University of Hawai'i
Department of Economics
Working Paper Series

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Working Paper No. 11-18

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December 2011

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Abstract

We consider payment schemes in experiments that model infinite-horizon games by using random termination. We compare paying subjects cumulatively for all periods of the game; with paying subjects for the last period only; with paying for one of the periods, chosen randomly. Theoretically, assuming expected utility maximization and risk neutrality, both the Cumulative and the Last period payment schemes induce preferences that are equivalent to maximizing the discounted sum of utilities. The Last-period payment is also robust under different attitudes towards risk. In comparison, paying subjects for one of the periods chosen randomly creates a present period bias. We further provide experimental evidence from infinitely repeated Prisoners' Dilemma games that supports the above theoretical predictions.

Key words: economic experiments; infinite-horizon games; random termination

JEL Codes: C90, C73

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*This is a follow-up on our earlier study of payment schemes in random termination games (Sherstyuk et al. 2011). The research was supported by the University of Hawaii College of Social Sciences research grant and the Grant-in-Aid for Scientific Research on Priority Areas from the Ministry of Education, Science and Culture of Japan. Special thank you goes to Andrew Schotter for a motivating discussion. We are grateful to Jay Viloria, Joshua Jensen and Chaning Jang for research assistantship.

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1 Motivation

Significant attention in experimental research has been recently paid to dynamic infinite-horizon settings. Such settings have been used to study asset markets (Camerer and Weigelt 1993), growth models (Lei and Noussair 2002), games with overlapping generations of players (Offerman et al. 2001), and infinitely repeated games (Roth and Murnighan 1978; Dal Bo 2005; Aoyagi and Frechette 2009; Duffy and Ochs 2009; Dal Bo and Frechette 2011). To model infinite-horizon games with discounting, experimental researchers use the random termination method: given that a period is reached, the game continues to the next period with a fixed probability (Roth and Murnighan 1978). Experimental research shows that the random termination method is indeed more successful in representing infinite-horizon games than continuing a game for a finite, known or unknown to subjects, number of periods (Offerman et al. 2001; Dal Bo 2005).

The infinite-horizon models assume that the subjects maximize the infinite sum of their discounted payoffs across periods, and thus call for paying the subjects cumulatively for all periods (the Cumulative payment scheme). Indeed, such cumulative payments are used in all studies cited above. However, the Cumulative payment scheme has two limitations. First, a game that continues into each next period with probability p is theoretically equivalent to an infinite-horizon game with the discount factor p only under the assumption of risk neutrality. Risk aversion may invalidate the cumulative payment scheme, at least theoretically. Second, a possible concern for researchers is that large variations in the actual number of periods realized under random termination may result in large variations in cumulative payments to subjects, even when per period earnings are fairly predictable. Furthermore, to preserve the incentives, researchers in some cases have to pay the same stream of cumulative payoffs to more than one experimental participant. For example, in the growth experiment by Lei and Noussair (2002), a horizon that did not terminate within a scheduled session time continued during the next session; if a substitute took place of the original subject in the continuation session, then both the substitute and the original subject were paid the amount of money that the substitute made. In the inter-generational infinite-horizon dynamic game experiment by Sherstyuk et al. (2009), each period game was played by a new generation of subjects, who were paid their own payoffs plus the sum of the payoffs of all their successors. Such payment scheme, while was necessary to induce proper dynamic incentives, produced a snowball effect on the experimenter expenditures.

The contribution of this paper is to explore, theoretically and experimentally, payment schemes that may provide a reasonable alternative to cumulative payments in random-termination games. Ideally, we seek a payment method that would allow for various attitudes towards risk, and at the same time reduce variability of the experimenter budget.

We explore two alternatives to the Cumulative payment scheme, and their consequences for subject motivation in random-continuation games. One alternative is the random selection payment method (Davis and Holt 1993) that is often used in individual choice or strategic game experiments containing multiple tasks. Each subject is paid based on one task, or a subset of tasks, chosen randomly at the end of the experiment (e.g., Charness and Rabin 2002; Chen and Li 2009). Aside from avoiding wealth and portfolio effects that may emerge if subjects are paid for each task (Holt 1986; Cox 2010),[1] there are also added advantages in economizing on the data collection efforts (Davis and Holt 1993). However, we demonstrate that in a dynamic infinite-horizon game setting, paying subjects for one period chosen randomly creates a present period bias. Therefore such Random payment scheme should not be used in infinite-horizon experimental settings.

Another alternative to the Cumulative payment is the Last period payment scheme, under which the subjects are paid for the last realized period of the game. We show that, theoretically, paying the subjects their earnings for just the last period of the horizon induces preferences that are equivalent, under expected utility representation, to maximizing the infinite sum of discounted utilities across periods. Moreover, unlike the cumulative payment, it does not require risk neutrality.

We then proceed to compare the three payment schemes, – cumulative, random and last period pay, – experimentally. We provide experimental evidence is support of the above theoretical arguments using an infinitely repeated Prisoners' Dilemma setting.

To the best of our knowledge, this is the first systematic study to consider the effects of payment methods on subject behavior in infinite-horizon experimental games, and to introduce the Last period payment as an alternative to Cumulative payment in such settings. Several experimental studies investigate determinants of cooperation in infinite-horizon games, focusing on the repeated Prisoners' Dilemma (PD) game. Following Roth and Murnighan (1978), these studies employ random continuation to model infinite repetition in the laboratory. Dal Bo (2005) compares cooperation rates in infinitely repeated PD games with

[1]Holt (1986) shows that the random selection method may be used if subjects behave in accordance with the independence axiom of expected utility theory. In a recent working paper, Azrieli et. al. (2011) demonstrate that in a multi-decision setting, paying for one decision problem, chosen randomly, is the only mechanism that elicits subjects choice behavior across various decision problems in the incentive compatible way. Several carefully designed experiments give reassuring evidence for using the random selection method in individual choice experiments (Starmer and Sugden 1991; Cubitt et. al. 1998; Hey and Lee 2005). We are unaware of experimental studies that test the validity of the random selection method in game theory experiments.

random termination with the finitely repeated games of the same expected length, and finds that cooperation rates are higher in games with random termination. Aoyagi and Frechette (2009) study collusion in infinitely repeated PD under imperfect monitoring. Duffy and Ochs (2009) compare cooperation rates in indefinitely repeated PD under fixed and random matchings. They find that with experience, frequencies of cooperation increase under fixed matching, but decline under random rematching, thus providing support for the theory of cooperation in infinitely repeated games. Dal Bo and Frechette (2011) study evolution of cooperation in infinitely repeated PD. They report that cooperation may be sustained only if it is supportable as equilibrium, and, further, that cooperation increases with experience only if it is risk dominant (as defined in Blonski and Spagnolo 2001). Blonski et al (2011) also provide evidence that the conditions for sustainable cooperation are more demanding that the standard theory of repeated games suggests, and are in line with the notion of risk-dominance as discussed above. All these studies use the Cumulative payment method.

We use an infinitely repeated Prisoners' Dilemma setting in the experimental test of the effect of payment schemes on subject behavior. This allows us not only to analyze the subject behavior under alternative payment schemes within our study, but also to compare our findings with other studies on the infinitely repeated experimental PD games.

Our experimental findings are largely consistent with the theoretical predictions. We find that cooperation rates are not statistically different under the Cumulative and the Last period payment schemes, but they are significantly lower under the Random payment scheme. This is explained by a lower percentage of subjects using cooperative strategies under the Random payment, as compared to the other two payment schemes. We further make a number of additional observations on determinants of subject behavior in random continuation games.

The rest of the paper is organized as follows. In Section 2, we present a theoretical comparison of the three payment schemes discussed above. The design of the experiments that we employ to test these payment methods is discussed in Section 3, and the results are reported in Section 4. Section 5 concludes.

2 Theory

2.1 Discount factors in dynamic games with random termination

Consider an infinite-horizon dynamic game, where $t = 1, ..$ refers to the period of the game. Let δ be a player's discount factor ($0 < \delta < 1$) and π_t the player's period-wise payoff in period t. The player's life-time payoff is given by

$$U \equiv \sum_{t=1}^{\infty} \delta^{t-1} \pi_t. \tag{1}$$

To implement such dynamic game in economic laboratory, experimenters have their subjects play the game where one period is followed by the next in a matter of a few minutes, and hence the subjects' time preference would not matter. Instead, the discount factor is induced by the possibility that the game may terminate at the end of each period (Roth and Murnighan 1978).[2] The following random termination rule is used: given that period t is reached, the game continues to the next period $t+1$ with probability p (such that $0 < p < 1$). Then the game ends in the first period with probability $1-p$, the second period with probability $p(1-p)$, the third with probability $p^2(1-p)$, and so on. The following describes the induced discount factor for each subject under alternative payment schemes.

Assume risk neutrality first. Implications of risk aversion will be discussed at the end of this section.

Cumulative payment scheme Suppose the subjects are informed that if the game ends in period T, then each subject receives the sum of the period-wise payoffs from all realized periods $1, \ldots, T$. Given the random variable T, the expected payoff to a player is given by:

$$\begin{aligned} EPay^{Cum} &= (1-p)\pi_1 + p(1-p)[\pi_1+\pi_2] + p^2(1-p)[\pi_1+\pi_2+\pi_3] + \ldots \\ &= \pi_1 \left\{(1-p) + (1-p)p + (1-p)p^2 + \ldots\right\} + \pi_2 \left\{(1-p)p + (1-p)p^2 + (1-p)p^3 + \ldots\right\} \\ &\quad + \pi_3 \left\{(1-p)p^2 + (1-p)p^3 + (1-p)p^4 + \ldots\right\} + \ldots \\ &= \pi_1(1-p)\cdot\frac{1}{1-p} + \pi_2(1-p)\cdot\frac{p}{1-p} + \pi_3(1-p)\cdot\frac{p^2}{1-p} + \cdots = \sum_{t=1}^{\infty} p^{t-1}\pi_t. \end{aligned} \tag{2}$$

Thus p (equal to one minus the termination probability) represents the period-wise discount factor. With p set equal to δ, the expected payoff under the Cumulative payment scheme is equivalent to U, the payoff under the original dynamic game given in equation (1).

Random payment scheme Under this scheme, the payoff to each player, if the game ends in period T, is randomly chosen from all the realized period-wise returns over T periods, $\pi_1, \pi_2, \ldots, \pi_T$. Then the period $t=1$ expected payoff is:

$$EPay^{Ran} \mid_{t=1} = (1-p)\pi_1 + p(1-p)\frac{1}{2}[\pi_1+\pi_2] + p^2(1-p)\frac{1}{3}[\pi_1+\pi_2+\pi_3] + \ldots$$

[2] Fudenberg and Tirole (1991, p. 148) note that the discount factor in an infinitely repeated game can represent pure time preference, or the possibility that the game may terminate at the end of each period.

$$
\begin{aligned}
&= \pi_1 \underbrace{\left\{(1-p) + (1-p)p\frac{1}{2} + (1-p)p^2\frac{1}{3} + \dots\right\}}_{\delta_1^r} \\
&+ \pi_2 \underbrace{\left\{(1-p)p\frac{1}{2} + (1-p)p^2\frac{1}{3} + (1-p)p^3\frac{1}{4} + \dots\right\}}_{\delta_2^r} \\
&+ \pi_3 \underbrace{\left\{(1-p)p^2\frac{1}{3} + (1-p)p^3\frac{1}{4} + (1-p)p^4\frac{1}{5} + \dots\right\}}_{\delta_3^r} \\
&= \frac{1-p}{p}\left[\pi_1\left\{-\log(1-p)\right\} + \pi_2\left\{-\log(1-p) - p\right\} + \pi_3\left\{-\log(1-p) - p - \frac{p^2}{2}\right\} + \dots\right]. \qquad (3)
\end{aligned}
$$

(We have $p + p^2\frac{1}{2} + p^3\frac{1}{3} + \cdots = -\log(1-p)$ because the left-hand side is the Maclaurin expansion of the right-hand side.) The implied discount factor is different from the one given in equation (1). In particular, the Random payment induces players to discount future returns more heavily than the Cumulative payment scheme. Therefore, the subjects are expected to be more myopic under the Random payment.

