Research Report

EFFECTS OF FINANCIAL INCENTIVES ON THE BREAKDOWN OF MUTUAL TRUST

James E. Parco,[1] Amnon Rapoport,[1] and William E. Stein[2]

[1]*Department of Management and Policy, Eller College of Business and Public Administration, University of Arizona, and* [2]*Department of Information and Operations Management, Mays College of Business, Texas A & M University*

Abstract—*Disagreements between psychologists and economists about the need for and size of financial incentives continue to be hotly discussed. We examine the effects of financial incentives in a class of interactive decision-making situations, called centipede games, in which mutual trust is essential for cooperation. Invoking backward induction, the Nash equilibrium solution for these games is counterintuitive. Our previous research showed that when the number of players in the centipede game is increased from two to three, the game is iterated in time, the players are rematched, and the stakes are unusually high, behavior approaches equilibrium play. Results from the present study show that reducing the size of the stakes elicits dramatically different patterns of behavior. We argue that when mutual trust is involved, the magnitude of financial incentives can induce a considerable difference.*

Psychologists and economists agree that a wide range of incentives can affect human decision behavior in the laboratory. However, they often disagree on the methodological and operational aspects involved in modeling and studying these incentives (Zwick, Erev, & Budescu, 1999). Economists almost always use financial incentives. In contrast, most psychologists who study judgment and decision making (JDM) use only hypothetical payments. A recent investigation of a 10-year sample of empirical studies published in the *Journal of Behavioral Decision Making* showed that only 48 of the 186 studies (26%) employed financial incentives. As Hertwig and Ortmann (2001) pointed out, this percentage very likely overestimates the use of financial incentives (strictly defined as performance-based monetary payments) in psychological research.

The discussion of the methodological differences in the way psychologists and economists design and conduct their experiments often focuses on the presence or absence of financial incentives (e.g., Camerer, 1997; Hertwig & Ortmann, 2001; Zwick et al., 1999). Important as this issue is, there is evidence that in assessing the validity of JDM experimental research and the potential applications of its findings, it is the magnitude of financial incentives, rather than their presence, that mostly matters (Camerer & Hogarth, 1999; Gneezy & Rustichini, 2000). Even when they are contingent on performance, low payments may not be sufficient to overcome the effects of habits, traditions, social norms, moral values, and various emotions that, although recognized as important, are presently excluded from most of the theories of individual and interactive decision making. Budget considerations typically impose a severe constraint on subjects' payments. In the United States, most JDM experiments that pay their participants limit individual payment to between \$10 and \$25 per 2-hr session. It is quite possible that for many experiments these financial incentives are sufficiently strong to overcome (at least in part) intrinsic, social, and other nonmonetary motivations. Nevertheless, for generalizing the laboratory results to real-life situations, it is important to break away from the customary budget constraints. The major purpose of the present study was to test the hypothesis that the magnitude of financial incentives in a class of interactive situations involving mutual trust matters.

The most important solution concept for interactive decision making in noncooperative games is the Nash equilibrium—an n-tuple of strategies with the property that none of the n players can benefit by unilateral deviation. Put differently, under equilibrium play, each strategy is a best response to the strategies of the remaining $n - 1$ players. Nash (1950, 1951) proved that every noncooperative n-person game with a finite strategy space has at least one equilibrium in either pure or mixed strategies.[1] Experimental studies designed to assess the descriptive power of the Nash equilibrium have been conducted in the past 30 years or so with mixed results.

The most well known example of the failure of the Nash equilibrium to account for interactive decision behavior is the two-person finitely iterated Prisoner's Dilemma (PD) game. When the number of rounds of play is common knowledge, backward induction—which is the procedure used to derive the equilibrium solution for the game—prompts defection of each player in each round, resulting in a unique equilibrium of defection of both players in the first round (e.g., Luce & Raiffa, 1957). There are now hundreds of experiments, with and without financial incentives, that have soundly rejected this prediction. A second, less known, but possibly more damaging example of the paradox of backward induction is the two-person centipede game, which is the focus of the present study. This game was first introduced by Rosenthal (1981) and subsequently studied theoretically by Aumann (1992, 1995, 1998), Binmore (1996), Ponti (2000), Reny (1992), Stalnaker (1998), and many other investigators. Aumann (1992) referred to the game as one of the "disturbing counterintuitive examples of rational interactive decision-making" (p. 219).

