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Can tournaments induce rational play in the centipede game? Exploring dominance vs. strategic uncertainty

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Abstract

We compare behavior in a one-shot Centipede game across several payoff structures including nonlinear payoff tournaments. Assuming Nash to be optimal, results suggest nonlinear tournament payoffs based on overall relative rewards are not sufficient to increase Nash results in the one-shot Centipede style setting. Evidence suggests that reducing strategic uncertainty is more important than increasing dominance in promoting Nash play.

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1. Introduction

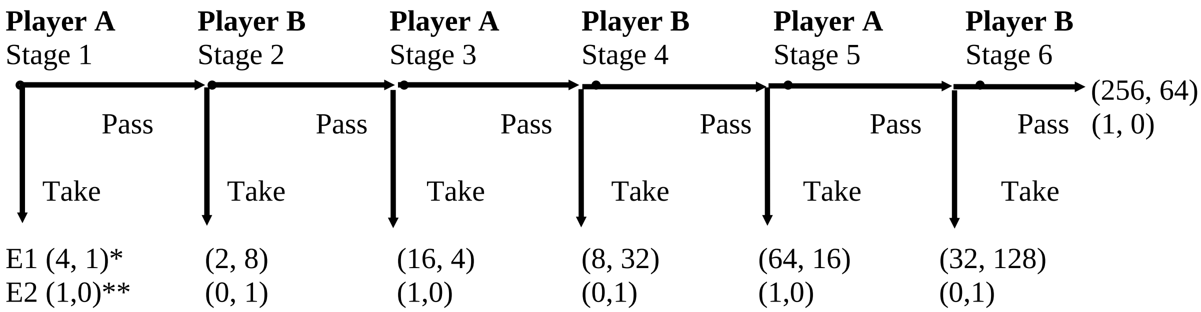
Recent work has shown that institutions which spotlight the opportunity costs of irrationality can overcome seemingly anomalous behavior (e.g., Cherry et al. 2003, Cox and Grether 1997). In the wilds, one classic institution is the tournament (e.g., Ehrenberg and Bognanno 1990, Jensen and Murphy 1990). Tournaments increase incentives for rational play because they provide sizable rewards for small/flat differences in measurable performance, thereby addressing one of the main problems plaguing gaming experiments for decades (e.g., Harrison 1989). In our previous experimental work on the power of institutions to generate rational behavior, we found that adding tournament incentives into classic gaming experiments resulted in *more* rational gaming behavior, not less, as has been feared by some (see Camerer and Hogarth 1999). We observed more self-interested bargains, more subgame perfection outcomes in endogenous timing contests, and more sincere bidding behavior in second-price auctions (e.g., Shogren et al. 2006, Baik et al. 1999, Shogren 1997).

Herein we want to up the ante—to stress test the power of tournament incentives to induce similar patterns of rational play in an unfavorable gaming environment, the one-shot centipede game. The one-shot centipede game provides a good robustness test of the power of tournament incentives because people rarely play as predicted—few players end the game immediately as predicted by backward induction that eliminate dominated outcomes, i.e., an immediate "take" (see Figure 1; Rosenthal 1981); Rather experimental evidence suggest a *dominance* problem exists. Unmotivated players seem unable or unwilling to work through more than a few steps of iterated elimination of dominated strategies (McKelvey and Palfrey 1992). While some dominance-solvable gaming experiments confirm that stronger incentives can help him over come his own dominance problem, he can still be affected by *strategic uncertainty*. Strategic uncertainty exists if he cannot safely presume the other players will also *behave* rationally or that they will *believe* he will act rational (see review in Camerer 2003). We consider two non-linear payoff tournaments—relative reward rankings and within game relative rankings—and these structures relationship between dominance and strategic uncertainty in inducing more people to act as if they were rational.

