Running Head: COOPERATION

How Economic Rewards Affect Cooperation Reconsidered

Dan R. Schley and John H. Kagel

The Ohio State University

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Address correspondence to Dan R. Schley, 1827 Neil Ave. Office 337, Columbus, OH, 43201. Email: schley.5@osu.edu

Abstract

In a recent report, Furlong and Opfer (FO; 2009) found that the level of cooperation observed in an iterated prisoner's dilemma game (IPD) could be varied in systematic ways by manipulating the numeric values of the payoffs to cooperation versus defection while holding the underlying economic values constant. We sought to determine if similar effects from numeric transformations would be observed under standard procedures employed in economic experiments. Results indicated a non-significant reversal in the influence of the numeric manipulation. We argue that the story proposed by FO is more complicated than initially thought. IPD games are dynamic, therefore the influence of a given manipulation must be considered with regard to the dynamics of the game. Furthermore, we demonstrate that FO's predictions regarding the influence of the numeric manipulations on cooperation depend upon the cells of the payoff matrix being considered.

How Economic Rewards Affect Cooperation Reconsidered

In a recent report Furlong and Opfer (2009; FO) found that the level of cooperation observed in an iterated prisoner's dilemma (IPD) game could be varied in systematic ways by manipulating the numeric values of the payoffs to cooperation versus defection while holding the underlying economic values constant. In their Study 1 FO found that individual cooperation rates increased substantially, from less than 10% to around 30%, by changing the payoff values for mutual cooperation from $3 to 300¢. That is, presenting the different payoff values in cents rather than dollars increased rates of cooperation. According to FO, the ratio between $3 (Cell R in Figure 1) and $5 (T) is perceived as greater than the ratio between 300¢ and 500¢, because individuals perceive payoffs logarithmically (Dehaene, 1997). This deviation from linear transformations of payoffs stands in marked contrast to standard economic notions of invariance to such transformations in situations such as this (Rapoport & Chammah, 1965).

Given that repeated IPD games serve as a workhorse for the study of cooperation and repeated play game behavior in economics, we sought to determine if similar effects from numeric transformations would be observed under standard procedures employed in economic experiments (Kagel & Roth, 1995). Therefore, six experimental sessions (*N*=114; 59.2% female; M_{age} = 21.1 years) were run employing FO's payoff structures (Figure 1) and the experimental economic methodology suggested by Dal Bo and Fréchette (2012; see Supplementary Materials online). Sessions (*n*s=16-20) were randomly assigned to either the "dollars" (*n*=56) or "cents" (*n*=58) conditions. In the "dollars" conditions, the payoffs for mutual and unilateral cooperation and mutual and unilateral defection were 3, 0, 1, and 5 points, respectively; these values were multiplied by 100 in the "cents condition. Subjects in the "dollars" and "cents" conditions were paid 3.5¢ and .035¢, respectively, per point. Therefore, the economic values were constant between conditions and only the numeric values of the points differed. Sessions lasted for one hour and subjects earned between \$8 and \$18 contingent on their play. Within a session, subjects were randomly paired, via computer, to another subject in the room. Match length was determined randomly, averaging 4 rounds, before being randomly paired with another subject.

Results and Discussion

Because later rounds within a given match are reactive to previous round's outcomes, analysis of the first round of each match provides a less adulterated investigation of the influence of the numeric manipulation on cooperation. Results of a repeated-measures probit regression indicated that the numeric manipulation had no influence, $p > 0.49$, nor its interaction with the match variable, $p > 0.41$. That is, subjects' cooperation in the "cents" condition (57.8%) did not differ from cooperation in the "dollars" condition (65.4%), on average, nor did the difference between the two conditions vary systematically by match (see Figure S1). If we analyzed data from all rounds, results indicated that the average influence of "cents" vs. "dollars" was not conventionally significant, $p > 0.08$, nor was its interaction with match, $p > .64$. Although not significant, we should note that whereas FO found that the "cents" condition produced greater cooperation than the "dollars" condition, our results indicate the opposite relationship (see Supplementary Materials online for full analyses).

