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In the long-run we are all dead: On the benefits of peer punishment in rich environments

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In the long-run we are all dead: On the benefits of peer punishment in rich environments*

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Abstract

We investigate whether peer punishment is an efficient mechanism for enforcing cooperation in an experiment with a long time horizon. Previous evidence suggests that the costs of peer punishment can be outweighed by the benefits of higher cooperation, if (*i*) there is a sufficiently long time horizon and (*ii*) punishment cannot be avenged. However, in most instances in daily life, when individuals interact for an extended period of time, punishment can be retaliated. We use a design that imposes minimal restrictions on who can punish whom or when, and allows participants to employ a wide range of punishment strategies including retaliation of punishment. Similar to previous research, we find that, when punishment cannot be avenged, peer punishment leads to higher earnings relative to a baseline treatment without any punishment opportunities. However, in the more general setting, we find no evidence of group earnings increasing over time relative to the baseline treatment. Our results raise questions under what conditions peer punishment can be an efficient mechanism for enforcing cooperation.

JEL Classification: C92, D70, H41

Keywords: altruistic punishment, counter-punishment, public good game, feuds

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"In the long run we are all dead. Economists set themselves too easy, too useless a task if in tempestuous seasons they can only tell us that when the storm is past the ocean is flat again."

– John Maynard Keynes (1923)

1 Introduction

Is peer punishment an efficient mechanism for establishing cooperation when private and public interest are at odds? This question has been the focus of numerous studies since the seminal works of Ostrom et al. (1992) and Fehr and Gächter (2000). These authors were the first to show that many individuals are willing to incur a cost to punish free riders, even if they cannot anticipate any material benefits from their actions. While the threat of peer punishment has been shown to have a positive impact on cooperation rates, its overall impact on efficiency is less clear due to the costs associated with punishment.

Gächter et al. (2008) noted that, although group earnings are often lower when peer punishment is permitted (e.g., Ostrom et al., 1992; Egas and Riedl, 2008; Fehr and Gächter, 2000, 2002; Nikiforakis and Normann, 2008), they tend to increase over the course of these experiments as cooperation rates rise and the need for punishment decreases. This suggests that, in the long run, the benefits of higher cooperation would outweigh the costs of punishment. In line with this, Gächter et al. (2008) showed that peer punishment opportunities can increase both cooperation levels and group earnings in an experiment in which individuals interact in fixed groups for an extended time horizon (50 periods). However, an important feature of the experiment by Gächter et al. (2008) is that the set of punishment strategies available to individuals is limited. In particular, individuals are given only a single opportunity in each period to punish anonymously other group members.

The present study contributes to this literature by examining whether peer punishment can increase group earnings in an environment that allows for a rich, realistic set of punishment strategies. The experiment imposes minimal restrictions on who can punish whom and when, and allows participants' actions to determine the duration of a single period of the game. This implies that individuals can punish free riders, counter-punish, punish non-punishers, punish counter-punishers, delay punishment to observe the actions of others, and more. Investigating the efficacy of peer punishment in such a set up is interesting for two reasons. First, at least some of the punishment strategies mentioned above have been shown to play an important role both in the lab (e.g., Denant-Boemont et al., 2007;

Nikiforakis, 2008; Nikiforakis et al., 2012) and in the field (Balafoutas and Nikiforakis, 2012; Guala, 2012). Second, recent evolutionary models suggest that peer punishment is less likely to lead to increases in group earnings in environments that allow for such a rich set of punishment strategies, even in the long run (Boyd et al., 2010; Janssen and Bushman, 2008; Rand et al., 2010; Rand and Nowak, 2011).