The process of backward induction in a two-player centipede game is straightforward. Consider the example in Figure 1. At each decision node, a player must decide whether to "stop" (move down) or "continue" (move right). If a player chooses to stop, the game terminates and the players receive the payoffs identified at the corresponding terminal node. Otherwise, the game progresses to the next decision node. At the final decision node of the game tree, the decision to stop dominates the decision to continue[2] (assuming that \$1,000,000 is preferred to \$0). At the next-to-last decision node, assuming that Player 2 will play rationally on his final move, Player 1 should stop, because, by the same logic, the decision to stop dominates a continue decision, and so forth. With the same reasoning applying to all moves, the decision to

Address correspondence to James E. Parco, 405 McClelland Hall, Department of Management and Policy, Eller College of Business and Public Administration, The University of Arizona, Tucson, AZ 85721; e-mail: parco@u.arizona.edu.

1. A mixed strategy is a probability distribution defined over the set of pure strategies.

2. A decision to continue at the final decision node also results in the termination of the game.

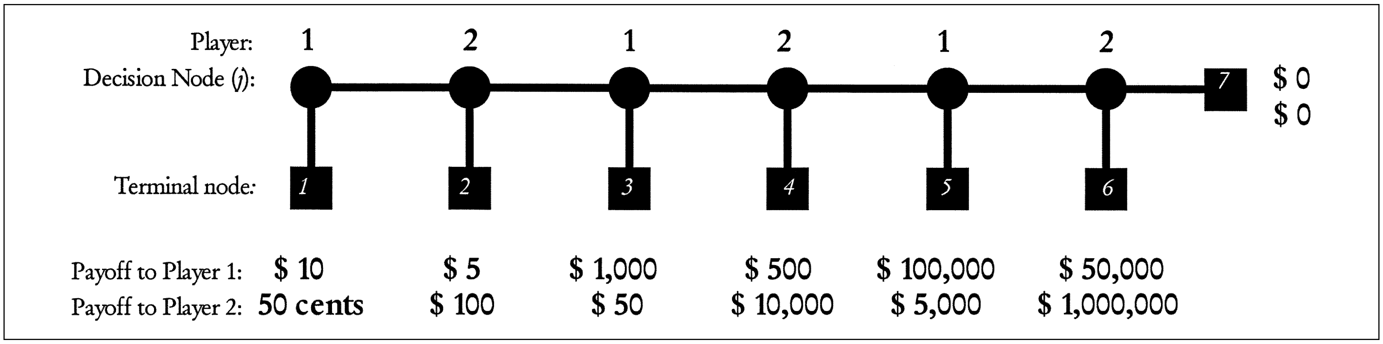

Fig. 1. A two-person, six-move centipede game (Aumann, 1992).

stop at the first decision node is the unique Nash equilibrium of the game. Note that the game can be extended to any finite number of moves, with the payoffs becoming astronomical, without changing the solution. Note, too, that if Player 2 finds himself at the second decision node, he learns that Player 1 did not make her inductive choice to stop at the first decision node. Therefore, he may consider it possible or even likely that she will not make her inductive choice during her next opportunity either. (See Reny, 1992, for further discussion of rationality in the centipede game.) Rationality permits the players to draw conclusions from past play and form estimates about future play in any way they want. One requires the considerably stronger assumption of *common knowledge of rationality* to derive the implication that the players should stop at each decision node (e.g., Aumann, 1995).

The backward-induction argument is not restricted to two players, nor is the centipede game limited to only two players. In a previous study (Rapoport, Stein, Parco, & Nicholas, 2000; hereafter RSPN), we extended the centipede game by adding a third player and experimentally implemented it for very high stakes (see Fig. 2). We compare the results of the present study to those of RSPN to assess the effects of the magnitude of the financial incentives on behavior. This comparison is straightforward, as the two studies were identical in terms of the population of participants and all the other details of the experimental design. The only exception was the size of the payoffs (compare Figs. 2 and 3). Our major finding is that decreasing the stakes produces dramatically different results.