We controlled for the dynamic nature of IPD games by simply investigating subjects' behavior on the first round of the first match. Results indicated that subjects' cooperation in the "cents" (52%) and "dollars" (52%) conditions did not differ, $p = .99$. Presumably in the first round of the first match, subjects' decisions were based solely on the values presented and not on past experience, and therefore should most likely reflect the influence of the numeric manipulation. Two additional studies with comparable results are presented in the Supplementary Materials online.

Whereas FO only consider the influence of the numeric manipulation on cells R and T of Figure 1, given FO's account, comparison of cells R and P produce the opposite results. For example, according to FO, individuals are *more* likely to defect in the "dollars" condition because the ratio between \$3 (Cell R in Figure 1) and \$5 (T) is perceived as greater than between 300¢ and 500¢. But if individuals consider cells R and P, they are *less* likely to defect in the "dollars" condition because the ratio between \$3 (R) and \$1 (P) is greater than between 300¢ and 100¢. Thus, even in a simple one-play prisoner's dilemma game the influence of the numeric manipulation depends upon the cells of the payoff matrix being considered.

More generally, in a repeated play PD game it is not just a matter of comparing the ratios 3/5 versus 300/500, but there is also a tradeoff between getting a gain of 2 or 200 (cells T-R) one time, while potentially sacrificing this same amount (cells R-P) for an unknown number of future rounds. The dynamics of this tradeoff would potentially offset any logarithmic ratio considerations.

Conclusions

Economic experiments for IPD games are designed to allow controlled investigation of behavior in dynamic environments. Whereas FO challenged Rapoport and Chammah's (1965) assumptions of linearity, we found that the linearity assumption held up in a more conventional economic experiment. The purpose of this article is not to assert that FO's findings are null, but to make the point that cooperative behavior in economic games is dynamic and not always approximated well in laboratory studies using computer opponents. Although we agree that individuals often attend to numeric values rather than economic values (Shafir, Diamond, & Tversky, 1997), conclusions regarding moderators of economic behavior should attempt to more fully account for the dynamic nature of economic decisions in environments such as this.