To see this, normalize the discount factors under the Cumulative payment, by multiplying them by $(1-p)$, so that they sum up to 1:

$$\delta_1^c = 1-p, \delta_2^c = (1-p)p, \delta_3^c = (1-p)p^2, \dots.$$

(The superscript c represents the Cumulative payment scheme.) Note that $\sum_{t=1}^{\infty} \delta_t^c = 1$. The discount factors under the Random payment scheme, $\delta_1^r, \delta_2^r, \dots$ are already normalized; they satisfy:

$$
\begin{aligned}
\sum_{t=1}^{\infty} \delta_t^r &= \frac{1-p}{p} \cdot \left(\begin{array}{ccccc}
p & +\frac{p^2}{2} & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\
 & +\frac{p^2}{2} & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\
 & & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\
 & & & +\frac{p^4}{4} & +\dots \\
 & & & & +\ddots
\end{array}\right) \\
&= \frac{1-p}{p}(p + p^2 + p^3 + \dots) = \frac{1-p}{p}\frac{p}{1-p} = 1.
\end{aligned}
$$

Then we observe that

$$\delta_1^c = 1-p < (1-p)(1+\frac{p}{2}+\dots) = (-ln(1-p))\frac{1-p}{p} = \delta_1^r \quad \forall p, 0<p<1. \qquad (4)$$

That is, in period 1, the Random payment scheme places a higher weight on the current period irrespective of the termination probability.

Figure 1 illustrates the normalized discount factor schedules with $p = 3/4$, the value that will be used in our experiment. The figure verifies that the Random payment scheme puts a larger weight on the initial period than the Cumulative payment does.

FIGURE 1 AROUND HERE

We further note that the Random payment scheme induces time inconsistency. This is because, as equation (3) indicates, the period-wise discount factor $\delta^r_{t+1}/\delta^r_t$ changes across periods. The optimal plan this period becomes suboptimal in the next period. This would be another undesirable feature of this payment scheme.

Specifically, under the Cumulative pay, the relative weights of the current and future periods do not change from period to period, hence, once period $t > 1$ is reached, without loss of generality we can re-adjust the current discount factors so that $\delta^c_t = \delta^c_1$, $\delta^c_{t+1} = \delta^c_2$, etc. In contrast, under the Random pay, the relative weights of the current and future periods will change from period to period because of the weight put on the past periods. The past periods have already occurred, and therefore have the same weight as the current period in terms of the probability of being paid. In Appendix A, we outline how the weights put on the current and the future periods change under the Random pay as the game progresses.

Is there any payment scheme, other than the Cumulative pay, that induces the same discounting as the objective function (1)? We now demonstrate that such discounting can be achieved by paying each subject based on their last period.

Last period payment scheme Each subject receives the payoff for the last realized period T. With probability $(1 - p)$ the game lasts for only one period and the subject receives π_1. With probability $(1-p)p$ the game lasts for exactly two periods and the subject receives π_2, etc. Hence, the subject's expected payoff is

$$EPay^{Last} = (1-p)\pi_1 + p(1-p)\pi_2 + p^2(1-p)\pi_3 + \cdots = (1-p)\sum_{t=1}^{\infty} p^{t-1}\pi_t. \tag{5}$$

This is exactly $(1 - p)$ times the expected payoff under the Cumulative payment scheme.

Hence, the theory predicts that, up to the normalization factor $(1 - p)$, the incentives induced under the Last period payment are the same as those induced under the Cumulative payment, with both being consistent with the objective function (1).

If the payoffs are replaced by utilities, and if the subject's utility is concave in the payoffs, then the above equivalence result does not hold. Specifically, the subject's expected utility under the Cumulative payment scheme is not equivalent to U, the subject's utility in the infinite-horizon setup defined in equation (1). This discrepancy implies that the subjects would behave more myopically under the cumulative payment scheme than what the payoff specification U predicts.[3] This has been pointed out in the literature; in the context of a growth model, Lei and Noussair (2002) note that risk averse agents would behave more myopically as they would under-weigh the future uncertain payoffs relative to the risk neutral agents. However, as it is obvious from equation (5), the subject's expected utility under the Last period payment scheme is still equivalent to U defined in equation (1). Therefore, if the subjects are risk averse, the Last period payment scheme induces the players' objective function under the original dynamic game more accurately than the Cumulative payment scheme.

2.2 Implications for supportability of cooperation

Consider the implications of the payment schemes for supportability of cooperation as equilibria in dynamic random-termination games. In agreement with the recent experimental literature on infinite horizon games (Dal Bo 2005; Duffy and Ochs 2009; Dal Bo and Frechette 2011; Blonski et al. 2011), we consider the simplest and best-studied among dynamic games, an infinitely repeated Prisoners' Dilemma game (PD). Qualitatively similar reasoning applies to other dynamic games; see Sherstyuk et al. (2011) for comparison of payment schemes in a more complex infinite-horizon game with dynamic externalities.

Denote a Prisoners' Dilemma stage game strategies as Cooperate and Defect. Let a be each player's payoff if both cooperate, b be own player payoff from defection if the other player cooperates, c be the payoff if both defect, and d be own payoff from cooperation if the other player defects. In a PD game, $b > a > c > d$, Defect dominates Cooperate, and $2a > b + d$, the mutual cooperation outcome is joint payoff-maximizing.

Compare supportability of the cooperative outcome in such a PD under Cumulative, Random and Last period pay using trigger (Nash reversion) strategies. As Cumulative and Last period payment schemes are theoretically equivalent (assuming risk-neutrality), it is sufficient to compare Cumulative and Random pay. To facilitate the comparison, we use

[3] Assume a strictly concave, increasing, and (without loss of generality) nonnegative-valued utility function u. Then u is subadditive, $u(\pi_1 + \pi_2 + \cdots + \pi_t) < u(\pi_1) + u(\pi_2) + \cdots + u(\pi_t)$ for all t. Hence, $u(\pi_1 + \pi_2) = u(\pi_1) + \alpha_2 u(\pi_2)$ for some $0 < \alpha_2 < 1$. Similarly, we have $u(\pi_1 + \pi_2 + \pi_3) = u(\pi_1) + \alpha_2 u(\pi_2) + \alpha_3 u(\pi_3)$ for some $0 < \alpha_3 < 1$, and so on. Therefore

$$EPay^{Cum} = u(\pi_1) + \sum_{t=2}^{\infty} p^{t-1} \alpha_t u(\pi_t), \;\; 0 < \alpha_t < 1 \;\text{ for all } t = 2, ...$$

Clearly, the weight placed on the utility in period 1 (relative to the utilities in the subsequent periods) is larger under the Cumulative payment scheme than in equation (1).

the normalized discount factors, $\sum_{t=1}^{\infty} \delta_t = 1$, for both Cumulative and Random payment schemes.

Supportability of Cooperation as a Subgame-Perfect Nash Equilibrium Cooperation may be supported as a Subgame Perfect Nash Equilibrium (SPNE) using the trigger strategy, from period $t = 1$ onwards, if one-shot gain from defection is outweighed by the future loss due to the defection, in every period. Under the trigger strategy,

$$Gain(Defect) = \delta_1(b - a),$$

$$Loss(Defect) = \delta_2(a - c) + \delta_3(a - c) + \cdots = (a - c)\sum_{t=2}^{\infty} \delta_t = (a - c)(1 - \delta_1),$$

where δ_t refers to the period t discount factor, with the current period denoted as $t = 1$; the last equality follows from the normalization of discount factors. Thus cooperation may be sustained as a SPNE starting from period $t = 1$ if:

$$\delta_1(b - a) \leq (1 - \delta_1)(a - c), \quad \text{or} \quad \frac{\delta_1}{1 - \delta_1} \leq \frac{a - c}{b - a}. \tag{6}$$

Under the Cumulative pay, the gains and losses from defection do not change in any period $t \geq 1$, assuming that the history has no defection up to this period, and $\delta_1^c = (1 - p)$, $(1 - \delta_1^c) = p$. Thus, under the Cumulative pay, cooperation in every period may be sustained as a SPNE if:

$$\frac{1 - p}{p} \leq \frac{a - c}{b - a}.$$

Under the Random pay, we have, from (3), $\delta_1^r = (-ln(1 - p))\frac{1-p}{p}$ and therefore $(1 - \delta_1^r) = 1 + (ln(1 - p))\frac{1-p}{p}$. Cooperation may be sustained as a Nash Equilibrium from period 1 if:

$$\frac{(-ln(1 - p))\frac{1-p}{p}}{1 + (ln(1 - p))\frac{1-p}{p}} \leq \frac{a - c}{b - a}.$$

As shown by inequality (4), $\delta_1^r > \delta_1^c$, which also implies that $(1 - \delta_1^r) < (1 - \delta_1^c)$. We obtain that $\frac{\delta_1^r}{1-\delta_1^r} > \frac{\delta_1^c}{1-\delta_1^c}$. Hence, under some parameter values, we may have:

$$\frac{\delta_1^c}{1 - \delta_1^c} \leq \frac{a - c}{b - a} < \frac{\delta_1^r}{1 - \delta_1^r}. \tag{7}$$

That is, for some parameter values, cooperation may be sustained as a SPNE starting from period 1 under the Cumulative, but not under the Random pay.

Example 1. Consider $p = 3/4$. Then $\delta_1^c = 0.25$, whereas $\delta_1^r = 0.46$. Let $a = 100$, $b = 180$, $c = 45$, $d = 0$. We obtain that, in period $t = 1$ under the Cumulative pay (as in any other period), $EPay^{Cum}(Cooperate) = 100 > 78.75 = EPay^{Cum}(Defect)$, and hence cooperation may be sustained as a SPNE. In contrast, in period $t = 1$ under Random, $EPay_1^{Ran}(Cooperate) = 100 < 107.4 = EPay_1^{Ran}(Defect)$, and hence cooperation may not be sustained as a SPNE under the Random pay from period $t = 1$.

