduction

Forward induction (FI), a refinement criterion, is based on the simple idea that an action taken by a player in an earlier stage of a game can indicate to others of her intended play in a later stage. Based on FI, an appropriately set outside option, when offered to one of the players who later participate in a coordination game, can facilitate equilibrium selection and coordination.[1] In this paper, we study in laboratory experiments the robustness and the true and independent predictive power of FI in a battle-of-the-sexes (BOS) game. We also examine the effects of social preferences on the FI prediction.

We start by discussing the baseline BOS game (Figure 1). It is a symmetric 2x2 coordination game in which two players, Row and Column, simultaneously and independently choose between two strategies – 1 and 2. BOS has two pure-strategy Nash equilibria; $(1, 2)$ and $(2, 1)$.[2] The equilibria do not differ with respect to either risk or payoff dominance. In the mixed-strategy Nash equilibrium, both players choose strategy 1 with ¼ probability. Figure 2 shows a second game, named BOS-300, which adds an outside option to the BOS game. It proceeds in two stages. In the first stage, the Row player is offered an outside option. If the Row player takes the outside option by choosing *Out*, then the game ends and each player receives a payoff of 300. Instead, if the Row player chooses *In*, then the players play the BOS game. This game has two pure-strategy subgame-perfect Nash equilibria (SPNE) – $((Out,1), 2)$ and $((In,2), 1)$.[3]

According to FI, if the Row player chooses *In* that signals her intention for obtaining a payoff of 600 in the BOS subgame. So, the Column player should assign a probability of 0 to the instance that the Row player chooses *In* and then chooses strategy 1 in the subgame. As a result, the Column player will choose strategy 1 in the subgame. In the first stage, therefore, the Row player chooses *In* and then in the subgame $(2, 1)$ is played. This is the FI prediction in BOS-300. FI thus eliminates $((Out,1), 2)$ and selects $((In,2), 1)$.

[1] See Kohlberg and Mertens (1986) and Van Damme (1989) for discussions on FI.
[2] The elements in a strategy profile correspond to strategy choices by Row and Column, respectively.
[3] In a two-stage game such as BOS-300, a strategy for a player specifies her move in the first stage (if available) and then in the subgame.

(Figure 1 and Figure 2 go here.)

Cooper, DeJong, Forsythe and Ross (1993) (CDFR, hereafter) test the above FI prediction in lab experiments. Table 1 below shows the results from the last 11 rounds of their experiments.[4] In BOS, subjects attain the equilibrium outcomes only 41% of the time. This rate is higher than the mixed-strategy prediction of 37.5% but lower than what we would expect had the subjects been able to successfully coordinate. In BOS-300, however, the rate of coordination is remarkably high. Conditional on the subgame being played, the players attain 90% of the time (as opposed to only 19% in BOS) the (2, 1) outcome. The frequency of disequilibrium outcomes goes down to 10%. Apparently, the results in BOS-300 provide a strong support for FI.

Table 1: Results from the Last 11 Rounds in Cooper el. al (1993).

Games	**Outcomes**			
	Outside Option	**(2, 1)**	**(1, 2)**	**Disequilibrium: (1,1) and (2,2)**
BOS	-	31 (19%)	37 (22%)	97 (59%)
BOS-300	33	119 (90%)	0 (0%)	13 (10%)
BOS-100	3	102 (63%)	5 (3%)	55 (34%)

Note: Figures in the parentheses show the frequency distribution in each treatment among four outcomes – (1, 2), (2, 1), (1, 1) and (2, 2).

Notice that BOS-300 is characterized by an asymmetry – the outside option is offered to one of the two players in the game. This asymmetry can affect coordination in the subgame and thereby the predictive power of FI. In order to test this, CDFR consider a third game, BOS-100 (Figure 3). In this game, if the Row player takes the outside option, each player receives a payoff of 100. Since this is less than the payoffs in both the subgame equilibria, the Row player cannot indicate her intended play in the subgame by choosing *In*. So, unlike in BOS-300, FI is inapplicable in BOS-100. BOS-100 and BOS-

[4] CDFR reports results from more than three treatments. We are concentrating only on the treatments of our interest. There were 165 observations in total in the last 11 rounds of each treatment.

300, however, have the same asymmetric feature; the asymmetry in offering the outside option is present in both games.

(Figure 3 goes here.)

Although FI induction doesn't have a role to play in BOS-100, Table 1 shows that 63% of the time the outcome (2, 1) is attained which is significantly higher than 19%, the rate observed in BOS. This shows that an asymmetry created in favor of a player in the first stage makes the equilibrium that favors the same player in the subgame focal. In BOS-300, we have a similar asymmetry and the focal point produced by the asymmetry coincides with the outcome FI predicts. The results from BOS-100 thus undermine FI by showing that its *apparent* predictive power in BOS-300 is actually not the *true* predictive power; the latter is lower than the former. Notice that the results in Table 1, however, do not suggest that FI doesn't have any predictive power. The difference in the results from BOS-300 and BOS-100 shows that a focal point alone cannot explain the level of coordination observed in BOS-300 and that FI can enhance coordination in addition to what's achieved solely by the focal point.

There are, however, three issues that cannot be addressed at all using the CDFR results. First, one might worry whether FI is robust to different types of asymmetry. It is possible that the success of FI prediction observed in BOS-300 is dependent on the specific type of asymmetry BOS-300 possesses; FI may not function in any other asymmetric situation. FI, however, does produce a unique prediction in another game with a different type of asymmetry. (We'll discuss a game like this in the next section.) If FI is not robust in practice, then the FI prediction will fail to find empirical support in this other game.

Second, we anticipate that the saliency of a focal point changes when its source is changed. In our FI context, it is an asymmetry that produces the focal point. Consequently, changing the asymmetry while keeping it favorable to the same player is likely to produce the same focal point but with a different saliency level. Since the focal point and FI predict the same outcome, the saliency of the focal point will then affect the apparent predictive power of FI. Moreover, FI's sole contribution towards coordination might also be different in different asymmetric situations. In other words, the true predictive power of FI in an asymmetric situation may change when the asymmetry type is changed.

Third, the CDFR results cannot tell whether FI has any predictive power at all in a symmetric situation. Given the results in CDFR and assuming that the FI prediction sustains in different asymmetric situations, it is still possible that the effectiveness of FI depends on the presence of some form of asymmetry that produces a focal point; the FI prediction might not work in a symmetric situation in which there isn't any confounding focal point. This third issue, therefore, is of even more significance than the previous two because it hinges on both the true and the independent predictive power of FI.

Now, before we list the questions we would like to answer in the current study, we take another look at Table 1. Notice that the Row player takes the outside option 33 times (20% of the 165 observations) in BOS-300. Given the frequency of outcomes in the subgame, this frequency is quite high.[5] With equal payoffs to the outside option to both players, it is possible that a Row player's choice between *Out* and *In* is influenced by inequality aversion. According to both Fehr and Schmidt (1999) and Bolton and Ockenfels (2000) models, a Row player with social preferences might prefer the outside option over (2, 1).[6] Moreover, the Column player can also have social preferences and might react when the Row player chooses *In* which she perceives as an "unfair" action. One can, therefore, conjecture that social preferences of the players might affect the FI prediction.

In all, we try to answer the following questions in this paper: (1) Can the FI prediction work in different asymmetric situations where the asymmetry creates a confounding focal point? (2) Is the apparent predictive power of FI is different under

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[5] Using the frequency of outcomes in the subgame of BOS-300, the expected payoff to the Row player for choosing *In* is 0.9(600)=540.

[6] In Fehr and Schmidt (1999), when x_i and x_j are the monetary payoffs to player *i* and player *j*, player *i*'s utility function is given by $u_i(x_i, x_j) = x_i - \alpha_i \max\{x_j - x_i, 0\} - \beta_i \max\{x_i - x_j, 0\}$ where $\alpha_i \geq \beta_i$ and $0 \leq \beta_i < 1$. Clearly, if β is large enough, then Row prefers the outside option to (2, 1). In Bolton and Ockenfels (2000), player *i*'s motivation function is given by $v_i(x_i, \sigma_i)$ where $\sigma_i = x_i/(x_i + x_j)$ if $(x_i + x_j) > 0$ or $\sigma_i = ½$ if $(x_i + x_j) = 0$. The function $v_i(x_i, \sigma_i)$ satisfies the following conditions: $v_{i1}(x_i, \sigma_i) \geq 0$, $v_{i11}(x_i, \sigma_i) \leq 0$, $v_{i2}(x_i, \sigma_i) = 0$ for $\sigma_i = ½$ and $v_{i22}(x_i, \sigma_i) < 0$. Therefore, any $\sigma_i \neq ½$ reduces the value of v_i compared to when $\sigma_i = ½$. Then, clearly, it is possible that Row prefers the outside option to (2, 1) when unequal payoffs corresponding to (2, 1) sufficiently reduces the value of her motivation function.

different asymmetry types and is it due to varying saliency of the focal point? (3) Does FI have any predictive power in the absence of a focal point? (4) Does social preferences affect the FI prediction? (5) Does controlling for social preference improve FI's predictive power?