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Author Note

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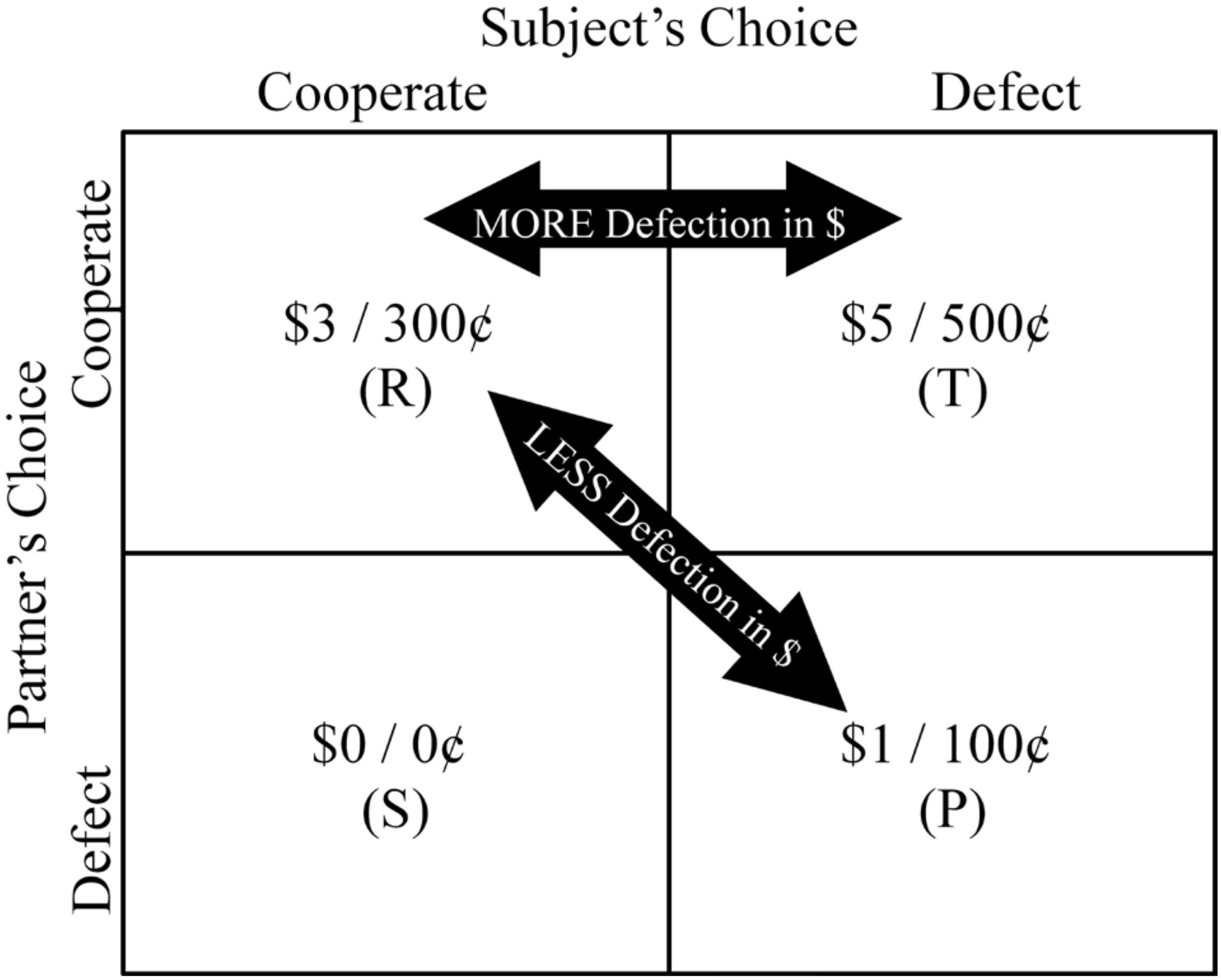

Figure 1. Payoff matrix from FO and current study. Values indicate payoffs in points in the "dollars" and "cents" conditions, arrows indicate the influence of numeric manipulation on cooperation/defection behavior, according to FO's account.

Supplementary Online Materials

Differences in Methodology

FO's subjects participated in an 80-round sequence against confederates (or computerized rivals) who were playing the classic tit-for-tat (TFT) strategy, known to generate high cooperation rates in IPD game strategy tournaments (Axelrod and Hamilton, 1981). Although TFT is a reasonable approximation for the strategy of subjects, it does not account for the dynamics of playing against another subject. Furthermore, playing a single match for 80 rounds against a single opponent inhibits subjects' ability to learn from experience. Typically, beginning a new match against a novel opponent allows subjects to have a fresh start to try out different strategies.

The study presented in the main text recruited undergraduate students from the same university as FO's subjects. Match length was randomly determined with a 0.75 continuation probability after each round of play, which is sufficiently high to support cooperative play. Subjects were randomly re-matched following termination of a match for a total of one hour of play.

FO's subjects were presented the game in terms of the child's game Rock, Paper, Scissors. In the current study, sessions began with the payoff matrix being fully explained. Total accumulated earnings were paid in cash at the end of an experimental session.

Additional Results and Analyses Explained

Figure S1 reports the average frequency of individual subject cooperation in round 1 of each match over time under the two treatments (top panel) as well as the average frequency of cooperation over all rounds (bottom panel). The data have been truncated to the minimum number of matches (24) in the six experimental sessions.