In addition, under the Random pay, the relative gains and losses from cooperation and defection change from period to period, due to the changes in relative weights put on the present and the future. In particular, incentives to cooperate increase under the Random pay as the game progresses. This is discussed in detail in Appendix B. However, incentives to cooperate in periods beyond 1 could only matter if the players use strategies that are more forgiving than trigger. If an initial defection results in an infinite sequence of defections from the other player, as the trigger strategy suggests, then the gains from cooperation in later periods cannot be realized.[4]

Supportability of Cooperation as a Risk-Dominant Equilibrium Blonski and Spagnolo (2001), Dal Bo and Frechette (2011) and Blonski et al. (2011) present evidence that being a subgame-perfect Nash equilibrium is a necessary, but not a sufficient condition for cooperation to prevail in infinitely repeated PD games. They suggest that the following risk-dominance (RD) criterion, adopted to infinitely repeated PD games, organizes the data better than the SPNE criterion. Constrain attention to only two strategies, Trigger (T) and Always defect (AD), and define μ as the minimal belief about the others playing Trigger, rather than AD, that would make cooperation a best response. The lower μ is, the smaller is the basin of attraction of AD strategy, and the larger is the set of beliefs about the opponent's play that makes it worthwhile cooperating rather than defecting. Cooperation is risk-dominant if $\mu \leq 0.5$, i.e., if it is a best response as long as the player believes that the other player plays Trigger, rather than AD, with a probability of at least 50%. It is straightforward to show that Cooperation is risk-dominant if $\delta_1 \leq \frac{a-c}{b-d}$, a condition more demanding than condition (6) for supportability of cooperation as SPNE (see Blonski and Spagnolo 2001). Because $\delta_1^r > \delta_1^c$, there may be parameter values such that

$$\delta_1^c \leq \frac{a-c}{b-d} < \delta_1^r. \tag{8}$$

If this is the case, cooperation may be sustained as a RD equilibrium starting from period 1 under the Cumulative, but not under the Random pay.

[4]Previous experimental evidence (Dal Bo and Frechette 2011) indicates that within a repeated game, cooperation rates are the highest in period 1, and then decrease in later periods. This suggests that incentives to cooperate are the most critical in period 1.

Example 2. As in Example 1, consider $p = 3/4$, but now let $a = 100$, $b = 180$, $c = 25$, $d = 0$. The only difference from Example 1 is that the payoff from mutual defection c has changed from 45 (in Example 1) to 25. As before, $\delta_1^c = 0.25$, and $\delta_1^r = 0.46$. Cooperation may now be supported as a SPNE in period 1 under both Cumulative and Random pay: $EPay^{Cum}(Cooperate) = 100 > 63.75 = EPay^{Cum}(Defect)$, and $EPay_1^{Ran}(Cooperate) = 100 > 96.62 = EPay_1^{Ran}(Defect)$. However, $\frac{a-c}{b-d} = 0.42$, and hence $\delta_1^c = 0.25 \leq \frac{a-c}{b-d} < 0.46 = \delta_1^r$. In order to sustain cooperation from period 1, the minimum belief about the other player playing Trigger, rather than AD, under the Cumulative pay must be $\mu^c = 0.14$, whereas under the Random pay, it must be $\mu^r = 0.77$. That is, cooperation may be sustained as a risk-dominant equilibrium from period 1 under the Cumulative, but not under the Random pay.

3 Experimental design

The experiment is designed to test the effects of payment schemes on cooperation rates. We employ an infinite-horizon prisoner's dilemma (PD) experimental game as the simplest and the most-studied in the context of infinite-horizon games modeled using random continuation. Specific design elements build on the findings from the existing studies reviewed in Section 1, and on the theoretical predictions of Section 2.

In each experimental session, participants made decisions in a number of repeated PD games, with each game consisting of an indefinite number of periods. A game continued to the next period with a given continuation probability of $p = 0.75$, yielding the expected game length of 4 periods. Each experimental session belonged to one of the three treatments.

Treatments The three treatments differed in the way the subject total payoff within each repeated game was determined. (As before, T denotes the last realized period in the game):

1. Cumulative payment: Each subject receives the sum of the period-wise payoffs from all periods $1, \ldots, T$.

2. Random-period payment: The payoff to each subject is randomly chosen from all the realized period-wise payoffs over T periods.

3. Last-period payment: Each subject receives the payoff in period T, i.e. the last realized period of the game.

Based on the analysis from Section 2, we hypothesize that the Random payment treatment may result in more myopic (less cooperative) behavior than either the Cumulative or the

Last-period payment treatments. The Cumulative and the Last-period treatments should result in the same cooperation rates, provided the subjects are risk neutral.

The parameter values for the repeated PD game used in the experiment are presented in Table 1.

TABLE 1 AROUND HERE

To allow for a clear-cut distinction between the Cumulative and the Random payment schemes, we chose the parameters for the game so that incentives to cooperate would be substantially higher under the Cumulative then under the Random pay: $a = 100$, $b = 180$, $c = 20$, $d = 0$, with $p = 3/4$. Under these parameter values, cooperation is a SPNE and a risk-dominant action under Cumulative. Cooperation gives a 67% higher expected payoff than defection, assuming the other players are playing Trigger; further, it is sufficient that only 11 percent of the other players use Trigger, rather than Always Defect (AD) strategy, to make it worthwhile cooperating under Cumulative. In comparison, cooperation is only borderline supportable as SPNE under Random; in period 1 it gives only a 6% higher expected payoff than defection. Moreover, cooperation is not risk-dominant under Random; a player should believe that at least 60% of the other players are playing Trigger, rather than AD, to be induced to cooperate.[5] Gains from cooperation relative to defection continue to be lower under Random than under Cumulative in later periods (see Table 1).

Several indefinitely repeated PD games were conducted in each session. To allow the subjects to gain experience with the game, we targeted to complete at least 100 decision periods (around 25 repeated games) in each session, which was easily achieved within 1.5 hours of time allocated for the session (including instructions). The games stopped at the end of the repeated game in which the 100th period, counting from the start, was reached.

The subjects matchings were fixed within each repeated game, and the subjects were re-matched with a different other subject in each new repeated game. Up to 16 subjects participated in a session. For a session with N subjects, a round-robin matching procedure was used in the first $(N-1)$ games, so that each subject was matched with another subject

[5]It is possible to come up with parameter values such that, under Cumulative, cooperation is both supportable as a SPNE, and a risk-dominant action, whereas under Random, it is not supportable as a SPNE; e.g., $a = 52$, $b = 96$, $c = 27$, $d = 0$, and $p = 3/4$. However, gains from cooperation relative to defection are smaller under such parameter values, and the basin of attraction of AD strategy is larger. Previous studies (Dal Bo and Frechette 2011, Blonski et al. 2011) indicate that cooperation may prevail only when gains from cooperation far outweigh gains from defection. We therefore choose a setting that is very pro-cooperative under the Cumulative pay, and borderline cooperative, and not risk-dominant, under the Random pay.

they have not been matched before; after $(N-1)$ games, we used random rematching across games.[6]

Our pilot experiments indicated that the realized games duration, especially in the early repeated games, had a substantial effect on subject cooperation rates. To control for variations in cooperation rates across treatments caused by the realized lengths of games, we conducted the sessions in matched triplets, with one session per each treatment – Cumulative, Random and Last, – using the same pre-drawn sequence of random numbers to determine the repeated game lengths. A new pre-drawn sequence of random numbers was used for the next triplet of experimental sessions, and so on.[7]

Procedures The experiment was computerized using z-Tree software (Fischbacher, 2007). The actual runs were preceded by experimental instructions and review questions which checked the participants' understanding of how decisions translated into payoffs (attached). Participants made decisions in all decision periods until the games stopped. We used neutral language in the instructions, with each repeated game referred to as a "series," and periods of a repeated game referred to as "rounds."

The explanations of how continuation of the series to the next round was determined were similar to the experimental instructions given in Duffy and Ochs (2009). The participants were instructed that a random number between 1 and 100 was drawn for each round; if the number was 75 or below, then the series continued to the next round, and each participant was matched with the same other person as in the previous round. If the number was above 75, then the series ended. If a new series started, then each participant would be matched with a different other person than in the current round. To enhance the subject understanding of the random continuation process, the on-line program included a test box, which allowed the subjects to draw random numbers and explained how the random number draw for the round determined whether the current series continued to the next round or stopped. A screen shot of the decision screen is included in experimental instructions. At the end of each decision period, the subjects were informed about own and their match's decisions, their payoff, the random number draw, whether the series continued or stopped, and, correspondingly, whether they would be matched with the same or a different person in the next round. A history window provided a record of past decisions and payoffs.

[6] This matching protocol is the same as reported in Duffy and Ochs (2009); in comparison, Dal Bo and Frechette (2011) use random rematching across repeated games.

[7] The effect of realized duration of the previous game on subject decision to cooperate has been noted in the literature; e.g., Dal Bo and Frechette (2011). Engle-Warnick and Slonim (2006) use the same pre-drawn sequences of game lengths for multiple sessions to control for variations in repeated game durations.

The procedures were the same in all three treatments of the experiment, except for how the payment within each series (repeated game) was determined. The total payment for each subject was the sum of series (repeated games) payoffs.

At the end of the session, each subject responded to a short post-experiment survey (attached) which contained questions about one's age, gender, major, the number of economics courses taken, and the reasoning behind choices in the experiment.

Experimental sessions lasted up to 1.5 hours each, including instructions. The exchange rates were set at \$400 experimental = \$1 US in the Cumulative treatment, and \$100 experimental = \$1 US in the Last period and the Random pay treatments. The average payment was US \$22.49 per subject (\$22.93 under Cumulative, \$20.66 under Random, and \$22.91 under Last), including a \$5 participation fee.

4 Experimental results

The experiment was conducted at the University of Hawaii at Manoa in September - October 2011. It included the total of 158 subjects, mostly undergraduate students, with about half of the participants (49%) majoring in social sciences or business. 47.4% of the participants were men, and 52.6% were women. The mean number of economics courses taken by the participants was 1.51, and was not significantly different across treatments.

We conducted twelve experimental sessions, with four independent sessions per treatment, using four random number sequences (draws) to determine repeated game durations. Between 8 and 16 subjects participated in each session, with all but two sessions having at least 12 subjects. A summary of experimental sessions is given in Table 2.

TABLE 2 AROUND HERE

We present our analysis in three subsections. In subsection 4.1, we consider the effects of the payment schemes on subject cooperation rates. In subsection 4.2, we study if the differences across treatments may be traced to the differences in the strategies that the experimental participants adopt under different payment schemes. In subsection 4.3, we briefly discuss other findings of interest for random continuation games.

4.1 Cooperation rates across treatments

Figure 2 displays cooperation rates by decision period by session, with games separated by vertical lines. Each three sessions conducted under a given sequence of random draws are displayed on a separate panel. The sessions are labeled by the date conducted, and by treatment. Table 3 shows mean cooperation rates in each session grouped by the treatment and by the random draw sequence, for four time intervals of interest: overall, in the first game, and in the first and the last half of the session.[8] We show cooperation rates both for all rounds in a game (top part) and for the first rounds only (bottom part). The latter is of interest because of the time inconsistency and changing incentives to cooperate as the game progresses under the Random pay, as discussed in Section 2 above. The p-values for the differences between each two treatments for the Wilcoxon signed ranks test for matched pairs, using session averages as units of observation, are reported below the tables. Given our theoretical prediction that cooperation rates under Cumulative are no different from those under Last, and both are higher than under Random, we use two-sided test for the comparison of Cumulative and Last period pay, and one-sided tests for the comparison of Cumulative and Random, and Random and Last, payment schemes.