The experiment consists of three experimental treatments. In the *No Punishment* treatment, individuals play the standard linear public-good game without punishment opportunities for 30 periods.[1] At the start of each period, individuals are given identical endowments and must decide how much to contribute to a group account. Contributions increase group earnings, but reduce private earnings. In the *Standard Punishment* treatment, individuals play a linear public-good game with punishment opportunities that resembles the set up in Gächter et al. (2008). In particular, after observing the contribution of each group member, individuals can reduce each other's earnings by assigning costly punishment points. While group composition remains the same, "meta-strategies" that use punishment in response to actions in previous periods are prevented by providing group members with new identification numbers at the start of each period. Finally, the *Rich Punishment* treatment follows the design of Nikiforakis and Engelmann (2011). In this treatment, new punishment stages are entered as long as punishment is meted out and individuals are in the position to continue punishing others. This implies that individuals may use none or several punishment stages in each period.[2]

Similar to Gächter et al. (2008), we find that, when punishers are anonymous and there is a single punishment opportunity in each period, peer punishment eventually leads to higher earnings relative to the *No Punishment* treatment. However, when a rich set of punishment strategies is available, in line with the predictions of the aforementioned evolutionary models, we find no evidence of group earnings increasing over time relative to the *No Punishment* treatment. This is despite the fact that cooperation levels are similar in the *Standard* and *Rich Punishment* treatments. The reason is that some individuals engage in feuding.[3] As a result, punishment expenditure shows no sign of declining over

[1] We decided to use a shorter time horizon than Gächter et al. (2008) as allowing for a rich set of punishment strategies can increase considerably the duration of the experiment. We chose to allow for 30 periods based on the evidence in Gächter et al. (2008), which indicates that 30 periods should suffice for the benefits of punishment to outweigh its costs.

[2] The two most important differences between our study and Nikiforakis and Engelmann (2011) are that (*i*) in our previous study we did not consider behavior in a treatment without punishment opportunities and thus could not address our present research question, and (*ii*) that we considered a shorter time horizon (10 periods) than we do here, which also prevented us from studying long-run effects of the availability of complex punishment strategies.

[3] The word "feud" is typically used in the literature to refer to a situation in which two or more parties are involved in a sequence of retaliatory actions over an extended period of time, which sometimes lead to

Treatment	No. of punishment stages	Subjects' ID	No. of groups
No Punishment (NP)	0	Fixed	10
Standard Punishment (SP)	1	Random	10
Rich Punishment (RP)	≥ 1, Endogenous	Fixed	10

Table 1: Overview of the experimental treatments

time. Our results therefore raise questions about whether peer punishment can be an efficient mechanism for enforcing cooperation, even in the long run.

The rest of the paper is organized as follows. In the next session we present the experimental design. In Section 3 we present the results from our experiment. Section 4 concludes by discussing the implication of our results.

2 The Experiment

2.1 Experimental Design

The experiment consists of three treatments. The design of the treatments follows that used in previous public-good experiments with peer punishment. We discuss each of the treatments in sequence. Table 1 summarizes the experimental design.

2.1.1 The *Rich Punishment* treatment

This treatment is similar to the *LF* treatment in Nikiforakis and Engelmann (2011). The game is divided into a number of stages. The first stage is a standard public good game. Four players simultaneously decide how much of their initial endowment of 20 Experimental Currency Units (ECU) to contribute to a group account. Contributions are multiplied by 1.6 and then distributed equally among the four players. Hence, the marginal per capita return is $1.6/4 = 0.4$. If the players' contributions are $c_i, i = 1, ..., 4$, player i's earnings after the contribution stage are given by

$$\pi_i^0 = 20 - c_i + 0.4 \sum_{h=1}^{4} c_h.$$

killings. This is one reason we chose to use Keynes' famous quote in our title. Another reason we used Keynes' quote is the recent discussion on the long-run benefits of peer punishment. We do acknowledge that, had Keynes been still alive, he may have felt that we have quoted him somewhat out of context. At the same time, however, we hope he would have found our title appropriate and perhaps even entertaining.

The contribution stage is followed by a number of punishment stages. In each punishment stage s, player i can assign *punishment points* to group member j, p_{ij}^s, as long as $\pi_i^{s-1} > 0$ and $\pi_j^{s-1} \geq 0$. Assigning a punishment point costs the punishing player 1 ECU and the punished player 3 ECU.[4] Only integer numbers of points can be assigned and the maximum total number of points a player can assign is equal to his current payoff. That is, $\sum_{j=1,j\neq i}^{4} p_{ij}^s \leq \pi_i^{s-1}$. No restrictions were imposed on the number of punishment points a player could receive. Player i's earnings at the end of punishment stage s are, therefore, given by

$$\pi_i^s = \pi_i^{s-1} - 3 * \sum_{j=1,j\neq i}^{4} p_{ji}^s - \sum_{j=1,j\neq i}^{4} p_{ij.}^s$$