METHOD

Participants

Thirty undergraduate students from the University of Arizona volunteered to participate in a decision-making experiment for monetary payoff contingent on performance. Fifteen participants, both males and females, took part in each of two separate sessions. Each session lasted approximately 75 min.

Procedure

Two separate experimental sessions using different participants were conducted on separate days at the Economic Science Laboratory at the University of Arizona. At the beginning of each session, the 15 participants were seated at separate cubicles apart from one another, each containing a networked computer and set of written instructions, and proceeded to read the instructions at their own pace. (A complete set of instructions can be found at http://www.eller.arizona.edu/~map/research.) Any form of verbal communication was strictly forbidden.

Each session consisted of 60 trials. On each trial, the participants were randomly divided into five 3-person groups, and within each group randomly assigned to the roles of Players 1, 2, and 3. At the start of each trial, all the participants were individually informed of the trial number and assignment of roles. If a participant assumed the Player 1 role, the branches on the game tree displayed on his or her monitor were enabled, allowing the participant to make a decision. Simultaneously, Players 2 and 3 of the same group viewed an identical screen without the ability to make a decision. Decisions were made by clicking on either the "stop" (down) branch or the "continue" (right) branch emanating from the current decision node on the game tree. When selected, the branch turned color, and a "commit" button appeared on the screen, requiring the participant to confirm his or her decision. Once the decision was confirmed, the game trees on the monitors of the other two group members were updated, identifying the selected branch by changing its color. If the decision resulted in continuation of the game, the next player in the sequence (1, 2, 3, 1, 2, . . .) was enabled to make his or her choice in exactly the same manner, while the other two (inactive) players only viewed the updated game tree on their monitor. If the decision resulted in termination of the game, all three group members were immediately informed that the trial was completed. Participants were informed of only the outcomes of the games that they actually played.

The individual payoff was not cumulative. Rather, it was based on the outcomes of three trials that were chosen randomly by the computer prior to the start of the experiment. (Participants were informed of the numbers of these trials only after completing all 60 trials.) Individual payments in Session 1 varied from $0.72 to $27.20, with a median of $3.54. Individual payments in Session 2 varied from $0.13 to $12.97, with a median of $1.52. Because of the low payoffs, each subject received an additional subsidy of $5.00 (in addition to the $5.00 show-up fee).

The experimental design of the present study (see Fig. 3) was identical to that of the RSPN study (see Fig. 2), differing only in the number of sessions (four in the RSPN study vs. two in the present study) and the size of the stakes.[3] The stakes in the present study were smaller than

3. To reduce costs, we informed participants in the RSPN study that they would receive only 50% of their individual earnings in three trials randomly selected before the experiment started.

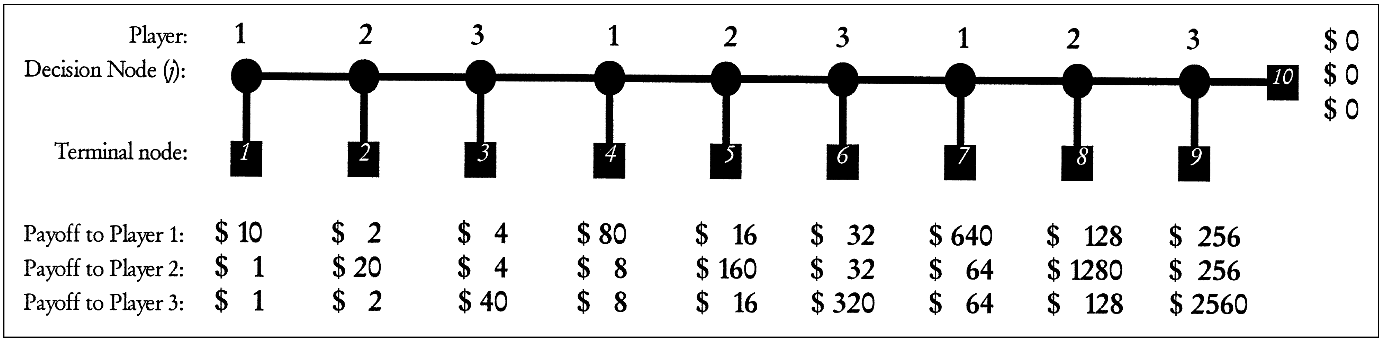

Fig. 2. The three-person, nine-move centipede game used in Rapoport, Stein, Parco, and Nicholas (2000).