FIGURE 2 and TABLE 3 AROUND HERE

Figure 2 and the Table 3 indicate that for each sequence of random draws, the highest cooperation rates were observed in the sessions conducted under either Cumulative or Last period payment scheme. Cooperation rates for the Random payment sessions were lower, or no higher, than under the other two treatments, under each random draw. Remarkably, these differences become apparent as early as in the very first repeated game. Overall, the subjects in the Cumulative sessions displayed the cooperation rate of 55%, as compared to 36% under Random, and 53% under Last (Table 3, top). The differences in cooperation rates between Cumulative and Random, and between Random and Last, are significant at 6.25% significance level, the highest significance level possible for this number of matched sessions. In comparison, the differences in overall cooperation rates between Cumulative and Last are insignificant ($p = 0.8750$). The same rankings of cooperation rates across treatments are confirmed for the first and the last halves of the sessions, or if we constrain the attention to average cooperation rates in the first rounds of repeated games (Table 3, bottom).

These differences in cooperation rates between treatments cannot be attributed to subject variations in intrinsic propensities to cooperate between Random and the other two treatments, as cooperation rates in the initial round of the first repeated game were over 50% in all but one session (Table 3, bottom), and indistinguishable across treatments; p-values for the differences between Cumulative and Random, Cumulative and Last, and Random and Last, are 0.4375, 0.8750, and 0.4375, correspondingly.

[8]The second half of the session is considered to start with the first repeated game that starts after 50 decision periods have passed.

In sum, the session-level data give us initial support for the hypotheses of the effect of payment schemes on incentives to cooperate. We now turn to individual-level data for further analysis. Table 4 displays the results of probit regression of decision to cooperate depending on the treatment and other explanatory variables of interest.

TABLE 4 AROUND HERE

We present the estimations of three models. Model 1 uses only treatment variables ("random" or "last", with "cumulative" serving as a baseline), "decision period" and "period squared" (counting from the beginning of the session) to account for subject experience, a dummy variable "new game" to account for a possible restart effect at the beginning of each new game, round within the current game, and the previous repeated game length as independent variables. Model 2 adds dummies for random draw sequences (draw 2, draw 3 and draw 4, with draw 1 used as a baseline), to control for possible differences due to sequences of game durations. Model 3 adds own decision in the first round of the first game as a proxy for individual intrinsic propensity to cooperate, and the previous decision of the other player, to account for subject responsiveness to other's decisions.

The results of probit regressions confirm the presence of treatment effects. In all three models, the coefficient of the treatment dummy "last" is not significantly different from zero, indicating no differences in propensity to cooperate between Cumulative and Last. In contrast, the coefficient of "random" is negative and highly significant ($p = 0.051$ under Model 1 and $p = 0.000$ under models 2 and model 3). According to Model 3, a participant under Random is 14.76 percent less likely to cooperate than a participant under Cumulative, controlling for differences in previous games lengths, the other player's previous decision, and own initial propensity to cooperate.[9] We conclude:

Result 1 *Consistent with the theoretical predictions, subject cooperation rates were no different between the Cumulative and the Last period payment schemes. Cooperation rates under the Random pay were significantly lower than under the other two payments schemes.*

4.2 Individual behavior: strategies

We now consider whether lower cooperation rates under Random pay as compared to Cumulative and Last period pay may be attributed to a lower percentage of experimental

[9] We checked the robustness of the results by excluding each of the twelve sessions, one at a time, from the regressions. The findings are robust to these modifications. In particular, the treatment effects persist if we exclude the most cooperative session (Cumulative pay session, Draw 1: cooperation rate=0.75%), or the least cooperative session (Random pay session, Draw 2: cooperation rate=0.17%), from the analysis.

participants using cooperative strategies under Random pay.

We use two approaches to study strategies: subjects' self-reported strategies from the post-experiment questionnaire, and strategies inferred from subject decisions in the experiment.

As part of the post-experiment questionnaire, participants in each session answered the following question: "How did you make your decision to choose between A and B?" ("A" is the cooperative action, and "B" is defection; see Table 1.) Two independent coders then classified the reported strategies into the following categories: (1) Mostly Cooperate; (2) Mostly Defect; (3) Tit-For-Tat (TFT); (4) Trigger (including Trigger-once-forgiving, which prescribes to revert to defection only after the second observed defection of the other player); (5) Win-Stay-Lose-Shift (WSLS), which prescribes cooperation if both cooperate or both defect, as discussed in Dal Bo and Frechette (2011); (6) Random choice; (7) Other (unclassified). The results are presented in Table 5, with modal strategies given in bold.

TABLE 5 AROUND HERE

Further, based on each subject's individual decisions, we calculated the percentages of correctly predicted actions for the following strategies: (1) Always Cooperate (AC); (2) Always Defect (AD); (3) TFT; (4) Trigger; (5) Trigger-once-forgiving, as explained above; (6) Trigger with Reversion (equivalent to Trigger, but reverting back to cooperation after both players cooperate); (7) WSLS, as explained above.

Table 6 below reports the percentage of subjects whose behavior is best explained by each of the above strategies, along with the average accuracy (percentage of correctly predicted actions) of these best predictor strategies.[10]

TABLE 6 AROUND HERE

The table reports that, on average, the best predictor strategies correctly explain between 80 and 89 percent of subject actions in each treatment, with the accuracy slightly increasing from the first to the second half of the sessions. (For many subjects, the accuracy of best predictor strategies was 100 percent.)

The differences in strategy compositions between the Random and the other two treatments are apparent from both self-reported and estimated strategies. From Table 5, 17.86%

[10]Table 7, included in Appendix C, reports the percentages of all actions that can be explained by each of the strategies listed above. Interestingly, the strategy that explains the highest percentage of actions overall is Trigger with Reversion, correctly predicting between 72 and 78 percent of all actions in each of the three treatments. TFT closely follows, explaining between 69 and 76 percent of all actions.

of subjects under Cumulative pay and 15.38% of subjects under Last period pay report using the non-cooperative "Mostly Defect" strategy. This compares with almost twice as high a share, or 32%, of subjects reporting using "Mostly Defect" strategy under Random pay, where it is the modal self-reported strategy. The modal self-reported strategies under Cumulative and Last are both pro-cooperative: TFT under Cumulative (26.79%) and "Mostly Cooperate" under Last (25%). Consistent with self-reports, "Always Defect" is estimated to be the best-predictor strategy for only 19.64% of subjects under Cumulative and 25% of subjects under Last, as compared to 42% of subjects under Random (Table 6, overall). TFT is the estimated modal strategy for Cumulative (used by 39.29% of subjects), and both TFT and Trigger-with-Reversion are the estimated modal strategies under Last (both used by 28.85% of subjects). In contrast, the estimated modal strategy under Random is "Always Defect" (used by 42% of subjects). We also observe that these differences across treatments hold for both the first and the second halves of the sessions, as well as overall.

Based on the above observations from Tables 5 and 6, we conclude:

Result 2 *Lower cooperation rates under the Random pay treatment as compared to the other two treatments are explained by a higher percentage of subjects adopting the non-cooperative "Always Defect" strategy under this treatment. In comparison, a higher percentage of subjects under the Cumulative and the Last payment treatments adopted pro-cooperative Tit-For-Tat or Trigger-with-Reversion strategies.*

A notable difference between Cumulative and Last is that cooperation rates (and shares of cooperative strategies) increase from the first to the last part of the sessions under Cumulative, but stay about the same under Last. In particular, the percentage of subjects estimated to use the non-cooperative "Always Defect" strategy decreases from 28.57% in the first half of the session to 17.86% in the second half of the session under the Cumulative pay (Table 6). In comparison, the percentage of subjects estimated to use this non-cooperative "Always Defect" strategy remains steady at 25% under the Last period pay. These percentages, however, are far lower than under the Random pay in both treatments and both halves of the sessions.

4.3 Other observations of interest

Before turning to the conclusions, we make some additional observations that are of interest in studying cooperation in random continuation repeated games. First, as part of the experimental design, we matched sessions by the random draw sequence that determined the repeated game durations. We now consider whether the realized game durations had a significant effect on subject behavior. Figure 2 suggests that, indeed, the dynamics of cooperation rates differed substantially across random draw sequences, and were somewhat similar for sessions within each random draw sequence. The estimations of determinants of cooperation using Models 2 and 3, reported in Table 4, strongly indicate that the random draw sequences had a significant effect on decision to cooperate, with coefficients of the "random draw" dummies all significant at one percent level. In particular, Draw 1 was the most pro-cooperative, and Draw 2 was the least pro-cooperative. How are these random draws different? We take a closer look at the realized game durations under the random draws. Both earlier studies (Dal Bo and Frechette 2011) and our estimations reported in Table 4 indicate that the previous game length has a positive and significant effect on cooperation. However, the differences in average game durations across the sequences of draws cannot explain the differences in cooperation rates: Returning to Table 2, we observe that Draw 1, although was the most cooperative, did not have the highest average game duration. The picture is different if we look at the average game duration in the first half of the sessions, i.e., in games starting before period 51 (also reported in Table 2). The average game duration in the first half of the session was the highest under Draw 1 (5 rounds), resulting in the highest cooperation rate. In contrast, the average game duration was the lowest under Draw 2 (3.64 rounds), resulting in the lowest cooperation rates. We conclude:

Result 3 *The history of previous game durations, especially early in the sessions, had a significant effect on subject behavior. Sessions that had longer repeated games in the first half resulted, on average, in higher cooperation rates.*

The above indicates that experimental participants do not always use the objective expected length of the game to weigh pros and cons of cooperation and defection, but instead may adjust their subjective beliefs about game durations based on past experiences.[11]

Further, as discussed is Sections 1 and 2 above, a widely studied question in the experimental literature on infinitely repeated games is whether the fundamentals of the PD game, such as Cooperation being the subgame perfect Nash Equilibrium (SPNE), or risk-dominant equilibrium (RD), have an effect on subject cooperation rates and their evolution over time (Duffy and Ocks, 2009; Dal Bo and Frechette 2011, Blonski et al. 2011). From Section 3, the parameter values employed in our design are such that cooperation is a SPNE and a risk-dominant equilibrium under the Cumulative and the Last payment schemes, and

[11]Participants' responses to post-experiment questionnaire indicate other possible misconceptions about game durations. Some participants believed that the probability of a repeated game ending increased once the game continued beyond the expected four rounds. For example, Subject 8 in Session 3 explained his choice between A and B as follows: "I chose A in the beginning, then chose it until either it was the 5th round where I chose B or until the other person chose B."

is (borderline) SPNE and is not risk-dominant under the Random pay. Consistent with the previous studies, we observe an upward trend in cooperation rates in all sessions under the Cumulative pay, and a non-decreasing or increasing trend in all sessions under the Last period pay. Overall, cooperation rates increased from 48% in the first half of the session to 63% in the second half of the sessions under Cumulative, and from 51% to 55% under Last (Table 3). However, we also observe a non-decreasing (or increasing) trend in cooperation in the sessions under the Random pay, where cooperation is not a risk-dominant action. Specifically, cooperation rates increased, on average, from 33% in the first half of the sessions to 39% in the second half of the sessions under the Random pay. This non-decreasing trend in cooperation rates may be attributed to time inconsistency under the Random pay, as discussed in Section 2. Subjects' increasing incentives to cooperate within each repeated game may have behavioral spillover effects on subsequent repeated games, leading to non-decreasing (or increasing) cooperation rates over time. The trend may also be explained by the experimental participants adopting more forgiving strategies than assumed in the standard theoretical analysis of supportability of cooperation. The analysis of Section 4.2 indicates that most of the participants employed strategies more forgiving than Trigger, such as TFT or Trigger-with-Reversion, allowing the game to return to the cooperative path even after observed defections.