2. Experiment 1: Relative reward tournament

Participants were recruited from undergraduate economics classes for two sessions, each with N = 21 subjects. Monitors read the basic information and the instructions for the five payoff structures; called *cases* (experimental instructions available on request). The five case instructions were randomly arranged within a packet of instructions for each player. They received a $5 participation fee upfront, and were notified that one case would be chosen at random to determine their take-home earnings. Each case described how points would be converted into dollar earnings.

Figure 1: Point Tree



*(Player A's points, Player B's points)
**(Player A's tallies, Player B's tallies)

Figure 1 shows the centipede game used in the experiment, called the *point tree*, which was identical for all games (in Figure 1 see first row of payoffs, E1). Each subject knew he or she would play one game against each and every other subject in their session (N – 1 = 20 *games*) per case to determine payoffs. Subjects were informed their role (Player A or B) in each game would be determined randomly. As required by games of complete and perfect information, every subject specified his *complete strategy space* by filling out one recording sheet for the five cases. The sheet asked whether he would PASS or TAKE at each of the six decision stages. Once the recording sheets for each of the five cases were completed, the subjects were finished with their task. Payoffs were determined and the subjects were paid in cash.

Experiment 1 considered five payoff structures, which were presented to the subjects as *colors* to remove economic jargon. The tournament with nonlinear payoffs (Blue) used a relative ranking scheme:

$180	Winner—player with greatest total points at the end
$100	2^{nd}
$60	3^{rd}
$25	4^{th}
$12	5^{th}-10^{th}
$7	11^{th} – 21^{st}

We designed the tournament with a $180 winner-payoff for less than an hours work to get all players to pay more attention to the incentives at work in the game, i.e., removes the temptation to PASS given the substantial opportunity cost for not eliminating dominated outcomes. If this reward structure is sufficient, each player will end the game immediately because he believes *all* other players will also follow the same rational strategy, which eliminates strategic uncertainty. But if this reward is insufficient, some players might be tempted to PASS, say in stage 1, hoping his opponent does the same in 2, so he can TAKE in stage 3, outscoring his opponent by more points (e.g., 12 = 16 – 4 vs. 3 = 4 – 1), which increases his total points and ranking.

As comparative benchmarks to more classic incentives, we consider four additional payoff structures: three base-bonus payoffs (Green, Orange, Pink) and one nonlinear step function (Purple). See Table I (below) for descriptions.

Now consider the results. A computer program combined each player's strategy against the other 20 players, in every combination of subjects and Player A/B roles (21 players playing each other twice = 420 games). We define our results by the "terminal" stage —the stage in which a player chooses TAKE for the first time. Table I (column E1) summarizes the stage 1 results.

Table I: Payoff Structures and Results

Payoff Structure	Expected Nash Pay	Max Pay	E1 Stage 1 Ending Proportion	E2 Stage 1 Ending Proportion	Difference Test (p- values)
Nonlinear Tournament (Blue) See payoffs in paper	\$24.48	\$180	0.119	0.381	p = 0.027
High Base / Low Piece Rate (Green) \$16 plus 1.5¢/cumulative point	\$16.75	\$93	0.167	0.167	p = 1.00
Medium Base & Piece (Pink) \$8 plus 3¢/c pt	\$13.00	\$62	0.143	0.119	p = 1.22
Low Base / High Piece (Orange) 5¢ /c pt	\$9.50	\$161	0.071	0.119	p = 0.524
Nonlinear Step (Purple) \$10-62; based on point ranges Points; Payoff 20-40; \$10 41-60; \$13 61-100; \$17 101-200; \$22 201-500; \$28 501-1,000; \$35 1,001-2,000; \$43 2,001-3,500; \$52 3,501+; \$62	\$2.50	\$62	0.095	0.023	p = 1.82

Despite the relatively large payoff that goes to the winner and runner-up (\$180 and \$100), the tournament did not outperform the other payoff structures at stage 1: only 11.9 percent rational play was observed, which fell between the 7.1 percent low in Low Base/High Piece and the 16.7 percent high for High Base/Low Piece. There was no statistical difference between any of the payoff structures for games ending in stage 1.