Results reported in the main text were analyzed using probit regressions with standard errors clustered at the subject level, with the dependent variable equal to 1 when a subject chose to cooperate in round 1 of a given match, 0 otherwise. Our regression specification employed variables known to impact behavior in games of this sort (Dal Bó and Fréchette, 2012). The omitted variable in the probits was the "cents" treatment with the D$ dummy variable accounting for any difference in intercept values between the "dollar" and "cents" treatments. M1 was a variable equal to 1 if a subject cooperated in round 1 of match 1 (0 otherwise), designed to capture individual subject tendencies to cooperate. M1 did not vary by condition, $p = 0.99$. MN was a variable equal to the match number designed to pick up the obvious tendency for cooperation rates to increase with match experience, with the MN×D$ variable picking up any difference on this score between the two conditions. Additional control variables included a PPart dummy variable set equal to 1 if a subject's previous partner cooperated in round 1 of the previous match (0 otherwise), and the PRN variable equal to the number of rounds in the previous match, which is known to affect initial levels of cooperation in the next round. Probit results are reported below in Table S1. Whereas this model investigates cooperation in the first round of each match, the second model investigates cooperation over all rounds, employing the same structure as the first model.

Study 2: Attempted Replication

In Study 2 we sought to directly replicate the FO paradigm following their procedures: An 80-play sequence against a computerized rival playing TFT using the exact software and procedures used by Study 2 of FO; though we only ran the $3 and 300¢ conditions. In addition, half of the subjects (*N*=99 recruited from the same university) were incentivized (*n*=47) to investigate whether incentives influenced the effect of the numeric manipulation (Camerer & Hogarth, 1999). Using similar probit models, results indicated that for the incentivized subjects there was no significant difference between the overall average rate of cooperation in the "cents" and "dollars" conditions ($p > 0.46$; 64% versus 56% cooperation rates, respectively). For the unpaid subjects there was also no significant difference between average overall rates of cooperation between treatments (p > 0.24; 42% versus 33%, respectively). Although not significant, we found results consistent with FO. One concern regarding Study 2 was that we did not observe increases in rate of cooperation over rounds, as we saw in Study 1, and is typically found in IPD games. These results suggest that the methodology employed by FO produced an experimental environment that did not express typical IPD behavior. Once again, we analyzed just the first round to attempt to parse out the dynamic elements of the IPD game. Results indicated 52% cooperation in the "cents" condition and 51% cooperation in the "dollars" condition, $p > .95$.

Study 3: Single-Play Game

It is difficult to interpret differences in overall rates of cooperation as being the effect of the numeric manipulation because overall rates depend upon the dynamic nature of IPD games. We have attempted to control for these dynamics by investigating the initial rounds of each study; results of these analyses indicated null influences of the numeric manipulation. Analyzing the first rounds of dynamic games attenuates dynamic inputs, but subjects are still likely basing their judgments in round 1 on future rounds. To further attempt to control the dynamic nature of prisoner's dilemma games we ran an unincentivized single-play version of the game. Subjects

(*N*=189) were recruited online from Mechanical Turk and paid $0.50 for completion of the study. Subjects were randomly assigned to either the “cents” or “dollars” conditions and presented the payoff matrix in Figure 1. Results indicated 60% and 66% cooperation in the “cents” and “dollars” conditions, respectively, $p > .44$. Therefore, we again failed to replicate FO. Given the payoffs in question here, these null results may result from some subjects attending primarily to the R and T cells of Figure 1 whereas others attended primarily to the R and P cells (see main text).

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Table S1. Results of Probit Regressions for analyses of first round in each match and all rounds.

	Analysis of first round in each match			Analysis of all rounds		
	Estimate (Standard Error)	Z-value	P-value	Estimate (Standard Error)	Z-value	P-value
Intercept	-0.662 (0.152)	-4.35	<.0001	-1.347 (0.135)	-9.98	<.0001
D$	0.146 (0.212)	0.69	0.49	0.267 (0.155)	1.73	0.08
MN	0.025 (0.007)	3.47	<.0001	0.013 (0.005)	2.83	0.005
MN×D$	0.010 (0.012)	0.83	0.41	0.003 (0.007)	0.47	0.64
M1	1.038 (0.196)	5.29	<.0001	0.652 (0.127)	5.15	<.0001
PPart	-0.069 (0.058)	-1.20	0.23	0.744 (0.062)	12.02	<.0001
PRN	0.023 (0.005)	4.55	<.0001	0.039 (0.005)	7.63	<.0001