Our experiments also provide an across-study confirmation of the significance of game fundamentals as determinants of subject behavior. Accidentally, the characteristics of the PD game we use, as presented in Table 1, are in many aspects similar to that studied in Duffy and Ocks (2009), where $a = 20$, $b = 30$, $c = 10$, $d = 0$, and $p = 0.9$. Under the Cumulative pay method, which is employed in Duffy and Ocks (2009) and in our Cumulative pay treatment, both games have the minimal discount factor to make cooperation supportable as a SPNE (using Nash reversion) at $\underline{\delta} = 0.5$; in both games, the expected payoff from cooperation is 67% higher than the payoff from defection; and in both games, the minimal belief about the other players using Trigger rather than AD that makes it a best response to cooperate is $\mu = 0.11$. Duffy and Ochs report about 55% overall cooperation rate under their parameters. Curiously, the overall cooperation rate under the Cumulative pay in our study is also 55%, suggesting the power of the game fundamentals in determining subject cooperation rates.

In addition, the regression results reported in Table 4 confirm previous findings on the existence of the restart effect, and on the effect of other's previous action as well as own initial action on one's decision to cooperate (Dal Bo and Frechette, 2011). Specifically, the coefficient on the "new game" dummy variable is positive and significant at any reasonable significance level in all three models estimating individual decisions to cooperate (Table 4); the restart effect is also obvious from comparing the average cooperation rates in all round with those in the first rounds of repeated games (Table 3, top and bottom).[12]

We also observe that the subjects who cooperated in the very first round of the first game were significantly more likely to cooperate later in the session as well; the coefficient on "own first decision" in the estimation of the decision to cooperate under Model 3 is positive and highly significant ($p = 0.010$). Finally, other player's previous cooperative action had a large positive effect on own decision to cooperate; $p = 0.000$ for the coefficient of "other's previous decision," Model 3, Table 4. This confirms that the subjects largely adopted strategies that were highly responsive to the other player's behavior.

Interestingly, we find that neither demographics (age and gender), nor major, nor the number of economics courses taken significantly affected the subject probability of cooperation.

5 Conclusions

In summary, this paper presents the first systematic study of the effects of the payment schemes on subject behavior in random continuation dynamic games. We show that, under the risk-neutrality assumption, the Cumulative and the Last period payment schemes are theoretically equivalent, whereas the Random period payment scheme induces a more myopic behavior. The latter is due to higher discounting of the future induced by the Random period payment in combination with random continuation.

The results of the experimental comparison of the three payment schemes, studied in the context of an infinitely repeated Prisoners' Dilemma game, largely support the theoretical predictions. In line with the proposed theory, we find that the Random period payment scheme results in more myopic behavior, manifested in lower cooperation rates, than the Cumulative or the Last period payment schemes. The Cumulative and the Last period payments result, overall, in similar cooperation rates among subjects. We further find that lower cooperation rates under the Random pay are explained, on the individual level, by a higher percentage of subjects adopting non-cooperative Always Defect strategies under this payment scheme, as compared to either the Cumulative or the Last period pay.

This paper also contributes to understanding of other determinants of cooperation in indefinitely repeated PD games. In particular, we find that realized lengths of repeated games early on in the session have a significant effect on subject decisions to cooperate, with

[12] We observe that, overall, cooperation rates in the first round were higher than in all rounds by 5% under the Cumulative pay (60% versus to 55%), by 7% under the Random pay (43% versus 36%), and by 14% under the Last period pay (67% versus 53%); see Table 3.

sessions that have longer games in the beginning typically resulting in higher cooperation rates throughout the session.

We now revisit the reasons for considering alternatives to Cumulative payment in random continuation games, as given in Section 1 above, and discuss the corresponding findings. One reason for considering alternatives to Cumulative pay was that the latter scheme assumes that the subjects are risk-neutral. In comparison, the Last period pay is theoretically applicable under any attitudes towards risk. The observed lack of significant differences between these two payment schemes in our experiment suggests that risk aversion does not play a significant role in simple indefinitely repeated experimental games that are repeated many times, as in our study. This is hardly surprising, as the stakes in each round of play are fairly small (with the maximum of \$0.45 under the Cumulative pay and \$1.80 under the Random and Last period pay), and there are many repetitions of the repeated game itself. All of this allows to smooth out the risk across decisions, and suggests an environment conducive to risk-neutrality.

Are the observed differences in subject behavior across payment schemes likely to hold for other dynamic games?[13] Our theoretical results suggest that Random pay could induce more myopic (less cooperative) behavior than either the Cumulative or the Last period pay in an arbitrary dynamic indefinite-horizon setting. In a related working paper, Sherstyuk et al. (2011) present results of an experiment that compares the three payment schemes using a complex indefinite-horizon game with dynamic externalities. The results of the latter study confirm that the Random payment scheme induces a significant present period bias, resulting in less cooperative outcomes as compared to the Cumulative or the Last period payment schemes. This suggests that the theoretically predicted present period bias induced by the Random pay is a robust phenomenon that is likely to be observed under a variety of indefinite-horizon experimental settings.

Another motivation for the search for an alternative to the Cumulative pay was to reduce variability of the experimenter budget that may be caused by variations in dynamic game lengths. While this is clearly not an issue in settings where each dynamic game is itself repeated many times, as is typical in studies of simple infinitely repeated games, experimenter budget variability may be a significant concern in other settings (see Section 1 for discussion). Comparing the variance of average per subject per repeated game payments under the three payment schemes clearly indicates on more variable pay under the Cumulative scheme.

[13] In testing the implications of the payment schemes in dynamic situations, one faces a trade-off between complexity of the game and the number of times the game can be repeated within a reasonable session length (1.5-3 hours). Our design choice in this experiment was to forego complexity in favor of repetition, thus allowing the subjects to gain experience with the game.

Specifically, the mean per subject per repeated game pay under Cumulative was US 69.73 cents, with the standard deviation of 60.78 cents, as compared the mean of 60.53 cents and the standard deviation of 20.22 cents under Random, and the mean of 73.33 cents and the standard deviation of 16.33 cents under the Last period pay. This confirms that using the Last period payment scheme reduces subject payoff variability within a repeated game.

Overall, our results strongly indicate that the Random period pay is not an acceptable alternatives to the Cumulative pay in inducing dynamic incentives in indefinite-horizon games, as it creates a present period bias. The Last period payment scheme appears to be a viable alternative as it induces incentives to cooperate similar to those under the Cumulative pay, at least in simple indefinite-horizon repeated games. In addition, the Last period payment scheme reduces payoff variability within a repeated game. Comparison of the Cumulative and the Last period payment schemes in other dynamic indefinite-horizon settings would be a promising avenue for further research.

The present-period bias induced by the Random pay be may be successfully exploited by experimentalists in other contexts. Azrieli et. al. (2011) show that the random payment method is the only incentive-compatible payment method in multiple-decision non-dynamic settings. The Random payment also appears to be a good alternative to the Cumulative payment for repeated (or more generally dynamic) settings where experimenters seek to reduce the dynamic game effects and focus the experimental subjects' attention on decisions in the current decision period. Examples of the latter may include auctions, markets, and other settings, where repetition is needed for subjects to gain experience with the game, but the supergame effects which come from repetition are to be minimized.

Appendix A: Discount factors in random continuation games in periods beyond Period 1

Consider how the relative weights between the current and the future change under the Random pay as the game progresses beyond period 1. In period 2, using manipulations similar to those for equation (3), we obtain that the expected payoff is:

$$EPay^r \mid_{t=2} = (1-p)\frac{1}{2}[\pi_1 + \pi_2] + p(1-p)\frac{1}{3}[\pi_1 + \pi_2 + \pi_3] + \dots$$

$$= \pi_1 \underbrace{\left\{(1-p)\frac{1}{2} + (1-p)p\frac{1}{3} + \dots\right\}}_{\delta_1^{r2}} +$$

$$+\pi_2 \underbrace{\left\{(1-p)\frac{1}{2}+(1-p)p\frac{1}{3}+(1-p)p^2\frac{1}{4}+\dots\right\}}_{\delta_2^{r2}}+$$

$$+\pi_3 \underbrace{\left\{(1-p)p\frac{1}{3}+(1-p)p^2\frac{1}{4}+(1-p)p^3\frac{1}{5}+\dots\right\}}_{\delta_3^{r2}}+\dots$$

$$=\frac{1-p}{p^2}\left[\pi_1\left\{-\log(1-p)-p\right\}+\pi_2\left\{-\log(1-p)-p\right\}+\pi_3\left\{-\log(1-p)-p-\frac{p^2}{2}\right\}+\dots\right]. \tag{9}$$

Here, δ_τ^{rt} denotes the weight put under Random pay on period τ when the game is in period t. Observe that $\delta_1^{r2}=\delta_2^{r2}$ in period 2, whereas we had, from equation (3), $\delta_1^{r1}>\delta_2^{r1}$ in period 1.

In general, assume the game has progressed to period $t\geq 2$. We obtain that the expected payoff in period t is:

$$EPay^r\mid_t=(1-p)\frac{1}{t}[\pi_1+\pi_2+...+\pi_t]+p(1-p)\frac{1}{t+1}[\pi_1+\pi_2+...+\pi_{t+1}]+\dots$$

$$=\frac{1-p}{p^t}\left[(\pi_1+\pi_2+...\pi_t)\left\{-\log(1-p)-p-\frac{p^2}{2}-...-\frac{p^{t-1}}{(t-1)}\right\}+\right.$$

$$\left.+\pi_{t+1}\left\{-\log(1-p)-p-\frac{p^2}{2}-...-\frac{p^{t-1}}{(t-1)}-\frac{p^t}{t}\right\}+\dots\right]$$

$$=\frac{1-p}{p^t}\left[\left(\sum_{s=1}^{t}\pi_s\right)\left\{-\log(1-p)-\sum_{s=2}^{t}\frac{p^{s-1}}{s-1}\right\}+\sum_{s=t+1}^{\infty}\left\{\pi_s\left(-\log(1-p)-\sum_{q=2}^{s}\frac{p^{q-1}}{q-1}\right)\right\}\right], \tag{10}$$

where $\delta_s^{rt}=\frac{1-p}{p^t}\{-\log(1-p)-\sum_{\tau=2}^{t}\frac{p^{\tau-1}}{\tau-1}\}$ is the weight put on each past period, $s<t$, and on the current period, $s=t$; and $\delta_s^{rt}=\frac{1-p}{p^t}\{-\log(1-p)-\sum_{\tau=2}^{s}\frac{p^{\tau-1}}{\tau-1}\}$ is the payoff weight put on a future period $s>t$. This implies that the relative weights put on the current period t and the future periods $s>t$, $\delta_t^{rt}/(\sum_{s=t+1}^{\infty}\delta_s^{rt})$, change as t increases.

Appendix B: Incentives to cooperate in later periods

Do relative incentives to cooperate and defect change, as the game progresses beyond the first period? As noted before, under the Cumulative pay, the gains and losses from defection do not change in periods beyond $t=1$. Under the Random pay, the relative gains and losses from cooperation and defection may change in later periods, due to the changes in relative weights put on the present and the future. Comparing gains from cooperation and defection under Random in period $t \geq 2$, from equation (10), the weight put on the current period t is δ_t^{rt}, and the future payoff weights are $\sum_{\tau=t+1}^{\infty} \delta_\tau^{rt}$. Hence, under the Nash reversion, the players in the PD game will have incentives to cooperate in period $t > 1$ if

$$\delta_t^{rt}(b-a) \leq (a-c) \sum_{\tau=t+1}^{\infty} \delta_\tau^{rt},$$

or

$$\frac{\delta_t^{rt}}{\sum_{\tau=t+1}^{\infty} \delta_\tau^{rt}} \leq \frac{a-c}{b-a}, \tag{11}$$

a condition less demanding than the requirement for cooperation in $t = 1$. Figure 3 present a numerical simulation of the current to future payoff weight ratios under continuation probability $p = 3/4$.