those in the RSPN study by a factor of 100. If all three payment trials in the present experiment were to terminate at the final decision node (with Player 3 making a stop decision), the maximum payoff per session would have been $460.80, averaging $30.72 per participant. The corresponding maximum payoff per session in the RSPN experiment would have been $23,040.00, averaging $1,536.00 per participant.

RESULTS

Table 1 (top panel) presents the proportions of games ending at each of the nine terminal nodes. Because of the random assignment of the 15 players to five 3-player groups and the possibility of rematching with 1 or more players, trials are not independent. In this "playing against the field" design, it is the population rather than the individual participant or 3-player group that is the unit of analysis. Therefore, Table 1 presents the results for each session separately, as well as the combined results across the two sessions. Within each session, the results are combined across the five 3-player groups in each trial and the 60 trials, for a total of 300 games. For comparison purposes, the results of the RSPN study are displayed (for each session separately and across sessions) in the lower panel of Table 1.

Several conclusions can be drawn from Table 1:

- All the nine decision nodes in each of the two sessions of the present study were reached at least twice (2/300 = .007).
- In both sessions in the present study, the proportion of stop decisions first increased, reaching a peak at the middle of the second round (fifth decision node), and then decreased.
- The patterns of behavior in the present and previous RSPN studies are entirely different. Whereas only 2.5% of all the games in the present study ended immediately with a stop decision at the first decision node, the corresponding result for the RSPN study (39.2%) is 15 times higher. Whereas only 25.2% of the games in the present study ended in Round 1 (terminal nodes 1, 2, and 3), with one of the three group members stopping at the first opportunity, the corresponding result for the RSPN study is 83.4%. And whereas the proportion of stopping in the present study first increased, from 2.5% to 26.3%, and then decreased, in the RSPN study the proportion of stopping reached its maximum of 39.2% at the first decision node and then decreased steadily.

Table 2 presents the (inferred) conditional probabilities of a stop decision at decision node j, denoted by p_j. The table supports the conclusions already drawn from Table 1, namely, that the patterns of behavior in the present and RSPN studies are very different. In the present study, the values of p_j increase in j. In contrast, the conditional probabilities in the RSPN study are remarkably stable across decision nodes $j = 1$ to $j = 8$. Table 2 shows that this result holds not only for the summary results, but also for each session separately.

The major reason for the difference between the two studies is the dynamics of play: convergence to equilibrium in the RSPN study in contrast to no evidence for learning in the present study. Figure 4 exhibits the arithmetic moving average (in steps of 5) of the conditional probabilities p_j ($j = 1, 2, 3$) for the two sessions of the present study. Within each session, the probabilities are presented separately for the three decision nodes in Round 1, namely, 1, 2, and 3. The figure shows