To answer the first two questions, we construct a game in which the outside option is offered to both players. In this game, the payoffs to the outside option are asymmetric and designed in a way which allows only one of the player to indicate her intention by rejecting the outside option. So, FI gives a unique prediction in this game. This game eliminates the asymmetry in offering the outside option but introduces an asymmetry with respect to the payoffs the outside option gives. The experimental results for this game support FI confirming that FI functions in different asymmetric situations; the apparent predictive power is, however, different in the two asymmetric situations. To find out the presence of a focal point and its saliency, we consider a second game with only one difference – the payoffs to outside option make FI inapplicable. The experimental results from the second game support our hypothesis that there is a focal point in the first game. The results also show that FI's performance is about the same in the two asymmetric situations; it is the saliency of the focal point that causes the difference in the apparent predictive power of FI. Overall, the saliency of the focal point in our study is less than that in CDFR findings.

We construct a symmetric game – one that doesn't have either the asymmetry of the outside option or the asymmetry of payoffs to the outside option – to answer our third question. Although it is a symmetric game, FI produces predictions when BOS subgames are played at certain nodes of this game. We find support in favor of FI in our data from these experiments. This result, for the first time, shows that FI also functions in the absence of any other confounding factor in a symmetric game.

Finally, we consider a game which is similar to BOS-300 where we control for social preferences by manipulating the payoffs to the outside option offered to the Row player. We find that social preferences affect FI's prediction and controlling for such preferences can provide a better support in favor of FI. The support comes in the form of higher coordination on $(2, 1)$; the acceptance rate of the outside option, however, is not much different when the subjects are relatively experienced.

This paper complements several other experimental studies on FI. Cooper et al. (1992a) test the FI prediction in a game where, instead of the BOS game, a 2x2 coordination game with two Pareto-ranked equilibria is played in the second stage. Their results support the FI prediction. Brandts and Holt (1995) is an experimental study to test the FI prediction in a BOS game. They find strong support for FI in a game in which the predictions of FI and dominance coincide, but the support is very little when the dominance prediction is absent. Brandts, Cabrales and Charness (2007) analyze the strategic interaction between an incumbent and an entrant in an entry game in which the unique game theoretic prediction is based on FI. They find strong evidence in support of FI.

All the studies discussed above involve asymmetry in offering the outside option which can potentially affect the FI prediction. To our knowledge, Van Huyck et al. (1993) and Yavas (2002) are the only experimental studies that consider a symmetric situation. In Van Huyck et al. (1993), subjects first participate in an auction to purchase the right to play a coordination game (median-action game) with multiple Pareto-ranked equilibria and then play this game. In accord with the FI argument, they find that the price in the auction helps the subjects coordinate on Pareto-superior equilibria. But there are other factors besides FI that can explain this result. For example, “loss-avoidance” as a selection principle can lead to the results observed by this study. Although the price the subjects pay in the auction is a sunk cost, subjects may view this price as a loss which they try to recoup by coordinating on a Pareto-superior equilibrium in the median-action game. Cachon and Camerer (1996) test the loss-avoidance hypothesis and find supporting evidence. In their experiments, instead of participating in an auction, subjects pay a fixed fee to obtain the right to play a median-action game. The mandatory fee makes the FI argument inapplicable while the loss-avoidance hypothesis still applies. They find that the mandatory fee improves coordination. This shows that some of the coordination achieved in Van Huyck et al. (1993) is due to a sunk-cost effect.

Yavas (2002) reports results of experiments where both players who participate in a stag-hunt game in the second stage are offered in the first stage an outside option with symmetric payoffs. As predicted by FI, the outside option significantly increases the level of coordination. Since both players can indicate their intentions by rejecting the outside option, it is, however, not clear whether the level of coordination observed in this study is due to FI or a player trying to recoup her opportunity cost of rejecting the outside option.

There are several ways in which the current paper distinguishes itself from the studies discussed above. All the prior studies consider only one asymmetry type – asymmetry in offering the outside option – and fail to control for confounding factors even when the game they consider is symmetric. We consider the FI prediction in different types of asymmetric games as well as in a completely symmetric game in which there isn't any confounding factor. This enables us to test the robustness as well as the true and independent predictive power of FI. Moreover, we test whether social preferences affect the FI prediction. We also contribute to the literature on focal point by showing that payoff differences in the outside option can create focal points in the subgame played following the rejection of the option. This result, along with the CDFR result, confirms that an asymmetry in the outside option that favors one of players makes the BOS subgame equilibrium that favors the same player focal.[7]

The rest of this paper is organized as follows. Section II describes the experimental design in details, Section III discusses the results of the experiments and Section IV makes some concluding remarks.

II. Experimental Design

The games

This paper considers 7 games. Besides BOS, BOS-300 and BOS-100, we introduce four new games –BOS-BOTH-FI, BOS-BOTH, BOS-BOTH-SYM and BOS-SOCIAL (Figures 4, 5, 6 and 7). The descriptions of these games are given below.

(Figure 4 and Figure 5 go here.)

[7] The experimental studies on focal points have been focused on inducing focal points by assigning salient labels to the corresponding strategies (Mehta et al., 1994; Crawford et al., 2008) or by the payoff structure of the game (Cooper et al., 1990; Van Huyck et al., 1990, 1991; Straub, 1995) or by pre-play communication (Cooper et al., 1989, 1992b; Van Huyck et al., 1992; Brandts and MacLeod, 1995). Knez and Camerer (1995) is an exception which looks at the effects of offering an outside option to the Responder in an ultimatum game; the option gives positive and unequal payoffs to both the Proposer and the responder when the responder rejects the Proposer's offer. They find that the outside option can create multiple focal points.

BOS-BOTH-FI (Figure 4), unlike BOS-300, BOS-100 and BOS-SOCIAL, doesn't have the asymmetry in offering the outside option. In BOS-BOTH-FI, outside options are offered in the first stage to Row and Column. Players simultaneously and independently choose between *In* and *Out*. If either of the two players chooses *Out*, then the game ends. In that case, Row receives 300 and Column receives 100. Only when both the players choose *In* they move to the second stage where they participate in the BOS subgame. The game has three pure-strategy SPNE's – $\big((Out,1),\ (Out,2)\big)$, $\big((Out,1),\ (In,2)\big)$ and $\big((In,2),\ (In,1)\big)$.[8]

The payoffs to the outside option in BOS-BOTH-FI ensure that the FI argument applies only to Row. By rejecting 300, Row is able to indicate her intention of receiving 600 in the BOS subgame. A payoff of 100 in the outside option, however, does not allow Column to signal anything to Row. So, FI selects $\big((In,2),\ (In,1)\big)$. Conditional on the subgame being played, we hypothesize a higher coordination on $(2,\ 1)$ in this game than in BOS.

Although BOS-BOTH-FI eliminates the asymmetry present in BOS-300, BOS-100 and BOS-SOCIAL, it creates another type of asymmetry – the payoffs to the outside option are different for the players; Row earns a higher payoff when she takes the outside option. Both asymmetry types are, however, similar in the sense that they both favor Row. So, we hypothesize that the new asymmetry might make $(2,\ 1)$ focal and thereby produce a confounding effect.

BOS-BOTH (Figure 5) is designed to test the above focal point argument. There are two pure-strategy SPNE's in this game – $\big((In,1),\ (In,2)\big)$ and $\big((In,2),\ (In,1)\big)$. This game is very similar to BOS-BOTH-FI expect that the payoffs to the outside options don't allow either player to signal her intention by rejecting the option. BOS-BOTH and BOS-BOTH-FI, however, have the same asymmetry; Row receives a higher payoff to the outside option than Column does. If the focal point argument is at work, then it will select $\big((In,2),\ (In,1)\big)$. We hypothesize that, conditional on the subgame being played, there will be a higher coordination on $(2,\ 1)$ in this game than in BOS.

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[8] There is another equilibrium in which Row chooses *Out*; this is supported by the belief that Column will play according to the mixed-strategy Nash equilibrium in the subgame.

(Figure 6 and Figure 7 go here.)

Next, we consider the BOS-BOTH-SYM game (Figure 6). In this game, both the players are in the exact same situation and the players are not assigned the roles of Row and Column. In the first stage, two players (Player 1 and Player 2) simultaneously and independently choose between *In* and *Out*. Only when both players choose *Out*, the game ends. Otherwise, they play the BOS game in the second stage. Before they make their decisions in BOS, each player is told whether her opponent chose *In* or *Out*. This game has four pure-strategy SPNE's – $\big((Out,1),\ (In,2)\big)$, $\big((In,2),\ (Out,1)\big)$, $\big((In,1),\ (In,2)\big)$ and $\big((In,2),\ (In,1)\big)$.[9]

Notice that a player in the above game will choose *In* only when she is aiming at a payoff larger than 300. Otherwise, she should choose *Out* which gives her 300 or takes her to the BOS subgame. As a result, whenever one of the two players chooses *In*, the other player chooses *Out* and the BOS subgame is reached, FI predicts that the subgame equilibrium that favors the player who chose *In* will be attained in the subgame.[10] Notice also that FI cannot perform as a selection criterion in the whole game because both players move simultaneously in the first stage before anyone can signal her intention. An equilibrium selection for the whole game, in this case, will require coordination in the first stage which FI cannot facilitate.

