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How economic rewards affect cooperation reconsidered

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HIGHLIGHTS

- We investigate manipulating numeric values of payoffs in prisoner's dilemma games.
- We cannot replicate earlier results showing behavior is sensitive to such changes.
- We explore the role of differences in experimental procedures on reported results.
- Monetary incentives generate higher cooperation rates than in their absence.

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ABSTRACT

Recent studies suggest that payoffs in cents, compared to dollars, produce less defection in a repeated prisoner's dilemma game. We are unable to replicate these findings with conventional economic procedures or in a direct replication.

1. Introduction

Past research has demonstrated that individuals are often driven by the face value of a prospect, rather than its economic value (Shafir et al., 1997). In a recent paper Furlong and Opfer (2009, FO) report 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 payoff to cooperation versus defection while holding the underlying economic values constant. For example, in Study 1, individual cooperation rates increased substantially, from less than 10% to around 30%, by changing the payoff values for mutual cooperation from \$3 to the normatively equivalent 300¢ along with corresponding changes in the numeric values for a standard PD game's payoffs in Fig. 1.

FO's explanation for these changes in behavior rests on the observation that human brains represent numeric values logarithmically (for a review, see Dehaene, 2011), similar to how the brain processes other perceptual information (Stevens, 1961). In particular, they argue that comparing $\ln(R/T)$ for the payoffs in Fig. 1 will result in less temptation to defect when payoffs are in dollars than in cents because the logarithm of the ratio of payoffs ($\ln(3)/\ln(5) = 0.68 < \ln(300)/\ln(500) = 0.92$) is closer to 1 (equal returns) when represented in cents than when represented in dollars. Their motivation for focusing on payoff ratios is based on Rapoport and Chammah's (1965) cooperation index for PD games.[1] This deviation from the linear transformation of payoffs, in conjunction with the exclusive focus on the two cells R and T, stands in marked contrast to standard economic considerations for IPD games. The latter assumes both linear transformations of

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[1] Rapoport and Chammah (1965) base their cooperation index on the ratio of the difference between payoffs: $(R-T)/(T-S)$ and $(R-S)/(T-S)$ under the assumption that $T>0$, $S<0$, and $T+S=0$.

Partner's Choice	Participant's Choice: Cooperate	Participant's Choice: Defect
Cooperate	\$3 / 300¢ (R)	\$5 / 500¢ (T)
Defect	\$0 / 0¢ (S)	\$1 / 100¢ (P)

Fig. 1. Payoff matrix used by FO as well as the current studies. Values indicate payoffs in points in the "dollars" and "cents" conditions.

payoffs as well as dynamic considerations; if their partner chooses to cooperate and they choose to defect, then in the next round their partner will be very likely to defect, and it will be difficult to get back to mutual cooperation with its higher payoff.[2] Given the workhorse nature of PD games in economics, if FO's results can be replicated using standard experimental economic procedures it would have profound implications for experimental economics and for the profession as a whole.

There are a number of significant differences between FO's procedures and repeated play procedures employed in IPD games in economics which might be responsible for the numeric effects they identified. FO's subjects participated in an 80-play sequence against confederates (or computerized rivals) who were playing a tit-for-tat (TFT) strategy known to generate high cooperation rates (Axelrod and Hamilton, 1981) and to characterize a good deal of behavior (Dal Bó and Fréchette, 2011) in IPD games. Subjects were *not* told anything about the computer's strategy with the payoffs and moves described in terms of the game "Rock/Paper/Scissors". Subjects were instructed to earn "as much pretend money as possible", as there were no monetary payoffs in their experiment.

In contrast, in repeated play IPD game in economics, subjects typically play against other subjects who are free to employ whatever strategies they might choose. Payoffs are expressed in experimental currency units (ECUs) which are converted into dollars at the end of the game so that payoffs are contingent on subjects' actions. Choices are described in neutral terms, subjects are randomly matched with each other, and the number of rounds in each match is determined by an (announced) continuation probability that can, in theory, support cooperation (Dal Bó and Fréchette, 2011). Following the end of a given match, subjects are randomly re-matched with this process repeating for an announced period of time—in our case, the first match that ended after 60 minutes of play. Both continuation probabilities and payoffs typically remain constant throughout an experimental session, with enough subjects recruited for each session to limit any re-matching effects. Multiple matches against different players are designed to provide subjects with experience with the game and opportunities to try different strategies. Financial incentives are designed to control players' preferences and, at a minimum, are known to reduce the variance in outcomes (see Smith and Walker, 1993).