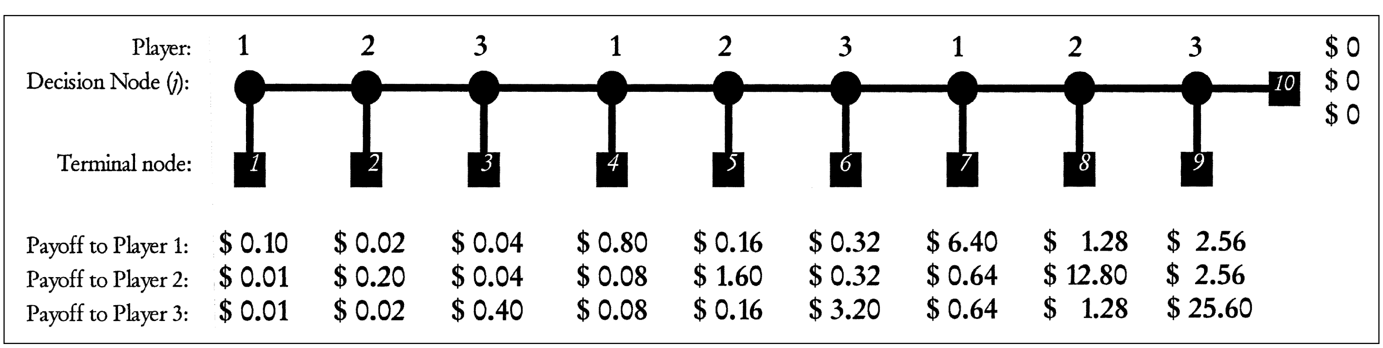

Fig. 3. The three-person, nine-move centipede game used in the present study.

Table 1. *Proportion of games ending at each terminal node*

Session	N[a]	Terminal node 1	2	3	4	5	6	7	8	9
Low-pay 9-move game (present study)										
1	300	.027	.043	.093	.240	.263	.227	.073	.017	.013[b]
2	300	.023	.067	.250	.243	.263	.097	.037	.007	.013
Across sessions	600	.025	.055	.172	.242	.263	.162	.055	.012	.013
High-pay 9-move game (RSPN)[c]										
1	300	.463	.317	.110	.050	.027	.020	.010	.003	.000
2	300	.393	.277	.157	.087	.030	.017	.023	.013	.003
3	300	.303	.280	.187	.093	.053	.037	.010	.003	.033
4	300	.407	.257	.183	.077	.037	.017	.013	.003	.007
Across sessions	1,200	.392	.283	.159	.077	.037	.023	.014	.006	.010

[a]Number of games (five groups of 3 randomly matched players per trial participating in 60 trials).
[b]A single Player 3 continued at the 9th decision node.
[c]RSPN = Rapoport, Stein, Parco, and Nicholas (2000).

very little evidence for learning across the 60 trials. Across both sessions and a relatively large number of trials, there is very little movement, if any at all, in the direction of equilibrium play.

Figure 5 portrays the corresponding results for the high-pay centipede experiment of RSPN. It, too, depicts the arithmetic moving averages separately for each of the sessions of the study. In contrast to Figure 4, Figure 5 shows a tendency for the three conditional probabilities p_1, p_2, and p_3 to increase sharply across trials. The patterns vary somewhat between sessions, indicating different population dynamics. The probability of stopping on the first decision node, p_1, increases steadily in Sessions 1 and 4. In Session 2, it reaches a plateau after 20 trials or so and then starts increasing again after Trial 40. In Session 3, the values of p_1 are rather flat for the first 45 trials or so, and only then start increasing. The trends in the values of p_2 and p_3, although in general increasing over time, are not as easily discernible. Except in Session 3, the mean values of p_1, p_2, and p_3 on the last 10 trials are all above .75. Indeed, during the last 10 trials of Sessions 1, 2, and 4, the game never progressed beyond the first round of play.

CONCLUSIONS

The direct comparison of the present low-pay centipede game with the high-pay centipede game of RSPN exhibits strong evidence, perhaps the strongest documented in the literature, that the magnitude of financial incentives makes a significant and substantial difference. Not only do financial incentives matter, but when they are sufficiently high

Table 2. *Inferred conditional probability of stopping on decision node* j

Session	N[a]	Decision node 1	2	3	4	5	6	7	8	9
Low-pay 9-move game (present study)										
1	300	.03	.04	.10	.29	.44	.69	.71	.56[b]	1.00[b]
2	300	.02	.07	.28	.37	.63	.63	.65	.33[b]	1.00[b]
Across sessions	600	.02	.06	.19	.33	.54	.66	.68	.44	1.00[b]
High-pay 9-move game (RSPN)[c]										
1	300	.46	.59	.50	.46	.44	.60	.75[b]	1.00	—[d]
2	300	.39	.46	.47	.50	.35	.29	.58	.80[b]	1.00[b]
3	300	.30	.40	.45	.41	.39	.44	.21	.09	1.00[b]
4	300	.41	.43	.55	.50	.48	.42	.57[b]	.33[b]	1.00[b]
Across sessions	1,200	.39	.47	.49	.46	.42	.44	.52	.56	1.00

[a]Number of games (five groups of 3 randomly matched players per trial participating in 60 trials).
[b]Based on fewer than 10 observations.
[c]RSPN = Rapoport, Stein, Parco, and Nicholas (2000).
[d]Undefined.