Finally, we consider BOS-SOCIAL (Figure 7) which is very similar to BOS-300 except that it controls for social preferences. Recall that, in BOS-300, with equal payoffs to both players in the outside option, it is possible according to both Fehr-Schmidt and Bolton-Ockenfels models that both players prefer the outside option over $(2,\ 1)$. In BOS-SOCIAL, similar to that in BOS-300, the outside option is offered only to Row in the first stage. The payoffs to the outside option are different in BOS-SOCIAL – Row receives 400 and Column receives 0 when Row takes the option. These payoffs ensure that, for all possible values of the parameters in the social-preference models we have considered,

[9] There is another equilibrium in which both players choose *Out*; this is supported by the belief that the opponent will play according to the mixed-strategy Nash equilibrium in the subgame.
[10] Iterated Elimination of Weekly Dominated Strategies (IEWDS) also predicts similar outcomes since the strategies (*Out*,*2*) and (*In,1*) don't survive IEWDS.

both players prefer $(2, 1)$ over the outside option.[11] This game has the same two pure-strategy SPNE's as in BOS-300 – $((Out,1), 2)$ and $((In,2), 1)$, and Row is able to indicate her intention of receiving 600 in the subgame by rejecting the outside option which gives her 400. So, FI selects $((In,2), 1)$ in BOS-SOCIAL. Our hypothesis in this game is that the rejection of the outside option and the coordination on $(2, 1)$ will be higher in this game than in BOS-300.[12]

The Experimental Sessions

We have 7 treatments in this study (Table 2); one for each of the 7 games we consider. We adopted the design used in CDFR. In each treatment, we ran three sessions. Each session recruited 11 subjects. Upon arrival at the lab, a subject was seated in front of a computer terminal and was given a copy of the instructions. The instructions were also read aloud. A session consisted of 22 rounds of one and only one of the 7 games. In each round, one subject was matched with another subject. Thus, in each round we had 5 pairs; one subject was sitting out. At the end of a session, we had 110 observations.[13] So, each treatment produced 330 observations.

Within each of 5 pairs in a round in all but the BOS-BOTH-SYM treatment, one subject was assigned the role of Row and the other Column.[14] In a random manner, each subject played exactly twice with another subject (once as Row and once as Column) and seated out once during the entire session. So, in each session, each subject participated in 20 rounds; playing as Row in 10 rounds and Column in the other 10 rounds.

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[11] Since both players receive higher payoffs in (2, 1) than in the outside option and the payoff inequality is the same for both outcomes, both players prefer (2, 1) according to the Fehr-Schmidt model. Again, since both players receive higher payoffs in (2, 1) than in the outside option and σ_i is closer to ½ in (2, 1) than in the outside option for both players, both of them prefer (2, 1) according to the Bolton-Ockenfels model.

[12] We would like to point out that reciprocal motives do not suggest (2, 1) as the unique solution of BOS-SOCIAL. Based on the sequential reciprocity theory of Dufwenberg and Kirchsteiger (2004), with positive reciprocity, both ((*Out*,1), 2) and ((*In*,2), 1) are pure-strategy Sequential Reciprocity Equilibrium (SRE).

[13] In BOS, an observation consists of choices by Row and Column between strategies 1 and 2. In BOS-300, BOS-100 and BOS-SOCIAL, an observation consists of a choice by Row between *In* and *Out*, and then if the subgame is played, choices by Row and Column between strategies 1 and 2 as well. In BOS-BOTH-FI and BOS-BOTH (and BOS-BOTH-SYM), an observation consists of choices by Row and Column (Player 1 and Player 2) between *In* and *Out* in the first stage, and then if the subgame is played, their choices between strategies 1 and 2 as well.

[14] At the beginning of each round, subjects were informed of their assigned roles via computer terminals.

In BOS-BOTH-SYM, the players in a pair were not assigned any role.[15] Similar to the other treatments, each subject played exactly twice with another subject in two randomly selected rounds. Each subject also seated out once during the entire session. So, in each session, each subject participated in 20 rounds.

Table 2: Experimental Design.

Treatment	Sessions per Treatment	Subjects per Session	Decision-making Rounds per Session	Pairs/Observations per Round	Observations per Session	Total Observations per Treatment
BOS	3	11	22	5	110	330
BOS-300	3	11	22	5	110	330
BOS-100	3	11	22	5	110	330
BOS-BOTH-FI	3	11	22	5	110	330
BOS-BOTH	3	11	22	5	110	330
BOS-BOTH-SYM	3	11	22	5	110	330
BOS-SOCIAL	3	11	22	5	110	330

In all 7 treatments, at the end of each round in a session, a subject earned points according to the choices made and the payoffs specified in the game she was playing. This point determined the probability of winning in a binary lottery with two outcomes – $0 and $3. To implement the lottery, at the end of each round, the computer generated random numbers between 0 and 1000 for each subject separately. If this number is less than or equal to the points a subject earned, then the subject earned $3; she earned $0 otherwise. [16] Through out the session each subject accumulated her earnings which were paid in cash at the end of the session. The average earnings were about $20 and each session lasted for about an hour.

The experiments were run at the Economic Science Lab (ESL) at the University of Arizona. 231 undergraduate students were recruited for these experiments. All of our sessions were conducted on the computer terminals using zTree (Fischbacher, 2007).

[15] Both the players in BOS-BOTH-SYM were given the same instructions. In the instructions, the players were not identified even as Player 1 or Player 2.

[16] The points a subject earned divided by 1000 gave the probability of winning $3. So, higher points gave higher probability of winning.

III. Results

The results from the experiments, excluding those from the BOS-BOTH-SYM treatment, are summarized in Tables 3 and 4. Table 3 reports the frequencies of the outcomes in the first and the last 11 rounds separately; the latter in italics. In a similar manner, Table 4 lists the frequencies of strategies played. Using a Chi-square test,[17] we can reject in some of the treatments the hypothesis that the first and the last halves are the same with respect to distribution of outcomes and strategies played.[18] In our data analysis for treatment differences that follows, we look at the two halves of the data separately; with 165 observations in each half.

Replication of CDFR Treatments

In BOS, coordination failure is clearly visible – less than 50% of the time the subjects reached an equilibrium outcome with roughly equal frequency for each equilibrium (Table 3). The frequency distribution of outcomes is also significantly different from the mixed-strategy Nash equilibrium prediction ($\chi^2_{first} = 40.5$, $p < 0.001$ and $\chi^2_{last} = 25.9$, $p < 0.001$).[19]

In BOS-300, the outside option was taken at least 33.3% of the time (Table 3). Consistent with the FI prediction, however, the relative frequency of (2, 1) in the subgame is higher than in BOS – 61.8% (43.3%) in BOS-300 versus only 22.4% (21.8%) in BOS in the first half (second half). These differences are significant ($\chi^2_{first} = 11.97$, $p < 0.001$ and $\chi^2_{last} = 41.74$, $p < 0.001$).[20] The frequency distributions of the subgame outcomes in BOS-300 and BOS are significantly different ($\chi^2_{first} = 19.3$, $p < 0.001$ and $\chi^2_{last} = 49.4$, $p < 0.001$). The outcomes are also different in terms of *ex post* SPNE's

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[17] All the tests reported in this paper are two-tail Chi-square tests.
[18] The data in the first and the last halves are significantly different with respect to the frequencies of outcomes in BOS-300, BOS-100, BOS-BOTH-FI and BOS-BOTH, and the frequencies of Row's choice between *In* and *Out* in BOS-300 and BOS-100, and the frequencies of strategies played in the subgame in BOS-100.
[19] Within the parenthesis, we report the test results for the first and the last halves, respectively. In the remainder of the paper, whenever we report two results in this manner the results are to be interpreted this way.
[20] Throughout this paper, to test for treatment differences in terms of the level of coordination on (2, 1), we collapse the three other subgame outcomes into a single one and combine their frequencies.

observed. We observed significantly more equilibrium outcomes in BOS-300 (χ^2_{first} = 12.8, $p < 0.001$ and χ^2_{last} = 22.6, $p < 0.001$), but the frequency of (2, 1) as a proportion of all equilibria observed is not significantly different (χ^2_{first} = 1.69, p = 0.193 and χ^2_{last} = 1.24, p = 0.265).

We can also compare BOS and BOS-300 in terms of the strategies played by Row and Column in the subgame (Table 4). Chi-square tests show that there are significant differences in choices between strategies 1 and 2 – Row chooses strategy 2 with a higher proportion (χ^2_{first} = 12.0, $p < 0.001$ and χ^2_{last} = 26.1, $p < 0.001$) and Column chooses strategy 1 with a higher proportion in BOS-300 (χ^2_{first} = 6.6, p = 0.010 and χ^2_{last} = 24.5, $p < 0.001$).

Table 3: Frequencies of Outcomes in First and Last 11 Rounds (Last 11 Rounds in Italics).

Treatment	**Outside Option**	**Outcomes in the Subgame**			
		(2, 1)	**(1, 2)**	**(1, 1)**	**(2, 2)**
BOS	-	36 (21.8%) ***37*** ***(22.4%)***	45 (27.3%) ***43*** ***(26.1%)***	25 (15.2%) ***21*** ***(12.7%)***	59 (35.8%) ***64*** ***(38.8%)***
BOS-300	75 (45.5%) ***55*** ***(33.3%)***	39 (43.3%) ***68*** ***(61.8%)***	8 (8.9%) ***6*** ***(5.5%)***	10 (11.1%) ***5*** ***(4.5%)***	33 (36.7%) ***31*** ***(28.2%)***
BOS-100	22 (13.3%) ***9*** ***(5.5%)***	41 (28.7%) ***59*** ***(37.8%)***	31 (21.7%) ***26*** ***(16.7%)***	13 (9.1%) ***19*** ***(12.2%)***	58 (40.6%) ***52*** ***(33.3%)***
BOS-SOCIAL	41 (24.8%) ***50*** ***(30.3%)***	80 (64.5%) ***86*** ***(74.8%)***	5 (4.0%) ***3*** ***(2.6%)***	12 (9.7%) ***6*** ***(5.2%)***	27 (21.8%) ***20*** ***(17.4%)***
BOS-BOTH-FI	70 (42.4%) ***54*** ***(32.7%)***	64 (67.4%) ***88*** ***(79.3%)***	4 (4.2%) ***2*** ***(1.8%)***	9 (9.5%) ***4*** ***(3.6%)***	18 (18.9%) ***17*** ***(15.3%)***
BOS-BOTH	25 (15.2%) ***24*** ***(14.5%)***	59 (42.1%) ***73*** ***(51.8%)***	20 (14.3%) ***11*** ***(7.8%)***	18 (12.9%) ***18*** ***(12.8%)***	43 (30.7%) ***39*** ***(27.7%)***

Note: Percentages are given in parentheses; for outcomes in the subgame, the percentages show the distribution of the outcomes only within the subgame. The percentages for the outside option show the proportion of 165 observations in which the outside option was taken.