To determine whether or not these offsetting considerations would be sufficient to overcome any potential bias in subjects' numeric valuation of payoffs, we conducted two experimental treatments: Study 1 using standard economic procedures for infinitely repeated PD, and Study 2 employing FO's procedures.

[2] There is a theoretical inconsistency in FO's reasoning since if individuals consider $\ln(R/P)$; FO's reasoning implies that individuals would be less likely to defect in the "dollars" condition.

2. Experimental design and procedures

2.1. Study one

Six experimental sessions were conducted, with payoffs in points as shown in Fig. 1. Between 16 and 20 subjects participated in each session for a total of 56 and 58 subjects in the "dollars" and "cents" treatments, respectively. Match length was randomly determined with a 0.75 continuation probability after each round of play, sufficiently high to support cooperative play. Payoffs were in points with a conversion rate of 1 point $=$ 3.5 cents, and to keep real incentives the same along with budget limitations, a conversion rate of 1 point $=$ 0.035 cents in the "cents" treatment. Thus, short of subjects doing the conversion rate in their heads and using these values in comparing between alternatives, which is very unlikely, the experiment compares FO's cents and dollars treatments under standard experimental economic conditions. Subjects were recruited from the Economics Laboratory maintained at Ohio State University. This pool is heavily weighted with undergraduates who have enrolled in economics classes, as the Department services some 5000 students each quarter, only a small fraction of which are economics majors. Play for pay began immediately after reading the instructions.

2.2. Study two

Subjects played an 80-round sequence against a computerized rival playing TFT employing the exact software and procedures used in FO.[3] All subjects were recruited from Ohio State University with approximately half the subjects incentivized ($n = 47$), who were recruited from the Economics Department subject pool, with the remaining subjects ($n = 52$) not incentivized and recruited from the Psychology Department subject pool. In both cases the game was characterized using the "Rock/Paper/Scissors" terminology employed in FO's studies. The conversion rate for incentivized subjects was set to 8 cents and 0.08 cents per point, for the "dollars" and "cents" treatments, respectively.[4] In both cases the number of rounds was *not* announced in advance, with subjects being told that they would play for somewhere between 15 and 20 min, with sessions typically lasting 15 min.

3. Experimental results

3.1. Study one

Fig. 2 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. Inspection of Fig. 2 suggests little to distinguish between the dollar and cents treatments.

Formal statistical analysis focuses exclusively on round 1 play in each match, since choices after round 1 are reactive to previous rounds' outcomes, which severely complicates any sort of statistical analysis of individual subject behavior.[5] Probit regressions

[3] This would be FO's Study 2, which replicated their Study 1 results, using computerized respondents as opposed to the confederates employed in Study 1, though we only ran the \$3 and 300¢ treatments.

[4] The conversion rates were increased due to the fewer rounds of play in Study 2.

[5] Analyzing all rounds is tricky since after round 1 the choices for both players are correlated as they are determined by choices in the previous rounds. This is not impossible to deal with but gets quite complicated.