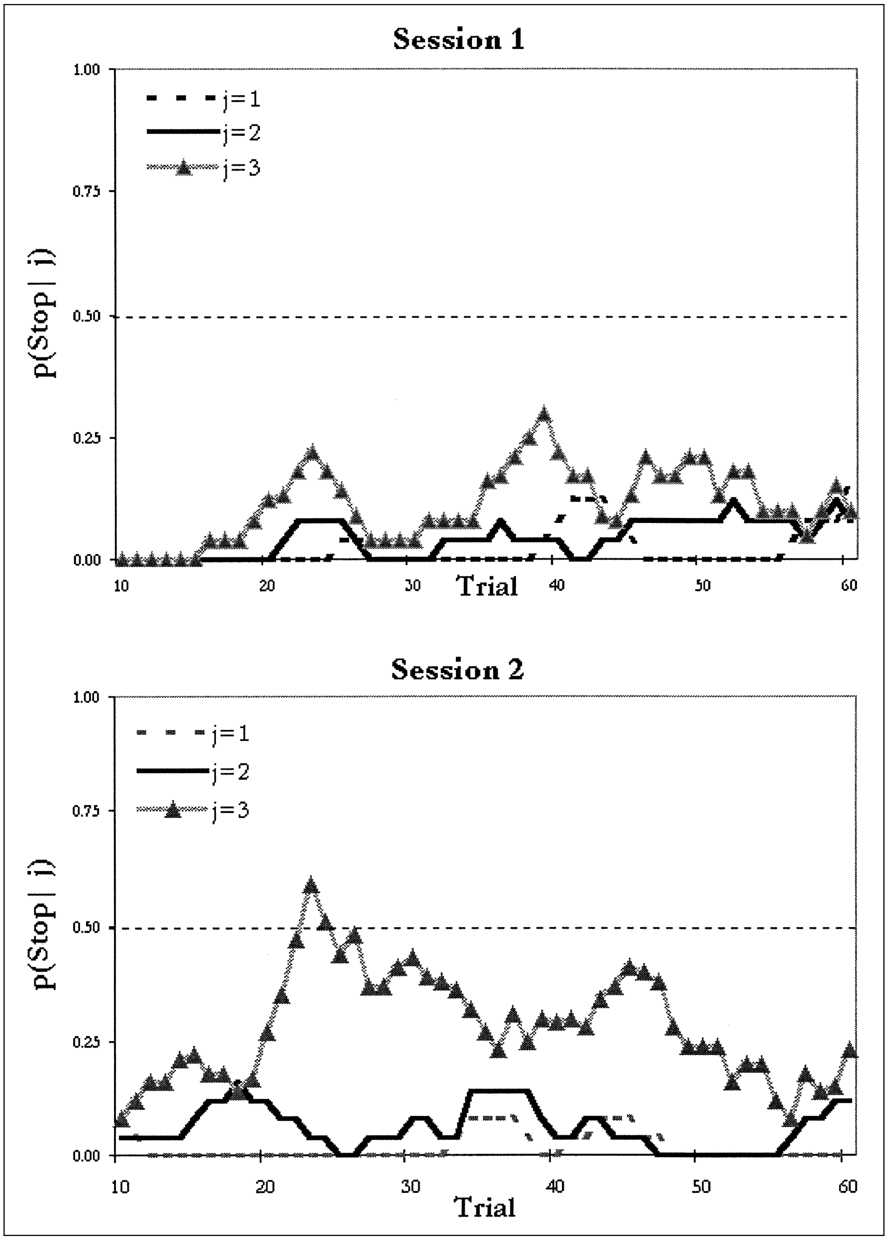

Fig. 4. Conditional probability of stopping at decision node *j* in the low-pay centipede game (present study).

they support Hertwig and Ortmann's (2001) conclusion that when learning is possible, monetary payments may bring the decisions closer to the predictions of the normative models. The generality of this finding beyond interactions that involve the dissolution of mutual trust is a topic for further research.