As we discussed in the Section I, CDFR found a focal point effect in BOS-300 which augmented the FI prediction. In order to find the presence of a similar effect, we look at the results from BOS-100. As predicted by the focal point hypothesis, the relative frequency of (2, 1) in Table 3 is higher in BOS-100 than in BOS ($\chi^2_{first} = 1.6$, $p = 0.206$ and $\chi^2_{last} = 8.3$, $p = 0.004$). On the other hand, this frequency is lower in BOS-100 than in BOS-300 ($\chi^2_{first} = 4.6$, $p = 0.032$ and $\chi^2_{last} = 13.9$, $p < 0.001$) which supports FI. Similar to the CDFR results, our results thus establish that the FI prediction and a focal point coincide on (2, 1) in BOS-300 and that both factors contribute separately towards a higher coordination on (2, 1).

Table 4: Frequencies of Strategies Played in First and Last 11 Rounds (Last 11 Rounds in Italics).

Treatment	**Row's Outside Option**	**Column's Outside Option**	**Row's Subgame Play**		**Column's Subgame Play**	
			Str. 1	**Str. 2**	**Str. 1**	**Str. 2**
BOS	-	-	70 (42.4%) ***64 (38.8%)***	95 (57.6%) ***101 (61.2%)***	61 (37.0%) ***58 (35.2%)***	104 (63.0%) ***107 (64.8%)***
BOS-300	75 (45.5%) ***55 (16.7%)***	-	18 (20.0%) ***11 (10.0%)***	72 (80.0%) ***99 (90.0%)***	49 (54.4%) ***73 (66.4%)***	41 (45.6%) ***37 (33.6%)***
BOS-100	22 (13.3%) ***9 (2.7%)***	-	44 (30.8%) ***45 (28.8%)***	99 (69.2%) ***111 (71.2%)***	54 (37.8%) ***78 (50.0%)***	89 (62.2%) ***78 (50.0%)***
BOS-SOCIAL	41 (24.8%) ***50 (15.2%)***	-	17 (13.7%) ***9 (7.8%)***	107 (86.3%) ***106 (92.2%)***	92 (74.2%) ***92 (80.0%)***	32 (25.8%) ***23 (20.0%)***
BOS-BOTH-FI	62 (37.6%) ***48 (14.5%)***	15 (9.1%) ***11 (3.3%)***	13 (13.7%) ***6 (5.4%)***	82 (86.3%) ***105 (94.6%)***	73 (76.8%) ***92 (82.9%)***	22 (23.2%) ***19 (17.1%)***
BOS-BOTH	18 (10.9%) ***13 (3.9%)***	9 (5.5%) ***12 (3.6%)***	38 (27.1%) ***29 (20.6%)***	102 (72.9%) ***112 (79.4%)***	77 (55.0%) ***91 (64.5%)***	63 (45.0%) ***50 (35.5%)***

The focal point effect, however, doesn't appear to be very strong. Compared to BOS, as we discussed above, BOS-100 produced higher coordination on (2, 1) only when the subjects were experienced. The frequency distributions of the subgame outcomes in BOS-100 and BOS are significantly different only in the second half of the experiments (χ^2_{first} = 5.2, p = 0.158 and χ^2_{last} = 19.2, p < 0.01) and the frequency of (2, 1) as a proportion of all equilibria observed is also significantly different, once again, in the second half of the experiments (χ^2_{first} = 1.9, p = 0.168 and χ^2_{last} = 8.2, p < 0.004). Moreover, we didn't observe any significant difference in the frequency of equilibrium outcomes observed (χ^2_{first} = 0.8, p = 0.371 and χ^2_{last} = 0.2, p = 0.655). The effect of the focal point is also not very strong in terms of the strategies played in the subgame (Table 4) – Row's choice of strategy 2 is significantly higher in BOS-100 than in BOS only in the first half of the experiments (χ^2_{first} = 4.0, p = 0.045 and χ^2_{last} = 3.1, p = 0.078) while Column's choice of strategy 1 is higher in BOS-100 than in BOS only in the second half of the experiments (χ^2_{first} = 0.001, p = 0.975 and χ^2_{last} = 6.6, p = 0.010).

Our results in BOS, BOS-300 and BOS-100 look qualitatively similar to those in CDFR. The frequency with which Row takes the outside option is higher in our study but given the difference between the two studies in terms of the subgame strategy choices by the players and the resulting expected payoff to choosing *In*, this difference doesn't appear to be disproportionate.[21] The difference in the subgame strategy choices, in turn, arises from lower coordination levels in BOS-300 and BOS-100 in the current study. We argue that FI is equally effective in both the studies and it is a weaker focal point effect which results in the difference in the coordination levels. To see this, recall that the same focal point is present in both BOS-300 and BOS-100 while FI applies only to BOS-300. Hence, any difference that we may observe between these two experiments in terms of coordination on (2, 1) is attributable to FI. Now, notice that this difference is about the same in the two studies (Tables 1 and 3). Then it must be the case that FI's contribution to coordination is the same while that of the focal point is lower in our data. We conclude that FI has significant predictive power and the asymmetry of outside option creates a confounding effect via creating a focal point, but the saliency of the focal point is much weaker than the CDFR findings.[22]

[21] In fact, Row's expected payoff by choosing *In* in the first half is 277.6 which is less than the payoff to the outside option (300). The expected payoff to *In* in the second half is 381.8; it was 540 in CDFR.

[22] The subjects in CDFR participated in a one-shot dominant strategy game before they participated in BOS, BOS-300 or BOS-100 experiments. The quantitative difference between our results and those in CDFR can arise from this additional subject experience or difference between subject pools or both.

A Second Type of Asymmetry and FI

Next, we look at the results from the experiments on the BOS-BOTH-FI game (Figure 4). Although the outside option is offered to both players, FI applies and predicts the (2, 1) outcome in this game. BOS-BOTH-FI doesn't have the asymmetry of outside option but it has the asymmetry of payoffs to the outside options – Row receives a higher payoff. Although the type of asymmetry in this game is different than the one in BOS-300, we hypothesized that FI is robust and its prediction holds in BOS-BOTH-FI. The results from the experiments support our hypothesis. Table 3 shows that the coordination on (2, 1) is higher in BOS-BOTH-FI than in BOS – 67.4% (79.3%) in BOS-BOTH-FI while only 21.8% (22.4%) in BOS in the first half (second half); the differences are significant in both halves ($\chi^2_{first} = 50.94$, $p < 0.001$ and $\chi^2_{last} = 84.3$, $p < 0.001$). The frequency distributions of the subgame outcomes in the two experiments are also significantly different ($\chi^2_{first} = 56.8$, $p < 0.001$ and $\chi^2_{last} = 89.9$, $p < 0.001$). In terms of the equilibria observed, there are significantly more equilibrium outcomes in BOS-BOTH-FI ($\chi^2_{first} = 36.1$, $p < 0.001$ and $\chi^2_{last} = 51.2$, $p < 0.001$) and the frequency of (2, 1) as a proportion of all equilibria observed is significantly different in the last half of the experiments ($\chi^2_{first} = 0.1$, $p = 0.752$ and $\chi^2_{last} = 4.5$, $p = 0.034$).

There are significant differences between BOS-BOTH-FI and BOS also in choices of the subgame strategies (Table 4) – Row chooses strategy 2 with a higher proportion ($\chi^2_{first} = 21.6$, $p < 0.001$ and $\chi^2_{last} = 37.3$, $p < 0.001$) and Column chooses strategy 1 with a higher proportion ($\chi^2_{first} = 36.8$, $p < 0.001$ and $\chi^2_{last} = 59.0$, $p < 0.001$) in BOS-BOTH-FI. The results from BOS-BOTH-FI are thus consistent with FI. In fact, the apparent performance of FI appears to be better in BOS-BOTH-FI than in BOS-300 – Row's acceptance rate of the outside option is about the same while there is significantly more coordination on (2, 1) in BOS-BOTH-FI ($\chi^2_{first} = 9.9$, $p = 0.002$ and $\chi^2_{last} = 7.3$, $p = 0.007$). As we will discuss later, this is mainly due to a focal point effect. But first, we need to verify that there is a focal point in BOS-BOTH-FI as we had expected.