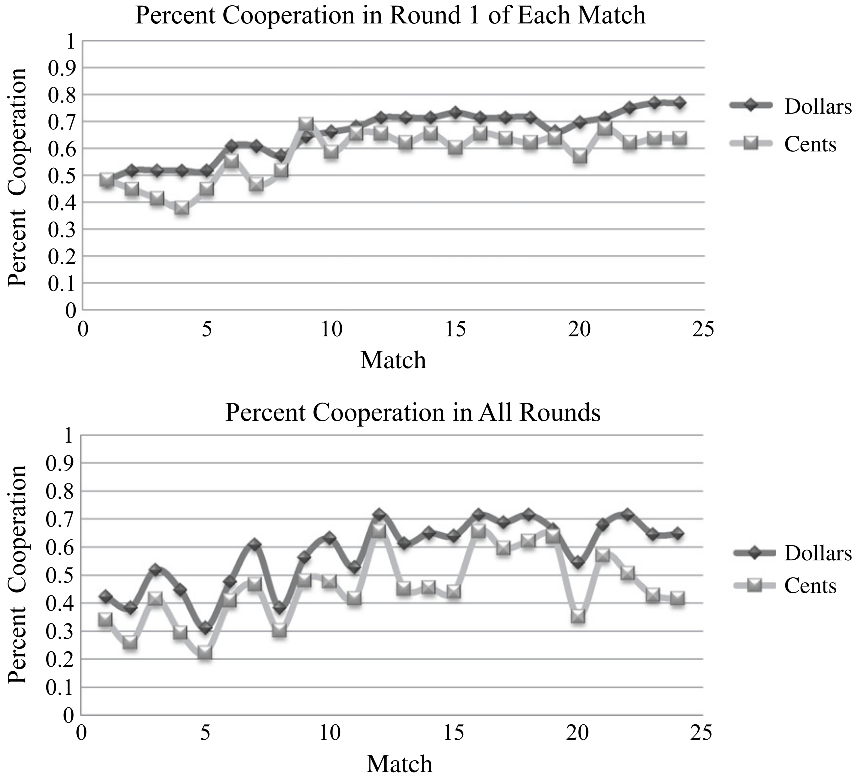

Fig. 2. Average rates of cooperation in Study 1 for the first round (top panel) and all rounds (bottom panel) of each match.

were employed with the dependent variable equal to 1 when a subject chooses to cooperate in round 1, and 0 otherwise. Our regression specification employs variables known to impact behavior in games of this sort (Dal Bó and Fréchette, 2011). The omitted variable in the probits is the "cents" treatment with the $D\$$ dummy variable accounting for any impact of the "dollar" treatment (value equal to 1 in the dollar treatment; 0 otherwise). $M1$ is a variable equal to 1 if a subject cooperated in round 1 of match 1 (0 otherwise), designed to capture individual subject tendencies to be cooperative or not. A separate probit looking at any potential differences in cooperation between the two treatments for round 1 of match 1 showed no significant differences ($p > 0.995$). Mn is equal to the match number, designed to pick up the obvious time trend in the data, with the $MN \times D\$$ variable picking up any difference in time trends between the dollar and cents treatments. Additional control variables include a $PPart$ dummy variable equal to 1 if a subject's previous partner cooperated in round 1 of the previous match (0 otherwise), with the PRN equal to the number of rounds in the previous match. Probit results are reported below:

$$\begin{aligned} Pcoop = {} & \underset{(0.015)^{*}}{-0.662} + \underset{(0.212)}{0.146D\$} + \underset{(0.007)^{*}}{0.025\,Mn} + \underset{(0.012)}{0.010Mn \times D\$} \\ & + \underset{(0.196)^{*}}{1.038\,M1} - \underset{(0.058)}{0.069\,PPart} + \underset{(0.005)^{*}}{0.023\,PRN} \end{aligned}$$

Standard errors (clustered at the subject level) are reported just below coefficient values with the superscript $*$ attached to statistically significant coefficient values, all of which have a $p < 0.01$ (two-tailed test). Most importantly, there are no significant effects at anything approaching conventional levels for either of the two main treatment; $D\$$ (57.8% and 65.4% cooperation in the "cents" and "dollars" treatment, $p > 0.49$) and the $MN \times D\$$ interaction term ($p > 0.41$), or for the sum of the two coefficients ($p > 0.45$).

Given the failure to replicate FO's results, finding instead a non-significant reversal of their observed effect, Study 2 sought to replicate their results following their procedures.