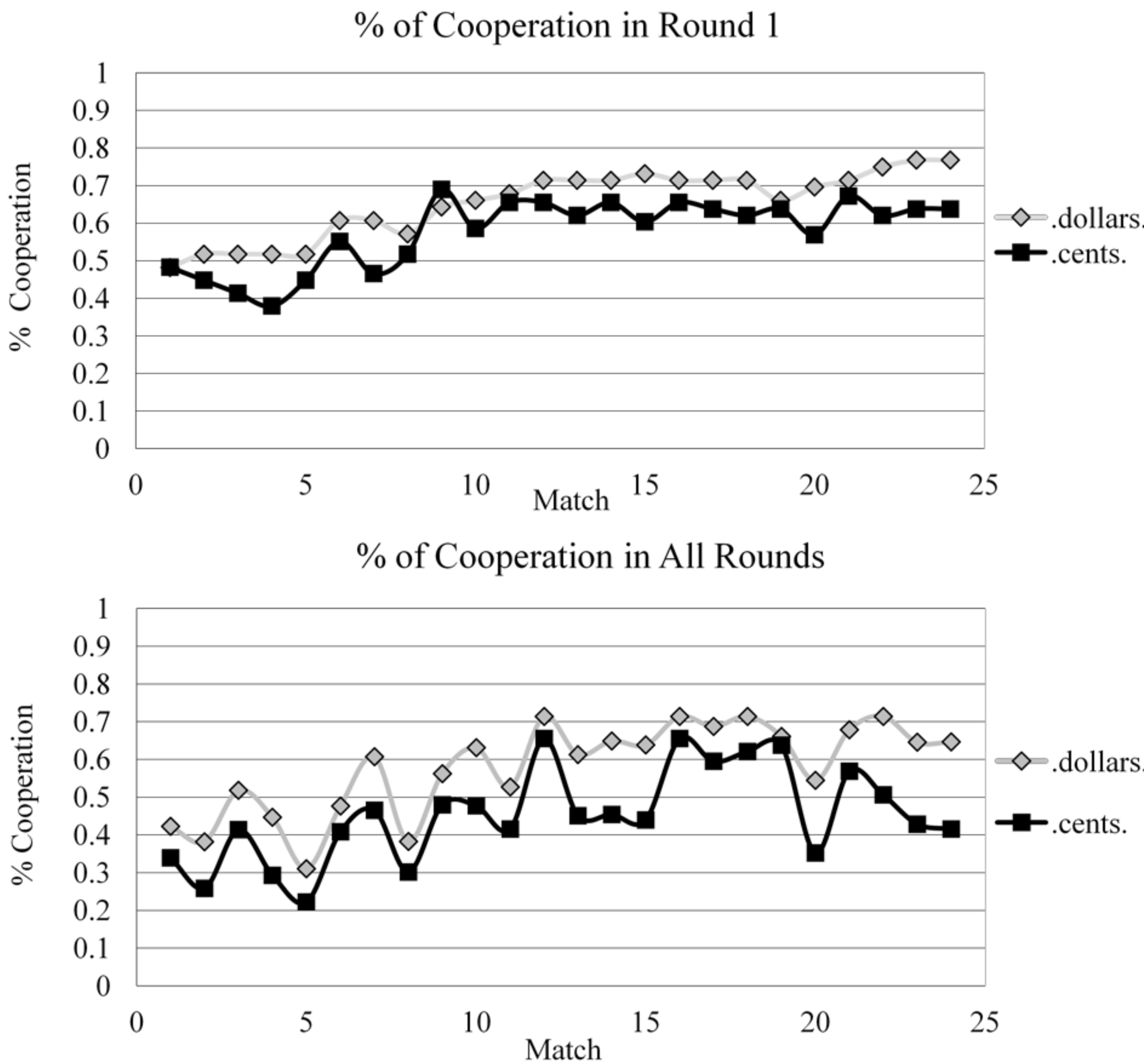

Figure S1. Rates of cooperation plotted against match for the first round (top panel) and all rounds (bottom panel) of each match.