To see if the asymmetry in BOS-BOTH-FI creates a focal point which has worked in favor of FI, we look at the results from the experiments on the BOS-BOTH game (Figure 5). The outside option is offered to both players in this game but unlike BOS-BOTH-FI, FI doesn't apply here. BOS-BOTH-FI and BOS-BOTH, however, have the same asymmetry as both games give the players unequal payoffs to the outside option. So, if the asymmetry can create a focal point, then it should do the same in both games and there should be higher coordination on (2, 1) in BOS-BOTH compared to BOS. As predicted by the focal point argument, we see in Table 3 that the frequency of (2, 1) is higher in BOS-BOTH than in BOS – 42.1% (51.8%) in BOS-BOTH versus only 21.8% (22.4%) in BOS in the first half (second half); all the differences are significant (χ^2_{first} = 13.6, $p < 0.001$ and χ^2_{last} = 27.2, $p < 0.001$). The results are different in terms of the frequency distributions of the subgame outcomes in the two experiments (χ^2_{first} = 16.9, $p < 0.001$ and χ^2_{last} = 35.4, $p < 0.001$).

The frequency of (2, 1) as a proportion of all equilibria observed is also significantly different in BOS-BOTH than in BOS (χ^2_{first} = 13.9, $p < 0.001$ and χ^2_{last} = 28.9, $p < 0.001$). But we didn't observe any significant difference in the frequency of equilibrium outcomes observed (χ^2_{first} = 0.01, p = 0.920 and χ^2_{last} = 0.1, p = 0.752). Choices of subgame strategies in Table 4 are also different in BOS-BOTH and BOS for both players; Row choosing strategy 2 (χ^2_{first} = 7.1, p = 0.008 and χ^2_{last} = 11.1, p = 0.001) and Column choosing strategy 1 with a higher proportion in BOS-BOTH (χ^2_{first} = 9.2, p = 0.002 and χ^2_{last} = 25.1, $p < 0.001$). The results from BOS-BOTH thus support the focal point hypothesis. In fact, the focal point in BOS-BOTH appear to be more salient than the one in BOS-100 as the relative frequency of (2, 1) is lower in the latter one.

Since FI applies to BOS-BOTH-FI but not to BOS-BOTH, we expect a higher coordination on (2, 1) in BOS-BOTH-FI. Consistent with our expectation, we find in Table 3 that the relative frequency of (2, 1) in the subgame is higher in BOS-BOTH-FI than in BOS-BOTH (χ^2_{first} = 13.4, $p < 0.001$ and χ^2_{last} = 19.2, $p < 0.001$). Once again, our conclusion here is similar to what we had reached at after comparing the results from BOS-300 and BOS-100: the FI prediction holds and an asymmetry in the first stage can create a focal point in the BOS subgame which enhances FI's apparent performance.

Now, notice that the difference between BOS-300 and BOS-100 in terms of the level of coordination on (2, 1) is very similar to that between BOS-BOTH-FI and BOS-BOTH. Thus, the effect of FI is similar in the two asymmetric situations we consider. The level of coordination achieved in BOS-BOTH-FI, however, is higher than that in BOS-300. This difference, therefore, stems mainly from the difference in focal point saliency in different asymmetric situations. This claim is substantiated by a higher relative frequency of (2, 1) in the subgame in BOS-BOTH than in BOS-100 (χ^2_{first} = 5.0, p = 0.025 and χ^2_{last} = 5.3, p = 0.021). So, based on all our findings, we summarize that FI can work in different asymmetric games and the true predictive power of FI is the same across these games; the observed predictive power of FI are different under different situations, mainly due to changes in the focal point saliency.

Symmetry (No Focal Point) and FI

In spite of our results so far, it is still possible that the effectiveness of FI is completely dependent on the presence of a focal point. That is, there may not be any predictive power of FI when there is no focal point. So, the true power of FI in the absence of a confounding factor is still unknown to us. To investigate this, we look at the results from the experiments on the BOS-BOTH-SYM game (Figure 6) in which the outside option is offered to both players and the payoffs to the players to the option are equal. In this game, the BOS subgame is played when at least one of the two players rejects the outside option. According to FI, when only one player rejects the outside option, the subgame equilibrium that favors this player will be played.

The results from BOS-BOTH-SYM are given in Table 5. More than 41% of the time one of the players rejected the outside option while the other did not. In these *In-Out* cases, 31.0% (39.7%) of the time the players coordinated on the subgame equilibrium that favors the player who rejected the outside option in the first half (second half); only 12.7% (5.9%) of the time they coordinated on the other subgame equilibrium. So, there is more than twice (six times) as much coordination on the FI predicted outcome in the first half (second half). These differences are significant (χ^2_{first} = 5.5, p = 0.019 and χ^2_{last} = 17.1, $p < 0.001$). Recall that in BOS, the two equilibria had roughly the same frequency. The BOS-BOTH-SYM results, therefore, provide evidence in favor of FI. The significance of this result is huge as it confirms that the FI argument works even in a symmetric situation. This result, for the first time, establishes that FI argument has some power of its own and can function as an independent selection criterion.

Table 5: Frequencies of Outcomes in BOS-BOTH-SYM in First and Last 11 Rounds (Last 11 Rounds in Italics).

Out-Out	**In-In**	**In-Out**			
77 (46.7%) ***89*** ***(54.0%)***	17 (10.3%) ***8*** ***(4.8%)***	71 (43.0%) ***68*** ***(41.2%)***			
		Subgame Equilibrium Favorable to the Player Choosing *In*	**Subgame Equilibrium Favorable to the Player Choosing *Out***	**(1, 1)**	**(2, 2)**
		22 (31.0%) ***27*** ***(39.7%)***	9 (12.7%) ***4*** ***(5.9%)***	3 (4.2%) ***2*** ***(2.9%)***	37 (52.1%) ***35*** ***(51.5%)***

We, however, notice that the disequilibrium outcomes were reached in more than 50% of the *In-Out* cases. So, although the effect of FI on coordination is significant, it's not very strong. At the same time, we acknowledge that the decision making in this game is somewhat difficult because, unlike BOS-BOTH-FI and BOS-BOTH, the BOS subgame is played anytime one of the players reject the outside option. In order to be able to understand and respond according to FI, players have to pay careful attention to the first stage history before they participate in the second stage. In the experiments, although subjects were informed about the first stage choices of the opponents before they participate in the second stage, they may have occasionally lost dynamic consistency when choosing in the second stage.

Social Preferences and FI

In the BOS-SOCIAL game (Figure 7), similar to BOS-300, the FI argument applies. In BOS-SOCIAL, we controlled for social preferences with the expectation that the acceptance rate of the outside option will be lower and the coordination on (2, 1) will be higher than in BOS-300. In the experiments (Table 3), consistent with our hypothesis, the outside option is taken with a lower frequency in BOS-SOCIAL than in BOS-300; the difference is significant in the first half of the experiments ($\chi^2_{first} = 14.5$, $p < 0.001$ and $\chi^2_{last} = 0.2$, $p = 0.655$). The relative frequency of (2, 1) in the subgame is significantly higher in BOS-SOCIAL – 64.5% (74.8%) in BOS-SOCIAL compared to only 43.3% (61.8%) in BOS-300 in the first half (second half) (χ^2_{first} = 8.64, p = 0.003 and χ^2_{last} = 3.80, p = 0.051). The frequency distributions of the subgame outcomes in BOS-SOCIAL and BOS-300 are significantly different in the first half of the experiments (χ^2_{first} = 10.5, p = 0.015 and χ^2_{last} = 5.5, p = 0.139) and the frequency of (2, 1) as a proportion of all equilibria observed is also significantly different, again, in the first half (χ^2_{first} = 22.6, p < 0.001 and χ^2_{last} = 1.38, p = 0.240). The results of BOS-SOCIAL confirm that controlling for social preferences in an appropriate manner can provide stronger support for FI; this effect, however, diminishes as the subjects become relatively experienced.[23]

In the comparison of the subgame strategies choices in BOS-300 and BOS-SOCIAL (Table 4), we find that they are not significantly different for Row (χ^2_{first} = 1.08, p = 0.299 and χ^2_{last} = 0.11, p = 0.740) but they are for Column – she chooses strategy 2 with a significantly lower proportion in BOS-SOCIAL (χ^2_{first} = 8.19, p = 0.004 and χ^2_{last} = 4.67, p = 0.031). Thus, the differences between the two treatments are arising mainly from the difference in Column's strategy choices; Row's choices in either stage of BOS-SOCIAL don't appear to be much different than those in BOS-300, especially when the subjects are relatively experienced. Moreover, given the observed frequencies of subgame strategy choices by both players, the frequency with which Row accepts the outside option in BOS-SOCIAL is still slightly high in the second half of the experiment.[24] We, therefore, infer that Row's choices in BOS-300 are unaffected by her social preferences; the lower coordination level in BOS-300, compared to that in BOS-SOCIAL, is a result of Column's reaction when Row rejects the equitable distribution (300,300) in the outside option in BOS-300 – Column punishes Row by choosing strategy 2.[25]

Overall, the power of FI in our experiments didn't appear to be much different than that in the CDFR experiments. We have found support for all our hypotheses in both

[23] This is similar to the findings in experiments on repeated ultimatum games where it has been observed that offer amounts and rejection rates decrease (usually insignificantly) over time (Roth et al., 1991; Knez and Camerer, 1995; Slonim and Roth, 1998; List and Cherry, 2000).

[24] Using the frequency of outcomes, the expected payoff to Row's for choosing *In* is 395 and 454 in the first and the last halves, respectively.