The number of punishment stages in the *Rich Punishment* treatment is not restricted ex-ante, but is endogenously determined. A period ends if no punishment is meted out in a given stage or if further punishment is not permitted. Punishment in stage s is not permitted if $\pi_i^{s-1} \leq 0$, for all $i \in [1, 4]$, or if at least three players cannot be assigned any further punishment (that is, their earnings in the current period are already negative).[5] The fact that punishment is restricted to integers ensures that a period will end after finitely many punishment stages (namely a maximum of 34), a fact subjects were not informed about, but could have calculated.

At the start of the first punishment stage, players are informed about the contributions to the group account of each group member. In further punishment stages, every player is informed about the number of points assigned by each individual player to each of the players in the previous punishment stage. This enables a wide range of punishment strategies. For example, individuals can engage in peer punishment, counter-punish, punish non-punishers, delay punishment, or punish others' counter-punishers.

The game is repeated 30 times and group composition remains unchanged. At the start of the experiment, each group member is given an identification number that stays the same throughout the experiment. This implies that counter-punishment cannot be avoided (except in the final period) because even if a player cannot counter-punish in a given period if his payoff is already negative or zero, he can still do so in a later period. As we discuss in Nikiforakis and Engelmann (2011), we believe that this is a realistic feature of interactions

[4] In Nikiforakis and Engelmann (2011), one punishment point reduced the income of the target by 2 ECU. For the purpose of comparison, in this experiment we chose to use the same punishment effectiveness as Gächter et al. (2008) instead.

[5] Note that player i with $\pi_i^{s-1} = 0$ can be punished although he cannot punish. This ensures that a player cannot immunize himself against retaliation by spending all his income on punishing others.

occurring outside the laboratory, especially over an extended time period.[6] Even in the extreme case that one exterminates one's prime "opponent", a friend, colleague or family member of the victim can take revenge.

2.1.2 The *No Punishment* treatment

The purpose of this treatment is to provide a benchmark against which to evaluate whether the existence of punishment opportunities in the *Rich Punishment* treatment leads to higher group earnings. The game is the same as in the *Rich Punishment* treatment, but punishment of any kind is not permitted. Individuals only have to decide how much to contribute to the group account. After making this decision, individuals are informed of the contribution of the other group members to the group account and their earnings from the period.

Similar to the *Rich Punishment* treatment, the game is repeated 30 times. Group composition remains unchanged, as do the identification numbers that are assigned to group members at the start of the experiment.

2.1.3 The *Standard Punishment* treatment

This treatment is similar to the P50 treatment in Gächter et al. (2008). The game consists of two stages: a contribution stage and a punishment stage. In particular, after making their contribution to the group account, individuals are informed about the contribution of their group members and must decide whether, and by how much, they wish to reduce the earnings of each other. Contributions to the group account and punishment have the same payoff implications as in the *Rich Punishment* treatment.

As in Gächter et al. (2008) group composition remains unchanged throughout the experiment, but the identification number of each group member changes randomly at the start of each period. This implies that individuals cannot use "meta-strategies" such as counter-punishment, punishment of non-punishers etc., across periods. The game is repeated 30 times. While subjects in Gächter et al. (2008) played the game for 50 periods, their data suggests that 30 periods should suffice for the benefits of higher cooperation to offset the costs of punishment.

[6] See Balafoutas and Nikiforakis (2012) for evidence from a natural field experiment on costly punishment showing that the fear of counter-punishment is an important deterrent to punishing norm violations in one-shot interactions.

2.2 Procedures

The experiment was conducted at the Experimental Economics Laboratory at the University of Melbourne using z-Tree (Fischbacher, 2007). Subjects were recruited using ORSEE (Greiner, 2004). A total of 120 subjects participated in the experiment. We ran two sessions for each treatment. The first session consisted of four groups of four individuals each, while the second session consisted of six groups of four individuals. Thus we had 10 independent groups in each treatment. Participants were students at the University of Melbourne from various disciplines. None of the subjects had previously participated in a public good experiment or had experience with game theory.