3. Experiment 2: Within-game relative rankings

Why did players have the same response to the five payoff structures? (1) Was the environment too complicated for players or (2) were the incentives too weak to induce significant changes in rational behavior? We address these questions using a second tournament structure—within-game competition. In the wilds, within-game rewards are used to create stronger incentives then overall rewards, e.g., round robin sporting events in which wins and losses determine relative rankings and earnings (see Ehrenberg and Bognanno 1990). We use *tallies* to create within-game relative payoff rewards. A *tally* is earned for the player with the most points in each game. If player A has more points than B in game 17, A receives 1 tally. Two sessions of 21 students participated.

All aspects of Experiment 2 were identical to Experiment 1, except that we added the tallies into the Nonlinear Tournament. The winner who earned the most "tallies" would receive $180. The other four cases are identical to Experiment 1. The use of tallies transforms Figure 1 payoffs E1 into payoffs E2 —a 0-1 binary game. Note players never saw this transformed tree; they were given Figure 1 with payoffs E1.

Adding tallies transformed the centipede game into simple first-"taker" wins game. We recognize this is extreme—but we purposefully designed this experiment to test whether we can provide *any* incentive, extreme or not, for a majority of people to TAKE in stage 1 by *only altering payoff structure* to induce the Nash outcome. If most players respond to the tally tournament incentives, then we have some evidence that rational play in the one-shot centipede game is not universally rejected.

Our new results are positive—tallies tripled the level of subgame perfect play to 38.1 percent (Table I E2). Tally behavior differed from the other four incentive designs at the 3% level. The last column of Table I compares behavior across experiments 1 and 2. The test between the original and tally tournament gave a two-tailed p-value of 0.0272. The other four cases did not differ across experiments.

Experiment 2 results allow questions (1) and (2) above to be addressed. There is evidence that the environment *was not* too complicated. Comparing Table I E1 and E2 illustrates that the only significant change in play occurred for the tournament payoff structure. There was strong consistency in the play of the other four structures (having not changed) across the experiments by the different subject pools. This suggests that subjects were responding to the nature of the payoffs and not randomly assigning strategies across structures. The results suggest the Experiment I tournament *did not* provide strong enough incentives to induce rational behavior. Strategic uncertainty was clearly not eliminated leading to a vast majority of subjects passing at stage 1 likely in hopes of earning increased points (recall this is rational if it is believed the opponent will PASS).

When this temptation was removed (cannot earn more than one tally per game) several new respondents recognized that strategic uncertainty was not present and played accordingly, leading to a statistically significant change in the proportion of games ending in stage 1. These subjects were not victims of a dominance problem; their behavior is consistent with them having thought through how points were converted to tallies (recall the point tree they were given was not changed) and recognized the Nash equilibrium was also free of strategic uncertainty. This is further evidence that the environment was not too complicated, behavior adjusted to the change in incentives.

4. Discussion

Can tournament incentives induce people to play rationally in the centipede game? Our results are mixed —less than 1 in 10 people played as predicted in a tournament setting; whereas nearly 4 in 10 did in the tally tournament. From the perspective of trying eliminating strategic uncertainty, we moved subjects toward rational play with the tally tournament. But the increase in rational play came at a significant cost in terms of institutional credibility—we contorted the game into an extreme version of the centipede game. If such strict institutions are need to induce more rational play, additional research is needed to better understand how to institute the *right* incentive instead of simply adding additional money.

We purposefully chose a one-shot game to see if we could over come dominance just with serious incentives, not from learning by ones mistakes through repeated small payoff games. One might step back from the extreme and still increase rational play with repetition and feedback, as some learning will occur. Shogren and Hurley (1997), for example, found some evidence of learning in a four-round elimination centipede tournament. They observed rational play for 6 in every 10 players in the practice rounds, 7 in 10 in Round 1, and 10 in 10 in rounds 2-4 of the tournament. How much repetition is necessary for this to take place is a question for future research.

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