FIGURE 3 AROUND HERE

The figure indicates that, for periods $t > 1$, the Random payment scheme continues to induce the present period bias in behavior as compared to the Cumulative payment scheme, as $\frac{\delta_t^{rt}}{\sum_{\tau=t+1}^{\infty} \delta_\tau^{rt}} > \frac{1-p}{p}$. However, this bias decreases, and $\frac{\delta_t^{rt}}{\sum_{\tau=t+1}^{\infty} \delta_\tau^{rt}}$ approaches $\frac{1-p}{p}$ from above as t grows. This suggests that incentives to cooperate increase as the game progresses under the Random pay, but they are never as strong as incentives to cooperate under the Cumulative pay.

Appendix C: Table 7

TABLE 7 HERE

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List of Tables

List of Figures

Table 1: Experimental parameter values. Cooperation is SPNE and RD under Cumulative and Last period pay, borderline SPNE and not RD under Random pay

The stage game and continuation probability

p=0.75	A	B
A	100,100	0,180
B	180,0	20,20

Future weight in period 1

Minimal for SPNE	Cumulative&Last	Random
0.5	0.75	0.54

Min belief about Other playing Trigger to make Cooperation best response

Required for RD	Cumulative&Last	Random
0.5	0.111	0.604

Cooperate/Defect Payoff Ratio under Trigger, by period:

	period 1	period 2	period 3	period 4
Cumulative: Coop/Defect	1.67	1.67	1.67	1.67
Random: Coop/Defect	1.06	1.20	1.28	1.33

Table 2: Summary of experimental sessions

Date	Time	Session ID	# subjects	Random Draw number	Treat-ment	No of repeated games	No of decision periods	Avg game duration, rounds	Avg game duration, 1st half	Avg game duration, 2nd half	Avg pay per subject, $
10/7/2011	3:45 PM	1	14	1	Cumu	27	103	3.81	5	3	26.79
9/28/2011	10:30 AM	2	10	1	Last	27	103	3.81	5	3	25.10
9/28/2011	12:30 PM	3	12	1	Random	27	103	3.81	5	3	26.08
10/3/2011	1:45 PM	4	8	2	Random	29	101	3.48	3.64	3.33	17.25
10/5/2011	9:30 AM	5	14	2	Cumu	29	101	3.48	3.64	3.33	21.79
10/5/2011	2:45 PM	6	16	2	Last	29	101	3.48	3.64	3.33	22.81
10/5/2011	4:45 PM	7	16	3	Random	24	100	4.17	4.17	4.17	19.31
10/6/2011	4:45 PM	8	14	3	Cumu	24	100	4.17	4.17	4.17	19.29
10/7/2011	1:45 PM	9	14	3	Last	24	100	4.17	4.17	4.17	24.93
10/12/2011	2:45 PM	10	14	4	Random	25	100	4.00	4.33	3.69	19.50
10/12/2011	4:45 PM	11	12	4	Last	25	100	4.00	4.33	3.69	22.67
10/13/2011	4:45 PM	12	14	4	Cumu	25	100	4.00	4.33	3.69	23.86
	Total no of subjects:		144		No of subjects: Cumulative: 56; Random: 50; Last: 52						

Table 3: Cooperation rates by treatment and random draw sequence

All rounds

	Overall			First game			First half of the session			Last half of the session		
draw	Cum	Rand	Last	Cum	Rand	Last	Cum	Rand	Last	Cum	Rand	Last
1	0.75	0.54	0.60	0.56	0.24	0.38	0.69	0.41	0.57	0.81	0.68	0.65
2	0.45	0.17	0.45	0.37	0.25	0.44	0.37	0.18	0.41	0.54	0.17	0.49
3	0.38	0.35	0.62	0.57	0.56	0.79	0.29	0.34	0.63	0.47	0.36	0.62
4	0.62	0.33	0.46	0.44	0.32	0.36	0.54	0.34	0.46	0.71	0.32	0.46
All sessions	0.55	0.36	0.53	0.46	0.31	0.40	0.48	0.33	0.51	0.63	0.39	0.55
p -values, Wilcoxon signed ranks test:												
Cum>Rand:		*0.0625*			*0.0625*			*0.1250*			*0.0625*	
Cum=Last:		*0.8750*			*1.0000*			*1.0000*			*0.3750*	
Rand<Last:		*0.0625*			*0.0625*			*0.0625*			*0.1250*	

First rounds only

	Overall			First game			First half of the session			Last half of the session		
draw	Cum	Rand	Last	Cum	Rand	Last	Cum	Rand	Last	Cum	Rand	Last
1	0.87	0.69	0.79	0.71	0.50	0.70	0.84	0.55	0.73	0.89	0.80	0.83
2	0.45	0.19	0.57	0.57	0.50	0.63	0.37	0.23	0.53	0.53	0.14	0.61
3	0.42	0.39	0.80	0.57	0.56	0.79	0.41	0.32	0.76	0.42	0.45	0.85
4	0.68	0.40	0.57	0.50	0.79	0.42	0.62	0.45	0.58	0.73	0.35	0.56
All sessions	0.60	0.43	0.67	0.59	0.60	0.63	0.55	0.39	0.63	0.66	0.47	0.70
p=values, Wilcoxon signed ranks test:												
Cum>Rand:		*0.0625*			*0.4375*			*0.0625*			*0.1250*	
Cum=Last:		*0.6250*			*0.8750*			*0.6250*			*0.8750*	
Rand<Last:		*0.0625*			*0.4375*			*0.0625*			*0.0625*	

Table 4: Probit estimation of the determinants of decision to cooperate (reporting marginal effects)*

	Model 1			Model 2			Model 3		
	dF/dx	Robust Std. Err.	P>z	dF/dx	Robust Std. Err.	P>z	dF/dx	Robust Std. Err.	P>z
random	-0.1978	*(0.0986)*	0.051	-0.2141	*(0.0562)*	0.000	-0.1476	*(0.0399)*	0.000
last	-0.0232	*(0.0952)*	0.807	-0.0066	*(0.0664)*	0.921	-0.0137	*(0.0404)*	0.734
decision period	0.0036	*(0.0017)*	0.038	0.0037	*(0.0016)*	0.020	0.0028	*(0.0010)*	0.004
period squared	0.0000	*(0.0000)*	0.202	0.0000	*(0.0000)*	0.132	0.0000	*(0.0000)*	0.030
new game	0.0694	*(0.0187)*	0.000	0.0809	*(0.0192)*	0.000	0.1170	*(0.0282)*	0.000
game round	-0.0097	*(0.0041)*	0.016	-0.0086	*(0.0040)*	0.030	-0.0029	*(0.0025)*	0.238
prev. game length	0.0079	*(0.0024)*	0.001	0.0106	*(0.0024)*	0.000	0.0102	*(0.0023)*	0.000
draw 2				-0.2978	*(0.0443)*	0.000	-0.2047	*(0.0326)*	0.000
draw 3				-0.1862	*(0.0727)*	0.014	-0.1310	*(0.0479)*	0.007
draw 4				-0.1822	*(0.0585)*	0.003	-0.1239	*(0.0442)*	0.006
own first decision							0.1190	*(0.0457)*	0.010
other's previous decision							0.4568	*(0.0237)*	0.000
	Number of obs: 14736			Number of obs: 14736			Number of obs: 14736		
	Pseudo R2 = 0.0409			Pseudo R2= 0.0725			Pseudo R2= 0.2221		

(*) dF/dx is for discrete change of dummy variable from 0 to 1, calculated at the mean of the data.
Standard errors adjusted for clustering on session.

Table 5: Distribution of self-reported strategies, by treatment

	Cum		Random		Last	
Strategy*	No subjects	Percent	No subjects	Percent	No subjects	Percent
Mostly Cooperate	7	12.5	3	6	**13**	**25**
Mostly Defect	10	17.86	**16**	**32**	8	15.38
TFT	**15**	**26.79**	13	26	10	19.23
Trigger**	13	23.21	11	22	12	23.08
WSLS	1	1.79	1	2	0	0
Random	4	7.14	4	8	5	9.62
Other	6	10.71	2	4	4	7.69
Total	56	100	50	100	52	100

*Modal strategies are given in bold

**includes Trigger once-forgiving

Table 6: Distribution of best predictor strategies across subjects, by treatment*

	Overall			First half of the session			Last half of the session		
Strategy**	Cumu	Rand	Last	Cumu	Rand	Last	Cumu	Rand	Last
Always Coop	5.36%	2.00%	7.69%	1.79%	4.00%	11.54%	14.29%	4.00%	11.54%
Always Defect	19.64%	**42.00%**	25.00%	28.57%	**46.00%**	25.00%	17.86%	**38.00%**	25.00%
TFT	**39.29%**	28.00%	**28.85%**	**42.86%**	36.00%	**26.92%**	**41.07%**	26.00%	**30.77%**
Trigger	7.14%	8.00%	13.46%	12.50%	8.00%	19.23%	16.07%	16.00%	25.00%
Trigger-Reverse	26.79%	18.00%	**28.85%**	35.71%	10.00%	21.15%	16.07%	24.00%	23.08%
Trigger1forgive	14.29%	6.00%	9.62%	10.71%	6.00%	17.31%	25.00%	12.00%	17.31%
WSLS	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.57%	0.00%	0.00%
strategy mean accuracy	85.17%	80.57%	82.65%	84.27%	79.65%	82.69%	88.82%	84.09%	86.01%
No of subjects	56	50	52	56	50	52	56	50	52

*For several subjects more than one strategy has the highest predictive power; for this reason, the sum of percentages across strategies may be more than 100%.