Written instructions (including a set of control questions) were handed out at the beginning of the experiment. The experiment started only after all subjects answered the control questions correctly. Sessions lasted between 90 and 130 minutes. Following previous studies, (e.g. Fehr and Gächter, 2000; Gächter et al., 2008; Nikiforakis and Engelmann, 2011, Nikiforakis et al., 2012), subjects in the *Standard Punishment* treatment received an initial capital of 25 ECU to cover any losses due to punishment. Given the rich set of punishment strategies, subjects in the *Rich Punishment* treatment received a one-off payment of 125 ECU, while subjects in the *No Punishment* treatment did not receive any initial capital. Participants were paid in cash at the end of the experiment with earnings calculated at an exchange rate of 1 ECU = 6 Australian cents. Average earnings excluding the initial capital were approximately A$ 43.56. At the time of the experiment, the exchange rate between the Australian and the US dollar was approximately 1.

3 Experimental Results

We start by considering contributions to the public good in our three treatments. We observe:

Result 1: *Contributions are higher when punishment opportunities exist. Contributions are not significantly different in the Rich Punishment and Standard Punishment treatments.*

SUPPORT: Figure 1 presents the evolution of average contributions over the course of the experiment in each treatment. Panel A in Table 2 presents the average contribution in each treatment across all periods as well as in the first and second half of the experiment, while Panel B offers pairwise statistical comparisons of contributions across treatments based on non-parametric Mann-Whitney tests using the average in each group as an independent observation. As can be seen, the opportunity to punish other group members sustains contributions at intermediate levels in both the *Rich Punishment* (12.63) and *Standard*

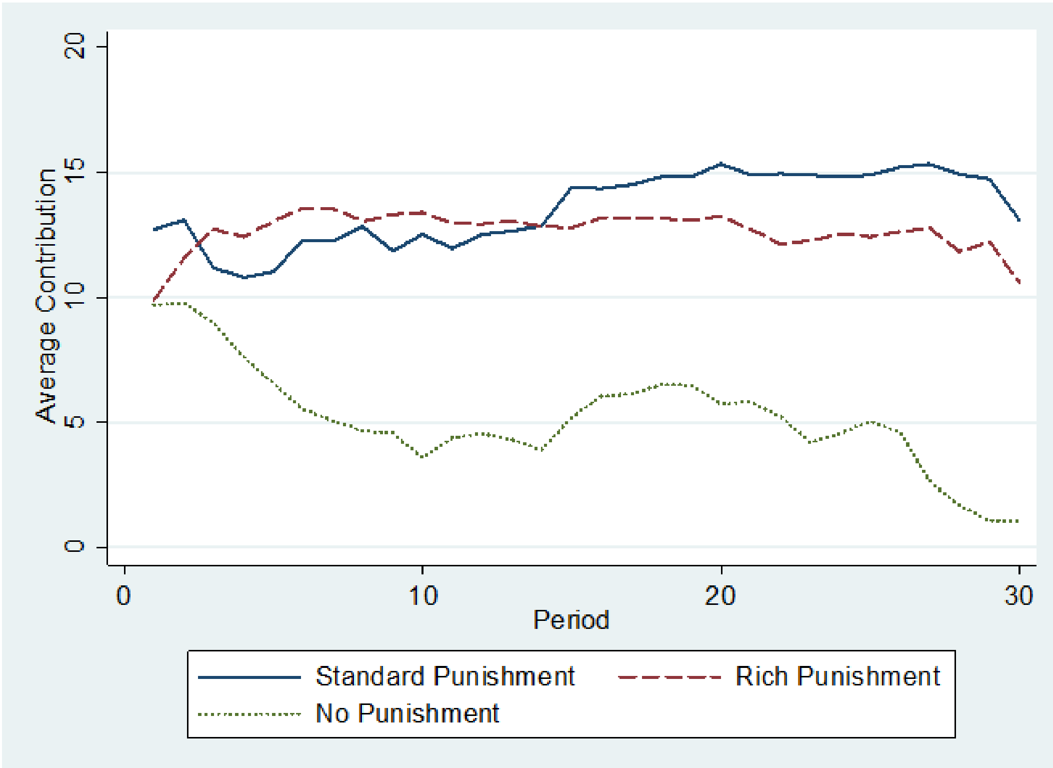

Figure 1: Evolution of average contribution across periods

Panel A: Average contribution			
Treatment	All Periods	Periods 1-15	Periods 16-30
No Punishment (NP)	5.17	5.89	4.45
Standard Punishment (SP)	13.54	12.33	14.76
Rich Punishment (RP)	12.63	12.74	12.53