[25] This result is similar to the findings in ultimatum and dictator games where Responders reject positive offers which they perceive as unfair. The Proposers are, however, mostly self-interested. See Camerer (2003) for an excellent review of the related literature.

halves of the experiments with the exception of BOS-SOCIAL where the results were supporting only in the first half. We also would like to point out that we notice an effect of subject experience on the effectiveness of FI. In BOS-300, BOS-BOTH-FI and BOS-BOTH-SYM, we find higher coordination on the FI-predicted outcome in the second half of the experiments; the differences are significant at less than 10% level in the first two treatments.[26] In spite of this, recall that we have been able to find significant treatment differences in most of our tests when applied only to the first half data. Moreover, as discussed earlier, given the subgame choice frequencies, the acceptance rates of the outside option are reasonable only in the first halves of BOS-300 and BOS-SOCIAL. We also found earlier that social preferences affect FI significantly only in the first half of BOS-SOCIAL. We conclude that, although FI's performance appears to be somewhat stronger when subjects are relatively experienced, FI can produce significant effects even when the subjects lack in experience.

IV. Conclusion

Previous experimental studies have shown that forward induction has some predictive power in practice. Cooper et al. (1993) test the prediction and find that the true predictive power is less than the apparent level due to a confounding focal point. Since an outside option is offered in the first stage only to one of the players who participate in a battle-of-the-sexes game in the second stage, the subgame equilibrium that favors the same player emerges as a focal point. The goal of this paper was to revisit forward induction in laboratory experiments and shed light on its robustness and test its true and independent predictive power.

To achieve our goal, we have tested the forward induction prediction in a game with a different asymmetry – the outside option is offered to both players but the payoffs to the option are asymmetric – as well as in another game which is completely symmetric. Our results, for the first time, show that forward induction is robust to

[26] Prior experimental studies have established that experience can facilitate coordination. There are several papers which study the effects of experience and learning on coordination in lab experiments, such as Crawford and Haller (1990), Boylan and El-Gamal (1992), Crawford (1995), Ho and Weigelt (1996), Cheung and Friedman (1997), Crawford and Broseta (1998), Camerer and Ho (1999) and Blume and Gneezy (2000).

different asymmetries and it has some significant predictive power even when there isn't any focal point (or any other confounding factor). This paper thus provides evidence showing that forward induction functions as an independent selection criterion.

We found that an asymmetry in the first stage of a game always produces a confounding focal point and the apparent predictive power of forward induction changes when the asymmetry is changed. The true predictive power of forward induction, however, is the same across asymmetries; the difference in the saliency of the focal point causes the variation in the apparent level. We also examined the effect of social preferences on the forward induction prediction. Our results suggest that fairness concerns related to the payoffs to the outside option can affect the prediction; controlling for such preferences produces additional support for forward induction.

References

Blume, A. and U. Gneezy. 2000. "An Experimental Investigation of Optimal Learning in Coordination Games" *Journal of Economic Theory*, 90(1): 161-172.

Bolton, G. E. and A. Ockenfels. 2000. "ERC: A Theory of Equity, Reciprocity, and Competition" *American Economic Review*, 90(1): 166-193.

Boylan, R. T. and M. A. El-Gamal. 1993. "Fictitious Play: A Statistical Study of Multiple Economic Experiments" *Games and Economic Behavior*, 5(2): 205–222.

Brandts, J., A. Cabrales, and G. Charness. 2007. "Forward Induction and Entry Deterrence: An Experiment" *Economic Theory*, 33(1): 183-209.

Brandts, J. and C. A. Holt. 1995. "Limitations of Dominance and Forward Induction: Experimental Evidence" *Economics Letters*, 49(4): 391-395.

Brandts, J. and W. B. MacLeod. 1995. "Equilibrium Selection in Experimental Games with Recommended Play" *Games and Economic Behavior*, 11(1): 36-63.

Cachon, G. P. and C. F. Camerer. 1996. "Loss-Avoidance and Forward Induction in Experimental Coordination Games" *The Quarterly Journal of Economics*, 111(1): 165-194.

Camerer, C. 2003. *Behavioral Game Theory: Experiments in Strategic Interaction*: Princeton University Press Princeton, NJ.

Camerer, C. and T. H. Ho. 1999. "Experience-Weighted Attraction Learning in Games: A Unifying Approach" *Econometrica*, 67(4): 827–74.

Cheung, Y. W. and D. Friedman. 1997. "Individual Learning in Normal Form Games: Some Laboratory Results" *Games and Economic Behavior*, 19(1): 46-76.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross. 1989. "Communication in the Battle of the Sexes Game: Some Experimental Results" *The RAND Journal of Economics*, 20(4): 568-587.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross. 1990. "Selection Criteria in Coordination Games: Some Experimental Results" *The American Economic Review*, 80(1): 218-233.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross. 1992a. "Forward Induction in Coordination Games" *Economics Letters*, 40(2): 167-172.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross. 1992b. "Communication in Coordination Games" *The Quarterly Journal of Economics*, 107(2): 739-771.

Cooper, R., D. V. DeJong, R. Forsythe, and T. W. Ross. 1993. "Forward Induction in the Battle-of-the-Sexes Games" *The American Economic Review*, 83(5): 1303-1316.

Crawford, V. and B. Broseta. 1998. "What Price Coordination? The Efficiency-Enhancing Effect of Auctioning the Right to Play" *American Economic Review*, 88(1): 198-225.

Crawford, V. P. 1995. "Adaptive Dynamics in Coordination Games" *Econometrica*, 63(1): 103-143.

Crawford, V. P., U. Gneezy, and Y. Rottenstreich. 2008. "The Power of Focal Points is Limited: Even Minute Payoff Asymmetry may Yield Large Coordination Failures" *American Economic Review*, 98(4): 1443-1458.

Crawford, V. P. and H. Haller. 1990. "Learning how to Cooperate: Optimal Play in Repeated Coordination Games" *Econometrica*, 58(3): 571-595.

Dufwenberg, M. and G. Kirchsteiger. 2004. "A Theory of Sequential Reciprocity" *Games and Economic Behavior*, 47(2): 268-298.

Fehr, E. and K. M. Schmidt. 1999. "A Theory of Fairness, Competition, and Cooperation*" *Quarterly Journal of Economics*, 114(3): 817-868.

Fischbacher, U. 2007. "Z-Tree: Zurich Toolbox for Ready-made Economic Experiments" *Experimental Economics*, 10(2): 171-178.

Ho, T. H. and K. Weigelt. 1996. "Task Complexity, Equilibrium Selection, and Learning: An Experimental Study" *Management Science*, 42(5): 659-679.

Knez, M. J. and C. F. Camerer. 1995. "Outside Options and Social Comparison in Three-Player Ultimatum Game Experiments" *Games and Economic Behavior*, 10(1): 65-94.

Kohlberg, E. and J. F. Mertens. 1986. "On the Strategic Stability of Equilibria" *Econometrica*, 54(5): 1003-1037.

List, J. A. and T. L. Cherry. 2000. "Learning to Accept in Ultimatum Games: Evidence from an Experimental Design that Generates Low Offers" *Experimental Economics*, 3(1): 11-29.

Mehta, J., C. Starmer, and R. Sugden. 1994. "The Nature of Salience: An Experimental Investigation of Pure Coordination Games" *The American Economic Review*, 84(3): 658-673.

Roth, A. E., V. Prasnikar, M. Okuno-Fujiwara, and S. Zamir. 1991. "Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study" *The American Economic Review*, 81(5): 1068-1095.

Slonim, R. and A. E. Roth. 1998. "Learning in High Stakes Ultimatum Games: An Experiment in the Slovak Republic" *Econometrica*, 66(3): 569-596.

Straub, P. G. 1995. "Risk Dominance and Coordination Failures in Static Games" *Quarterly Review of Economics and Finance*, 35(4): 339-364.

Van Damme, E. 1989. "Stable Equilibria and Forward Induction" *Journal of Economic Theory*, 48(2): 476-496.

Van Huyck, J., R. Battalio, and R. Beil. 1993. "Asset Markets as an Equilibrium Selection Mechanism: Coordination Failure, Game Form Auctions, and Tacit Communication" *Games and Economic Behavior*, 5(3): 485-504.

Van Huyck, J. B., R. C. Battalio, and R. O. Beil. 1990. "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure" *The American Economic Review*, 80(1): 234-248.

Van Huyck, J. B., R. C. Battalio, and R. O. Beil. 1991. "Strategic Uncertainty, Equilibrium Selection, and Coordination Failure in Average Opinion Games" *The Quarterly Journal of Economics*, 106(3): 885-910.

Van Huyck, J. B., A. B. Gillette, and R. C. Battalio. 1992. "Credible Assignments in Coordination Games" *Games and Economic Behavior*, 4(4): 606-626.

Yavas, A. 2002. "Endogenous Outside Options in Coordination Games: Experimental Evidence" *Journal of Economic Behavior and Organization*, 47(2): 221-236.

Figure 1: BOS.

		Column 1	Column 2
Row	1	0, 0	200, 600
	2	600, 200	0, 0

Figure 2: BOS-300.

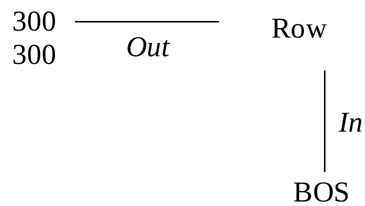


Figure 3: BOS-100.