**Modal strategies are given in bold.

Table 7: Percentage of correctly predicted actions, by strategy, by treatment: all observations

Strategy*	Overall			First half of the session			Last half of the session		
	Cumu	Rand	Last	Cumu	Rand	Last	Cumu	Rand	Last
Always Coop	55.37%	36.08%	52.80%	47.94%	33.28%	51.04%	63.27%	39.05%	54.66%
Always Defect	44.63%	63.92%	47.20%	52.06%	66.72%	48.96%	36.73%	60.95%	45.34%
TFT	75.95%	68.81%	71.81%	73.97%	66.83%	69.89%	78.06%	70.92%	73.83%
Trigger	71.00%	68.20%	72.28%	70.19%	67.57%	70.97%	71.87%	68.87%	73.67%
Trigger-Reverse	**78.01%**	**71.97%**	**75.91%**	**76.99%**	**70.42%**	**74.68%**	**79.08%**	**73.61%**	**77.19%**
Trigger1forgive	70.08%	60.65%	67.25%	66.38%	59.51%	67.29%	74.02%	61.85%	67.21%
WSLS	59.58%	41.87%	58.56%	54.95%	39.75%	56.77%	64.50%	44.12%	60.45%
No of obs	5656	5044	5246	2912	2596	2690	2744	2448	2556

*Best-predictor strategies are given in bold

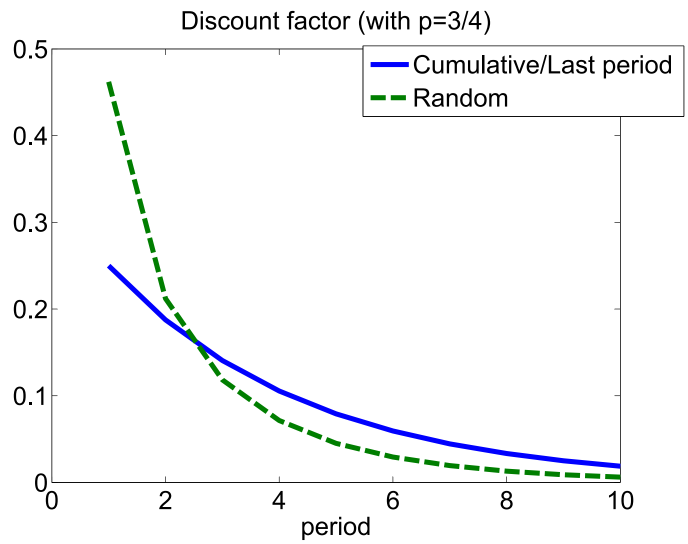


Figure 1: Discount factor schedule under alternative payment rules. ($p = 3/4$)

Figure 2: Dynamics of cooperation rates by period, by session
The vertical lines indicate the start of new game.

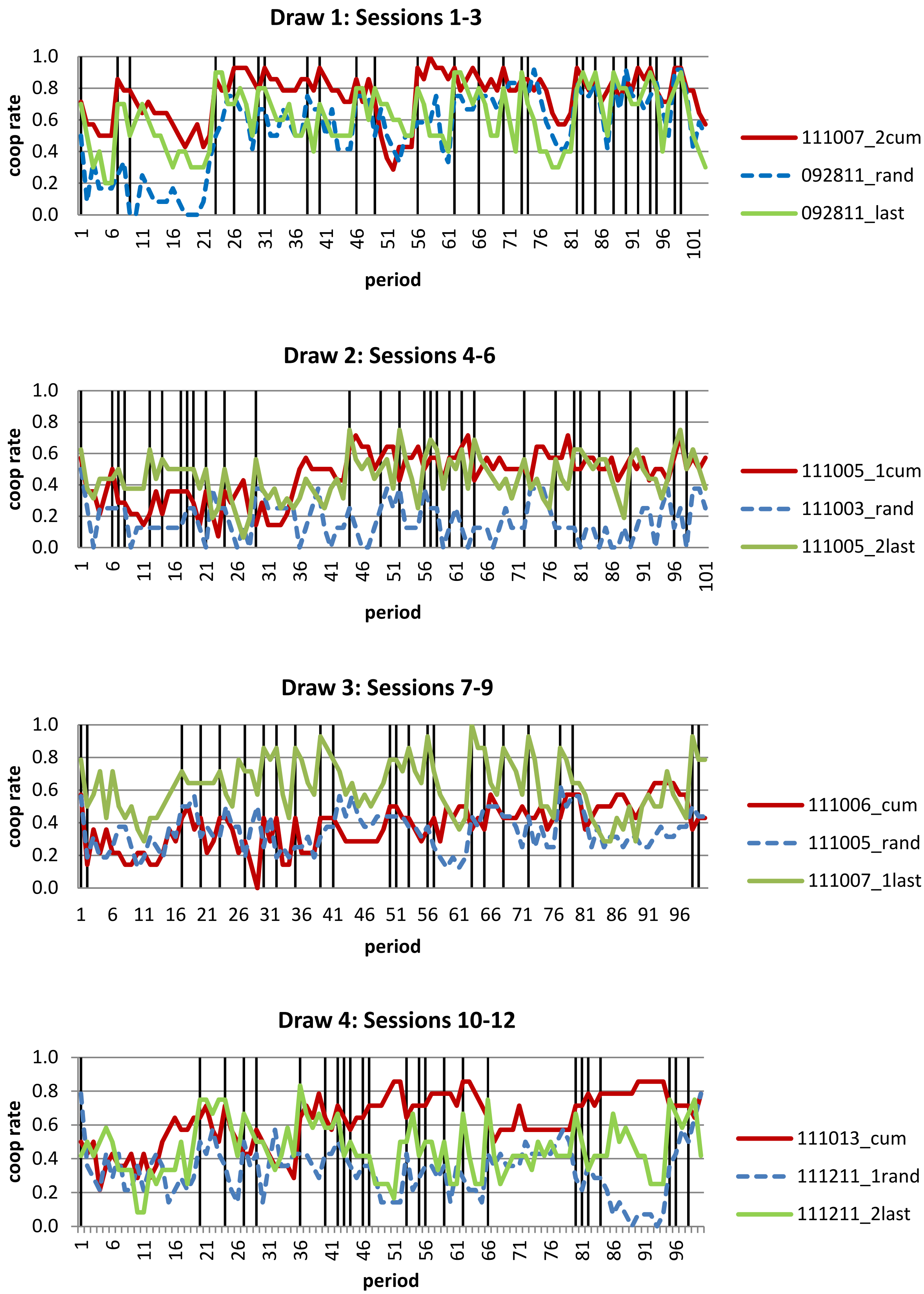
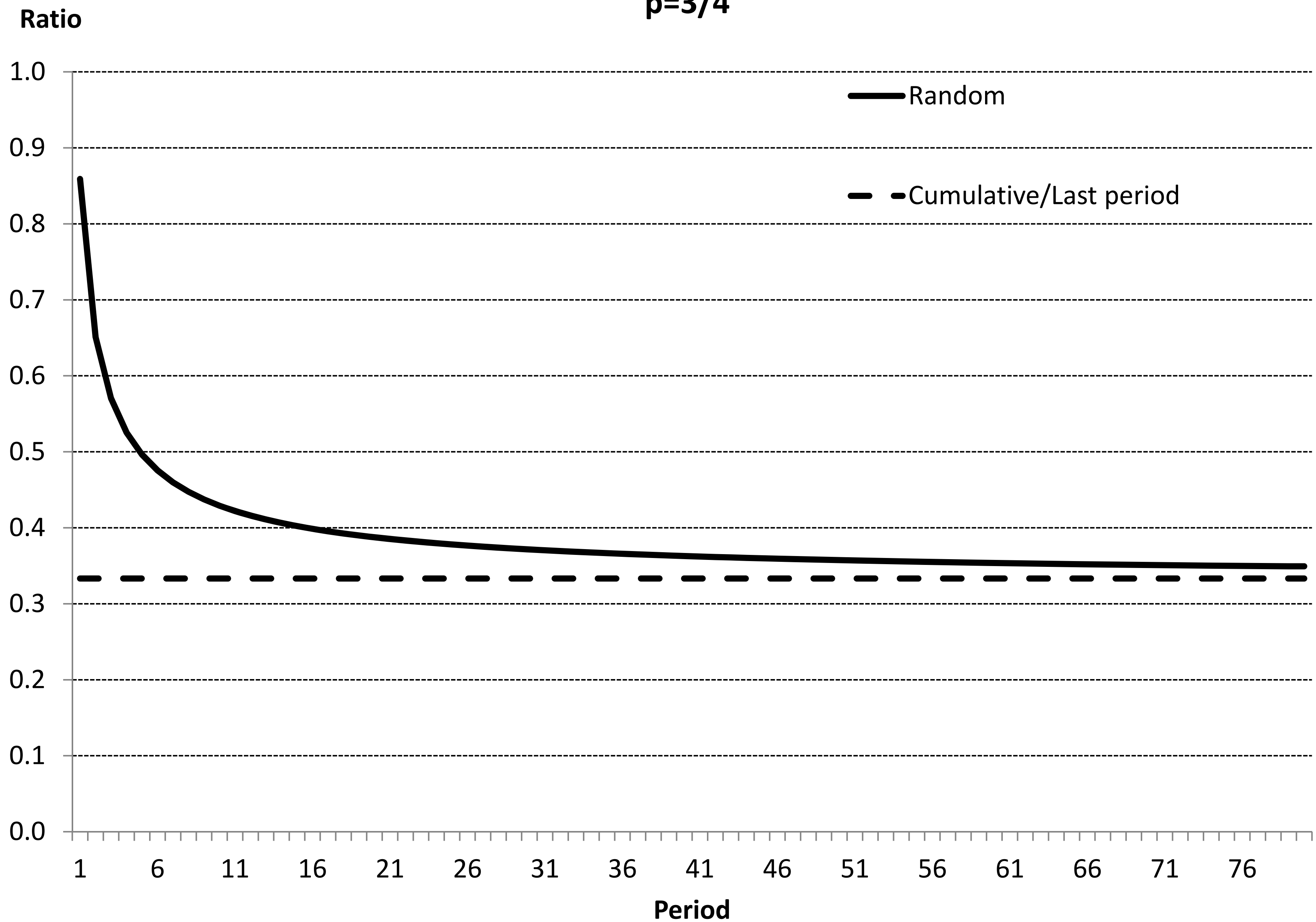


Figure 3: Ratios of the current payoff weight to the future payoff weights, p=3/4



Experimental Instructions

Introduction

Welcome and thank you for participating.

You are about to participate in an experiment in the economics of decision making in which you will earn money based on the decisions you make. All earnings you make are yours to keep and will be paid to you IN CASH at the end of the experiment. During the experiment all units of account will be in experimental dollars. Upon concluding the experiment the amount of experimental dollars you receive as payoff will be converted into dollars at the conversion rate of US $1 per 100 experimental dollars.[1] Your earnings plus a show-up fee of $5 dollars will be paid to you in private.

Do not communicate with the other participants except according to the specific rules of the experiment. If you have a question, feel free to raise your hand. I will come over to you and answer your question in private. Please turn off and put away all your electronic equipment.

The experiment will consist of several series of decision-making, each of which will have several rounds. You will also be asked to complete a short exit questionnaire.

In this experiment, you will be referred to by your ID number. Your ID number will be assigned to you by the computer and will be displayed on your computer screen.