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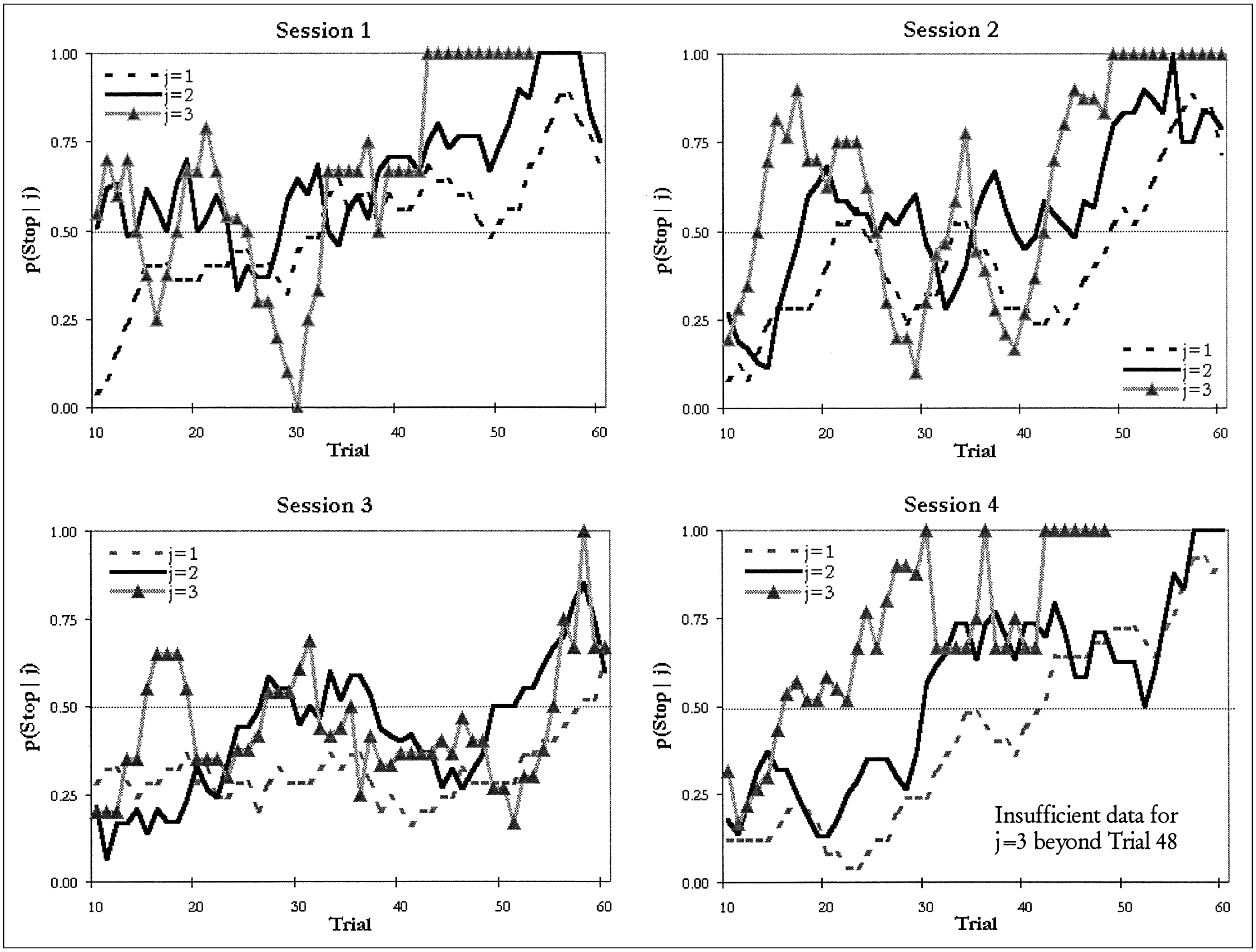

Fig. 5. Conditional probability of stopping at decision node *j* in the high-pay centipede game (Rapoport, Stein, Parco, & Nicholas, 2000).

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