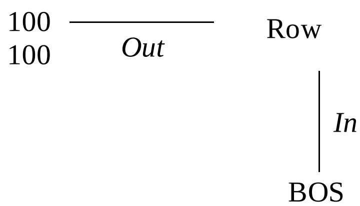


Figure 4: BOS-BOTH-FI.

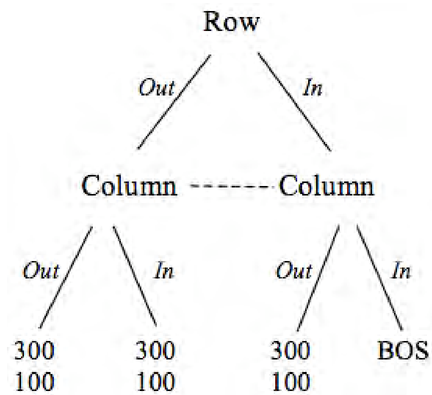


Figure 5: BOS-BOTH.

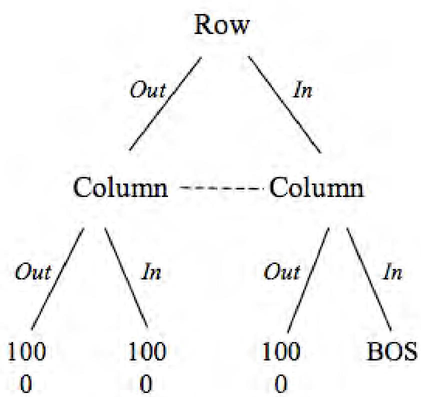


Figure 6: BOS-BOTH-SYM.

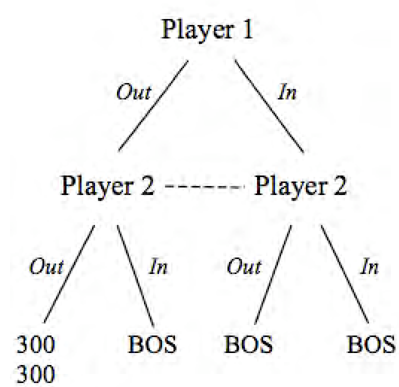
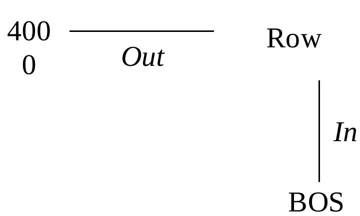


Figure 7: BOS-SOCIAL.



Instructions

(Not for publication.)

(The instructions used in BOS, BOS-300, BOS-BOTH-FI and BOS-BOTH-SYM are given below. The sections titled "General", "Phase-II" and "Phase-II Recording Rules" are the same in all the treatments; the treatments differ only in the "Phase-I" section. "Phase-I" for BOS and BOS-300 are given together. Then we give "Phase-I" for BOS-BOTH-FI and BOS-BOTH-SYM, one after another. Note that the instructions for BOS-100 and BOS-SOCIAL are very similar to those for BOS-300, and the instructions for BOS-BOTH are very similar to those for BOS-BOTH-FI.)

General

You are about to participate in an experiment in the economics of decision making. If you follow these instructions carefully and make good decisions, you might earn a considerable amount of money which will be paid to you in cash at the end of the experiment.

The experiment will consist of a series of separate decision making periods. Each period consists of two phases. In Phase-I you will be paired with another person and, based upon your combined actions, you will be able to earn points. In Phase-II, you will have the opportunity to earn dollars based upon the points you earn in Phase-I. We begin by describing Phase-II so that you understand how the points you earn affect the number of dollars you earn. Then, we describe Phase-I in detail so that you understand how to earn points.

Phase-II

At the end of Phase-I, you will have earned points according to the rules we will discuss below. The number of dollars you earn in Phase-II will depend partly on the number of points you earned in Phase-I and partly on chance. Specifically, the computer will randomly draw a number between 0 to 1000 where each of these numbers is equally likely. If this number is LESS THAN OR EQUAL TO the number of points you earned in Phase-I, you WIN $3.00. If the number drawn by the computer is GREATER THAN the number points you earned in Phase-I, you WIN $0.00. For example, if you have 600 points, you have a 60% chance of winning $3.00. Notice that the more points you have, the larger will be your chance of winning the $3.00 prize.

Phase-I

(BOS and BOS-300; the additional texts for BOS-300 are given in italics.)

In each decision making period, you will be paired with another person. One of you will be designated the Row player and the other will be designated the Column player. At the beginning of the period, *the Row player must select one of the two options.*

If option 1 is selected by the Row player, each player will receive 300 points and the decision making period will end. If option 2 is selected both the Row player and the Column player will be asked to separately and independently select an action. You will only have two actions to choose from. If you are the Column player, you may choose either C1 or C2. If you are the Row player, you may choose either R1 or R2. The combined actions of the Row player and the Column player jointly determine the number of points earned by the Row player and the number of points earned by the Column player.

Since there is not an even number of people participating in this experiment, you will occasionally be required to not participate during a particular period. At the beginning of each period you will be told via your terminal whether you are a Row or Column player or sitting out this period. In your folder you will find a record sheet. On this sheet you will indicate, based on the message previously received on your terminal, whether you are a Row or Column player or sitting out this period.

In today's experiments, you will play against each person twice – once as the Row player and once as the Column player. However, you will not know the identification of the person you are playing against in any period. Similarly, nobody in your decision making pair will know your identification in any period. Further, you will not be told who these people are either during or after the experiment. The points that you earn in each period will be determined by the rules given below.

Specific Instructions to Row Player:

In those periods in which you are the Row player, *you must first choose one of the two options. You will receive a message on your terminal stating:*

" WHAT OPTION DO YOU CHOOSE ? "

If you select option 1 and enter your choice into the computer via your terminal (by pressing the appropriate button on the computer screen), the decision making period ends and you and the Column player will each earn 300 points. You will receive a message stating:

" YOU CHOSE OPTION 1, YOUR PERIOD POINTS ARE <u>300</u> . "

If you select option 2 (by pressing the appropriate button on the computer screen), then you and the Column player must separately and independently decide on actions which will jointly determine the number of points earned by you and the number of points earned by the Column player. *You will receive a message on your screen stating:*

" YOU CHOSE OPTION 2, WHAT ACTION DO YOU SELECT ? "

As the Row player, you may either choose action R1 or action R2 (by pressing the appropriate button on the computer screen). Similarly, the Column player may choose action C1 or action C2. The number of points earned by you is given by the following table for each pair of actions you and the Column player might select:

The Row Player's Points:

Column's Action

		C1	C2
Row's	R1	0	200
Action	R2	600	0

To read this table, suppose that you chose action R2 and the Column player chose action C1. You would then earn 600 points. Similarly, suppose that you chose action R1 and the Column player chose action C2. You would then earn 200 points. In a like manner, you can use this table to determine the number of points you would earn for all other pairs of actions you and the Column player may select. Column players also earn points depending upon the type of action they select. These are given in the next section of the instructions.

When you select an action, enter the action chosen into the computer via your terminal (by pressing the appropriate button) and record the action chosen on your record sheet. Once both you and the Column player have selected your actions and entered them into the computer via your terminals, the computer will determine the number of points earned by you based on the table given above. The result is then sent to you via your terminal. The message will look like the one below:

" YOUR PERIOD POINTS ARE _______ "

At the end of the period, you are to record your point earnings for Phase-I on your record sheet. Make sure you check your earnings in points against the computer's calculations. The computer will also inform you about the action taken by the Column player. Make sure you record this information on your record sheet.

Specific Instructions to Column Player:

In those periods in which you are the Column player, *you will first wait for the Row player to choose an option. If the Row player selects option 1, the decision making period ends and you will be informed of the number of points earned by you and the number of points earned by the Row player. You will receive a message on your screen stating:*

" ROW PLAYER CHOSE OPTION 1, YOUR PERIOD POINTS ARE 300 "

If the Row player selects option 2 then you and the Row player must separately and independently decide on actions which will jointly determine the number of points earned by you and the number of points earned by the Row player. *You will receive a message on your screen stating:*

" ROW PLAYER CHOSE OPTION 2, WHAT ACTION DO YOU CHOOSE ? "

As the Column player, you may either choose action C1 or action C2 (by pressing the appropriate button on the computer screen). The number of points earned by you is given by the following table for each pair of actions you and the Row player might select:

<u>The Column Player's Points</u>:

Column's Action

		C1	C2
Row's	R1	0	600
Action	R2	200	0

To read this table, suppose that you chose action C2 and the Row player chose action R1. You would then earn 600 points. Similarly, suppose that you chose action C1 and the Row player chose action R2. You would then earn 200 points. In a like manner, you can use this table to determine the number of points you would earn for all other pairs of actions you and the Row player may select.

When you select an action, enter the action chosen into the computer via your terminal (by pressing the appropriate button) and record the action chosen on your record sheet. Once both you and the Row player have selected your actions and entered them into the computer via your terminals, the computer will determine the number of points earned by you based on the table given above. The result is then sent to you via your terminal. The message will look like the one below:

" YOUR PERIOD POINTS ARE _______ "

At the end of the period, you are to record your point earnings for Phase-I on your record sheet. Make sure you check your earnings in points against the computer's calculations. The computer will also inform you about the action taken by the Row player. Make sure you record this information on your record sheet.