Decisions and Earnings

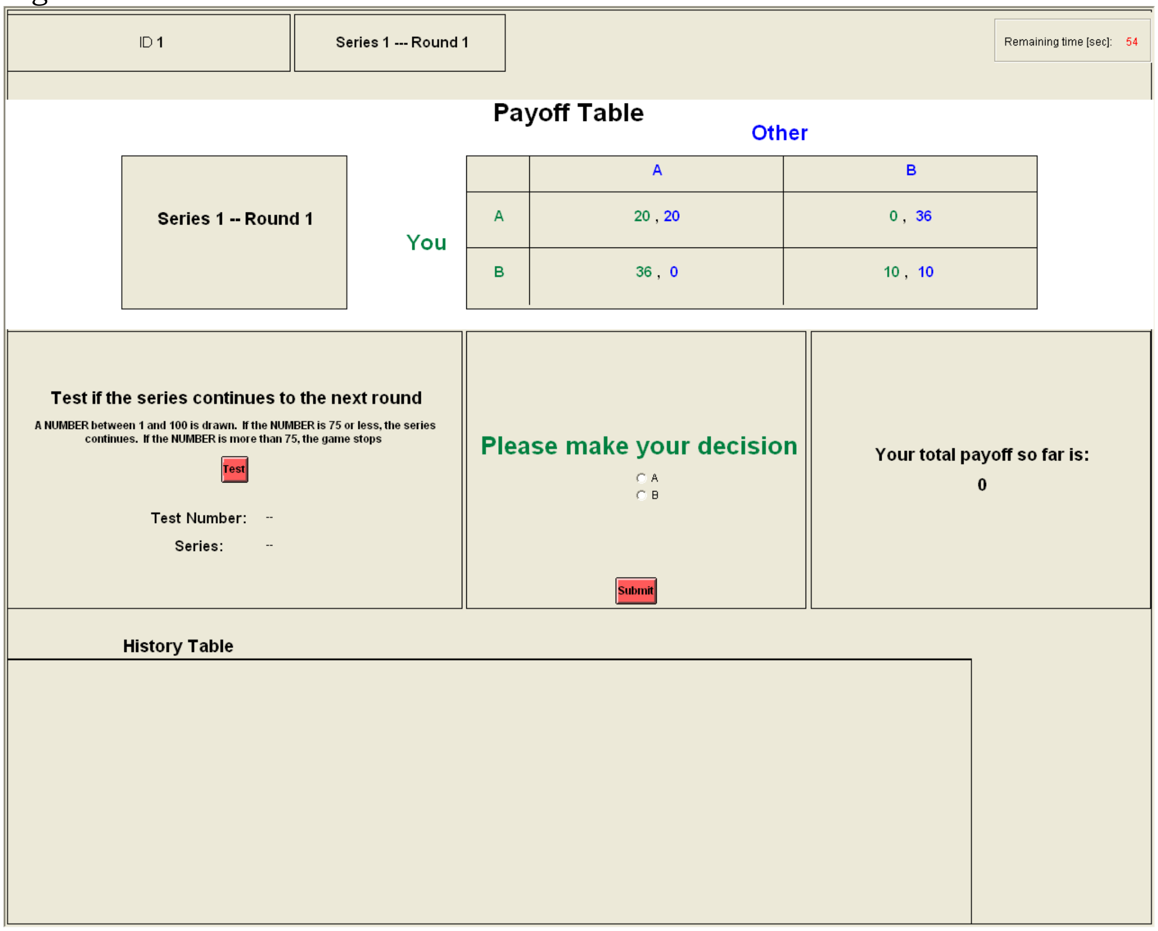
Decisions in this experiments will occur in a number of ***decision series***. At the beginning of each series you will be matched with another participant in this room. You will not be told which of the other participants you are matched with.

A series will consists of several ***decision rounds***. You will make decisions in each of the rounds. You will be matched with the SAME other person in all rounds of a given series, but you will be rematched with a DIFFERENT other person in the room every time a new series starts.

In each round, you will be asked to make a choice between options A and B, using a decision screen as in Figure 1 below. You will see several items on your screen, including a payoff table on top, and a decision box in the center.

[1] For the cumulative treatment, the corresponding sentence in the instructions read: "Upon concluding the experiment the amount of experimental dollars you receive as payoff will be converted into dollars at the conversion rate of US $.25 per 100 experimental dollars.

Figure 1



Payoff table The payoff table shows how much you and the other participant you are matched with can earn based on your and the other's decisions. (The numbers in these tables are hypothetical.)

Both you and the other participant have two choices, A or B. <u>Your payoff table will always display you as the row chooser</u>, and the other participant as the column chooser. Your and the other participant's payoffs are displayed in the cells corresponding to your and the other participant's choices, with <u>your payoff first, and the other's payoff second</u>. Your decision choices and payoffs will be displayed in **green**, and the Other's decisions and payoffs will be displayed in **blue**.

Example: Suppose, for example, that your payoff table is as given in Figure 1 above, then:

If you choose A, and the Other participant also chooses A, then the payoffs will be the ones written in the upper left hand corner of the table: Here you and the other will both earn a payoff of 20.

If you choose B and the other also chooses B, then the payoffs will be the ones written in the lower right hand corner of the table. Here you and the other participant will both earn a payoff of 10.

If you choose A and the other chooses B, then you earn 0 while the other will earn 36.

If If you choose B and the other chooses A, then you earn 36 while the other will earn 0.

ARE THERE ANY QUESTIONS?

Please complete the exercise in the Tutorial displayed on your computer screen now. Your screen shows a hypothetical payoff table. Please answer the questions on your screen regarding your payoff: enter numbers from your payoff table. When you have answered all questions, click OK button, and wait for further instructions.
(Keep your cursor in the box when typing)

Your payoff table will be given to you by the computer. The numbers in the payoff table may change between series. If they change, you will be informed.

Decision box. You will enter your decision by clicking "A" or "B" button in the box, which says "**Please make your decision**". It is located in the center of the decision screen; See Figure 1.

Results. After you and the other participant have entered their decisions, the computer results screen will display your and the other person's decision in this round, and your payoff for the current round. A history window at the bottom of the screen will display a history of your choices and payoffs in the previous rounds and series.

Continuation of the Series to the Next Round. The results screen will also display whether the series ends or continues to the next round. To determine whether the current decision series ends with this round or continues to the next round, the computer will draw a random number between 1 an 100. If this random number is 75 or less, the series will continue into the next round. If the number selected is greater than 75, then the series ends. If the series continues, you will then be matched with the SAME person in the next round. If a series ends, and a new series starts, then you will be matched with a DIFFERENT other person than in the previous series.

In sum, after each round there are THREE CHANCES OUT OF FOUR that this series continues to the next round where you will be matched with the SAME other person, and ONE CHANCE OUT OF FOUR that the series ends.

Suppose, for example, that number 68 is drawn by the computer. Then the series will continue, and you will be matched with the SAME person in the next round. Suppose, on the other hand, that number 92 is drawn. Then the series ends. If the new series starts, then you will be matched with a DIFFERENT other person than in this series.

You will be given a test box which illustrates how a random number determines whether a series continues or stops. The test box, which says **"Test if the series continues to the next round"** is located in the center left part of the decision screen; see Figure 1. You may click "Test" button in this box at any time, and as many times as you wish, before making your choice in a round. The computer will then draw a test random number and will inform you whether the series would continue or stop if this number were to be drawn. The numbers drawn will be for test purposes only, not the actual number number that will be drawn to determine continuation of the series into the next round.

Please practice with the test box located on your computer tutorial sceen now. (Click OK to go to the test sceen.) Click "Test" button in this box as many times as you wish, to see how the computer determines if the series continues or ends.

ARE THERE ANY QUESTIONS?

Click OK on the tutorial screen to continue.

Series Earnings and Total Earnings

Series Earnings

[The following two paragraphs appear for the CUMULATIVE treatment only]
Your earnings in each series is equal to the sum of your per round payoffs.

Suppose, for example, that the series ends after five rounds. Then the series earnings is the sum of your payoffs in these five rounds. Suppose now that the series ends after one round. Then your earnings in this series are equal to your round one payoff.

[The following two paragraphs paragraphs appear for the RANDOM treatment only]
After each series ends, one of the rounds in the series will be chosen by the computer randomly as PAID round. Your earnings in this series will be equal to your payoff in this paid round. Other rounds will be unpaid. You will be informed which round is paid when the series ends. Each round is equally likely to be paid, but which round is to be paid won't be determined until after the series ends.

Suppose, for example, that the series ends after five rounds. Then each one of the five rounds is equally likely to be paid. Suppose now that the series ends after one round. Then round one will be paid.

[The following two paragraphs appears for the LAST PERIOD treatment only]
After each series ends, the LAST round in the series will be the PAID round. Your earnings in this series will be equal to your payoff in this last round. Other rounds will be unpaid. Which round is going to be last won't be determined until the series ends.

Suppose, for example, that the series ends after five rounds. Then round five round will be paid. Suppose now that the series ends after one round. Then round one will be paid.

The experiment will continue for a fixed number of series. We suggest that you make your desions in each series carefully, as they will affect your total earnings in the experiment.

Total Earnings Your total earnings in this experiment will be equal to the sum of your series earning. In all times during the experiment, your current total earnings will be displayed in the center right part of your decision screen. You will be paid your total earnings IN CASH at the end of today's session.

ARE THERE ANY QUESTIONS?

Frequently asked questions

What is the difference between a round and a series?

Each series consists of several decision rounds. You will make decisions in each of the rounds. You are matched with the SAME other person in all rounds of a given series, but you are rematched with a DIFFERENT other person in the room every time a new series starts.

What does my payoff in a round depend upon?

It depends upon your decision and the decision of the other person you are matched with, as displayed in the Payoff Table.

How many rounds are there in a series?

The number of rounds in each series is determined randomly by the computer. After each round there are THREE CHANCES OUT OF FOUR that this series continues to the next round, and ONE CHANCE OUT OF FOUR that the series ends. <u>On average, you may expect the series to continue for three more rounds after the current round.</u> However, the series may end after any round, or continue for many rounds.

How is my payoff in a series determined?

[Answer given for the CUMULATIVE treatment] Your payoff in a series is a sum of your per round payoffs in this series.

[Answer given for the RANDOM treatment] When a series ends, one of the rounds in the series is chosen randomly as PAID round. Your earnings in this series is equal to your payoff in this paid round. Other rounds are unpaid.

[Answer given for the LAST PERIOD treatment] The LAST round in the series will be the paid round. Other rounds are unpaid. Which round is going to be the last won't be determined until the series ends.

How many series are there in this experiment?

The experiment will consist of a pre-determined number of decision series. I will announce when the experiment ends.

Review questions:

Suppose that you are given a payoff table as shown below:

Payoff Table **OTHER**

		A	B
YOU	**A**	**15, 15**	**12, 5**
	B	**70, 50**	**44, 44**

Please answer the following questions:

I. Consider the following choices in a decision round:

a. If you and other person both choose A, what is:
Your earning?______ Other's earning? ____________________

b. If you and other person both choose B, what is:
Your earning?______ Other's earning? ____________________

c. If you choose A, and the other person chooses B, what is:
Your earning?______ Other's earning? ____________________

d. If you choose B, and the other person chooses A, what is:
Your earning?______ Other's earning? ____________________

II. **Suppose that, at the end of a round, number 49 is drawn** to determine whether the series continues. **Will the current series continue to the next round?** Please circle the correct answer below:

a. The series will continue. I will be matched with the same other person next round as in this round.

b. The series will stop. If a new series starts, I will be matched with a different other person than in this round.

III. **Suppose that a decision series continues for FOUR rounds**, and the decisions that you and the other person make in each round are as in question I above: item (1) in round 1, item (2) in round 2, item (3) in round 3, and item (4) in round 4. **What are your total earnings in this series?** Please circle the correct answer below:

a. I will be paid the sum of round payoffs: 15+44+12+70=141

b. One of the rounds will be paid; I may earn 15, 44, 12 or 70, and all are equally likely.

c. Only the first round will be paid; I will earn 15.

d. Only the last round will be paid; I will earn 70.

Post-Experiment Questionnaire

YOUR ID in this experiment: ______________________________

1. How did you make your decision to choose between A and B?

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2. How easy to understand were the instructions?

_______Very Easy _______Easy _______Moderate _______Hard _______Very Hard

3. How many economics courses have you taken so far (including this semester)?

____

4. How many people in this session do you know?

____

5. What is your major?
____

6. What is your gender?

_______Male ________Female

7. What is your age?
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8. Please add any additional comments below

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THANK YOU FOR PARTICIPATING!