3.2. Study two

Fig. 3 reports average rates of cooperation in the paid sessions (top panel) and in the unpaid sessions (bottom panel). Each point in the graph represents the average rate of cooperation over four consecutive plays of the game. Formal statistical analysis consisted of a probit pooling the data from paid and unpaid sessions, and testing for treatment effects using separate treatment dummies, with standard errors clustered at the individual subject level. This is comparable to the ANOVAs reported in FO.[6] For the paid subjects there is no significant difference between the overall average rate of cooperation in the "cents" and "dollars" treatments ($p > 0.46$; 64% versus 56% cooperation rates for "cents" versus "dollars"). For the unpaid subjects there is also no significant difference between average overall rates of cooperation between treatments ($p > 0.24$; 42% versus 33% for "cents" versus "dollars"). Average rates of cooperation were significantly greater for paid versus unpaid subjects ($p < 0.01$), replicating unreported results from FO's experiment using subjects drawn from the Psychology subject pool (personal communication).

4. Conclusions

The results reported here should not be taken as denying the validity of reported cognitive limitations on evaluating numeric differences, particularly when considering differences in isolation (Burson et al., 2009; Pandelaere et al., 2011). For example, Pandelaere et al. (2011) asked subjects to rate the perceived difference in quality between two televisions that only differed in their quality rating scores. The quality ratings were scored on either a 10-point or 1000-point scale (scores were 7 versus 9 or 704 versus 903). Results indicated that subjects rated the perceived

6 Here we are used data from *all* 80 periods since there are no statistical issues resulting from subjects responding to other subjects' behavior.

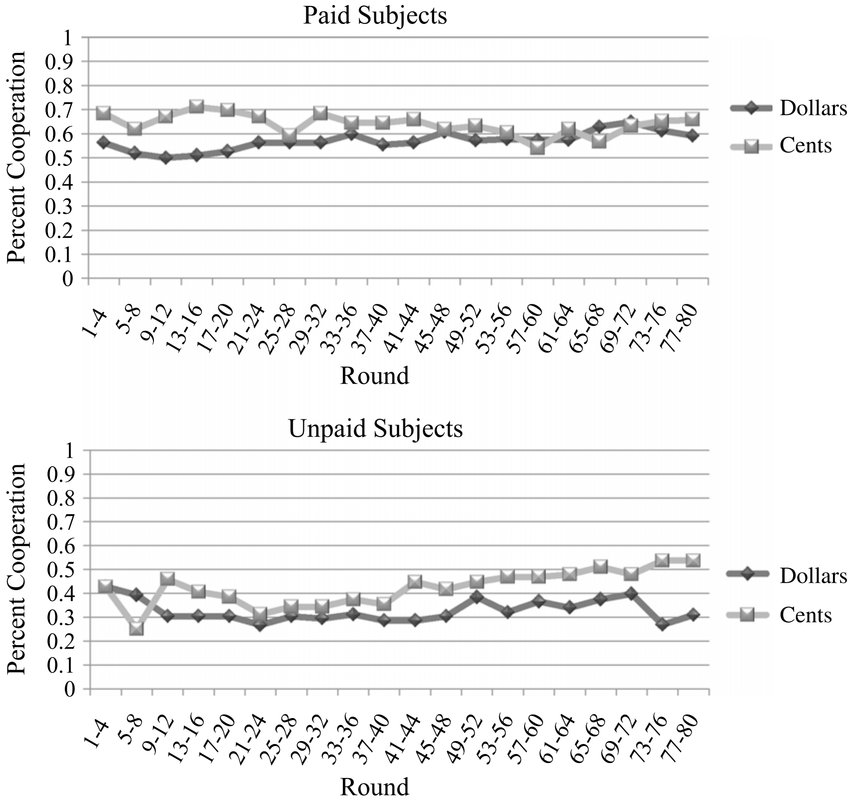

Fig. 3. Average rates of cooperation in Study 2 for paid and unpaid subjects.

quality differences as larger for the two televisions with quality rating scores presented on the 1000-point scale than for the two televisions with quality rating scores presented on the 10-point scale.[7] However in IPD games, and a number of other economic environments, isolated differences of this sort are not considered to be the determining factors. Thus, given the current findings, linear transformations of payoffs do not appear to influence behavior in IPD games.

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[7] Contrary to FO, this literature suggests that individuals are *more* sensitive to the differences in cents than in dollars.