<u>Phase-I</u> (BOS-BOTH-FI)

In each decision making period, you will be paired with another person. One of you will be designated the Row player and the other will be designated the Column player. At the beginning of the period, both the Row player and the Column player must separately and independently select an option. You will only have two options to choose from: option 1 and option 2. If either you or the other player or both select option 1, the decision making period will end and you will receive some points. Only when both you and the other player choose option 2, both of you will again be asked to separately and independently select an action. You will only have two actions to choose from. If you are the Column player, you may choose either C1 or C2. If you are the Row player, you may choose either R1 or R2. The decision making period ends after both the players have chosen their actions. The combined actions of the Row player and the Column player jointly determine the number of points earned by the Row player and the number of points earned by the Column player. The numbers of points earned by the players are given in the following sections of the instructions.

Since there is not an even number of people participating in this experiment, you will occasionally be required to not participate during a particular period. At the beginning of each period you will be told via your terminal whether you are a Row or Column player or sitting out this period. In your folder you will find a record sheet. On this sheet you will indicate, based on the message previously received on your terminal, whether you are a Row or Column player or sitting out this period.

In today's experiments, you will play against each person twice – once as the Row player and once as the Column player. However, you will not know the identification of the person you are playing against in any period. Similarly, nobody in your decision making pair will know your identification in any period. Further, you will not be told who these people are either during or after the experiment. The points that you earn in each period will be determined by the rules given below.

Specific Instructions to Row Player:

In those periods in which you are the Row player, you and the Column player must first separately and independently choose one of the two options. You will receive a message on your terminal stating:

" WHAT OPTION DO YOU CHOOSE ? "

If you select option 1 and enter your choice into the computer via your terminal (by pressing the appropriate button on the computer screen), the decision making period ends for both you and the Column player. In this situation, regardless of what the Column player chose, you will earn 300 points and the Column player will earn 100 points. You will receive a message stating:

" YOU CHOSE OPTION 1, YOUR PERIOD POINTS ARE <u>300</u> . "

If you select option 2 (by pressing the appropriate button on the computer screen), your points will depend on the option chosen by the Column player. If the Column player chose option 1, the decision making period ends for both you and the Column player, and you will receive 300 points and the Column player will receive 100 points. But if the Column player chose option 2 as well, then you and the Column player must separately and independently decide on actions which will jointly determine the number of points earned by you and the number of points earned by the Column player. You will receive a message on your screen stating:

“ BOTH YOU AND THE COLUMN PLAYER CHOSE OPTION 2, WHAT ACTION DO YOU SELECT ? ”

As the Row player, you may either choose action R1 or action R2 (by pressing the appropriate button on the computer screen). Similarly, the Column player may choose action C1 or action C2. The number of points earned by you is given by the following table for each pair of actions you and the Column player might select:

The Row Player’s Points:

Column’s Action

		C1	C2
Row’s	R1	0	200
Action	R2	600	0

To read this table, suppose that you chose action R2 and the Column player chose action C1. You would then earn 600 points. Similarly, suppose that you chose action R1 and the Column player chose action C2. You would then earn 200 points. In a like manner, you can use this table to determine the number of points you would earn for all other pairs of actions you and the Column player may select. Column players also earn points depending upon the type of action they select. These are given in the next section of the instructions.

When you select an action, enter the action chosen into the computer via your terminal (by pressing the appropriate button) and record the action chosen on your record sheet. Once both you and the Column player have selected your actions and entered them into the computer via your terminals, the computer will determine the number of points earned by you based on the table given above. The result is then sent to you via your terminal. The message will look like the one below:

“ YOUR PERIOD POINTS ARE _______ ”

At the end of the period, you are to record your point earnings for Phase-I on your record sheet. Make sure you check your earnings in points against the computer’s calculations. The computer will also inform you about the action taken by the Column player. Make sure you record this information on your record sheet.

Specific Instructions to Column Player:

In those periods in which you are the Column player, you and the Row player must first separately and independently choose one of the two options. You will receive a message on your terminal stating:

" WHAT OPTION DO YOU CHOOSE ? "

If you select option 1 and enter your choice into the computer via your terminal (by pressing the appropriate button on the computer screen), the decision making period ends for both you and the Row player. In this situation, regardless of what the Row player chose, you will earn 100 points and the Row player will earn 300 points. You will receive a message stating:

" YOU CHOSE OPTION 1, YOUR PERIOD POINTS ARE 100 . "

If you select option 2 (by pressing the appropriate button on the computer screen), your points will depend on the option chosen by the Row player. If the Row player chose option 1, as you already know from the previous section, the decision making period ends for both you and the Column player, and you will receive 100 points and the Row player will receive 300 points. But if the Row player chose option 2 as well, then you and the Row player must separately and independently decide on actions which will jointly determine the number of points earned by you and the number of points earned by the Row player. You will receive a message on your screen stating:

"BOTH YOU AND THE ROW PLAYER CHOSE OPTION 2, WHAT ACTION DO YOU SELECT ? "

As the Column player, you may either choose action C1 or action C2 (by pressing the appropriate button on the computer screen). Similarly, the Row player may choose action R1 or action R2. The number of points earned by you is given by the following table for each pair of actions you and the Row player might select:

The Column Player's Points:

Column's Action

		C1	C2
Row's	R1	0	600
Action	R2	200	0

To read this table, suppose that you chose action C2 and the Row player chose action R1. You would then earn 600 points. Similarly, suppose that you chose action C1 and the Row player chose action R2. You would then earn 200 points. In a like manner, you can use this table to determine the number of points you would earn for all other pairs of actions you and the Row player may select.

When you select an action, enter the action chosen into the computer via your terminal (by pressing the appropriate button) and record the action chosen on your record sheet. Once both you and the Row player have selected your actions and entered them into the computer via your terminals, the computer will determine the number of points earned by you based on the table given above. The result is then sent to you via your terminal. The message will look like the one below:

" YOUR PERIOD POINTS ARE _______ "

At the end of the period, you are to record your point earnings for Phase-I on your record sheet. Make sure you check your earnings in points against the computer's calculations. The computer will also inform you about the action taken by the Row player. Make sure you record this information on your record sheet.

Phase-I (BOS-BOTH-SYM)

In each decision making period, each person will be randomly paired with another person. Since there is not an even number of people participating in this experiment, you will occasionally be required to not participate during a particular period. At the beginning of each period you will be told via your computer terminal if you are sitting out this period. In your folder you will find a record sheet. On this sheet you will indicate, based on the message previously received on your terminal, whether you are playing or sitting out this period.

At the beginning of the period, both you and the other player you are paired with must separately and independently select an option by pressing a button on the computer screen. You will only have two options to choose from: option 1 and option 2. You will receive a message on your terminal stating:

" WHAT OPTION DO YOU CHOOSE ? "

If both you and the other player select option 1, the decision making period will end. Both you and the other player will receive 300 points. You will receive a message stating:

"BOTH YOU AND THE OTHER PLAYER CHOSE OPTION 1. THE CURRENT PERIOD ENDS. YOUR PERIOD POINTS ARE 300 . "

But if you or the other player or both select option 2, first you will be notified of the choice the other player actually made and then both of you will again be asked to separately and independently select an action. You will receive one of the following two messages:

"THE OTHER PLAYER CHOSE OPTION 1, WHAT ACTION DO YOU SELECT ? "
or,
"THE OTHER PLAYER CHOSE OPTION 2, WHAT ACTION DO YOU SELECT ? "

You will only have two actions to choose from: action 1 and action 2. The decision making period ends after you and the other player have chosen an action by pressing a button on the computer screen. The combined actions of the two players in a pair will jointly determine the number of points earned by the players in that pair. The number of points earned by you is given by the following table for each pair of actions you and the other player might select.

Your Points:

		Your Action 1	Your Action 2
The Other Player's Action	1	0	600
	2	200	0

To read this table, suppose that you chose action 2 and the other player chose action 1. You would then earn 600 points. Similarly, suppose that you chose action 1 and the other player chose action 2. You would then earn 200 points. In a like manner, you can use this table to determine the number of points you would earn for all other pairs of actions you and the other player may select. The table below shows the number of points earned by the other player for each pair of actions you and the other player might select. You can read this table the same way we read the above table.

The Other Player's Points:

		Your Action 1	Your Action 2
The Other Player's Action	1	0	200
	2	600	0

The computer will determine the number of points earned by you based on the tables given above. The result is then sent to you via your terminal. The message will look like the one below:

" YOUR PERIOD POINTS ARE _______ "

At the end of the period, you are to record your point earnings for Phase-I on your record sheet. Make sure you check your earnings in points against the computer's calculations. The computer will also inform you about the action taken by the other player. Make sure you record this information on your record sheet.

Phase-II Recording Rules

To help you with the record keeping, at the end of each period, the computer will summarize choices made, your point earnings, the random number drawn by the computer and your dollar earnings.

After recording the choices made and your Phase-I points for a given decision making period, you are to record the dollars you earn in Phase-II. First, record the random number drawn by the computer. If the number drawn is LESS THAN OR EQUAL TO the number of points you earned in Phase-I, circle $3.00 in the next column; otherwise circle $0.00 in that column. Make sure you check your earnings in dollars against the computer's calculations.

At the end of the experiment, add up your total earnings in dollars and record this amount in your record sheet. You will be paid in cash these earnings in addition to your show-up fee.

In summary, your earnings in the experiment will be the total of the amounts you win in all Phase-II lotteries. The amount of money you earn will depend partly upon luck and partly upon whether you have made good decisions in Phase-I. Notice that the more points you earn in Phase-I, the more likely you will win Phase-II. Are there any questions?