Panel B: Statistical comparison (Mann-Whitney, two-sided, $p-$values)			
Treatment comparison	All Periods	Periods 1-15	Periods 16-30
NP – SP	0.0032	0.0191	0.0051
NP – RP	0.0311	0.0283	0.0963
SP – RP	0.8206	0.9397	0.5961

Table 2: Contributions across treatments

Punishment (13.54) treatments. Contributions are significantly higher both in the *Rich Punishment* treatment and in the *Standard Punishment* treatment than in the *No Punishment* treatment at the 5%-level in the first half of the experiment. In the second half, contributions in the *Rich Punishment* treatment are only significantly higher than in the *No Punishment* treatment at the 10%-level, but in the *Standard Punishment* treatment they are significantly higher than in the *No Punishment* treatment at the 1%-level.

Average contributions are nearly identical in the first half of the *Standard Punishment* and the *Rich Punishment* treatment but diverge slightly over time. However, neither the slight decrease in the *Rich Punishment* treatment is significant (Wilcoxon signrank, two-sided, $p-$value $= 0.7989$), nor the increase in the *Standard Punishment* treatment (Wilcoxon signrank, two-sided, $p-$value $= 0.1394$), nor the difference between the two treatments in the second half ($p-$value $= 0.5961$).[7] Therefore, allowing individuals to choose from a richer set of punishment strategies does not affect contributions substantially or significantly in the experiment. Our main interest, however, does not lie in contributions, but in overall earnings, which take into account punishment costs.

Result 2: *Group earnings increase over time in the Standard Punishment treatment, but not in the Rich Punishment treatment. Consequently, while earnings are significantly higher in the second half of the experiment in the Standard Punishment than in the No Punishment treatment, we find no significant difference between the earnings in the Rich Punishment and No Punishment treatments in the second part of the experiment, even in the last periods.*

SUPPORT: Figure 2 presents the evolution of group earnings across periods in the *Standard Punishment* treatment and the *Rich Punishment* treatment relative to the *No Punishment* treatment. Over time, earnings are decreasing significantly in the *No Punishment* treatment (Spearman, $\rho = -0.5926$, $p-$value < 0.0001) and are increasing in the *Standard Punishment* treatment (Spearman, $\rho = 0.7499$, $p-$value < 0.0001). Earnings show only a very slight and insignificant upward trend in the *Rich Punishment* treatment (Spearman, $\rho = 0.2458$, $p-$value $= 0.1904$). Panel A in Table 3 presents the average group earnings in the first and second half of the experiment in each treatment, and Panel B compares statistically earnings across treatments. While earnings are similar in the first half of the experiment in the *Standard* and *No Punishment* treatments (23.55 and 23.53, respectively), earnings are substantially and significantly higher in the *Standard Punishment* treatment than in the *No Punishment* treatment in the second half of the experiment (27.69 and 22.67, respectively, $p-$value $= 0.0283$). This is not only due to the divergence in contributions discussed above, but also due to a substantial decrease in punishment from the first to the second

[7] The observed decline in contributions in the second half of the experiment in the *No Punishment* treatment is weakly statistically significant (Wilcoxon signrank, two-sided, $p-$value$=0.0926$).

Panel A: Average earnings			
Treatment	All Periods	Periods 1-15	Periods 16-30
No Punishment (NP)	23.10	23.53	22.67
Standard Punishment (SP)	25.62	23.55	27.69
Rich Punishment (RP)	23.00	23.45	24.34

Panel B: Statistical comparison (Mann-Whitney, two-sided, $p-$values)			
Treatment comparison	All Periods	Periods 1-15	Periods 16-30
NP – SP	0.1508	0.7055	0.0283
NP – RP	0.8798	0.8206	0.8798
SP – RP	0.5967	0.8798	0.3250

Table 3: Earnings across treatments

half in the *Standard Punishment* treatment (as will be shown below). We thus replicate the finding of Gächter et al. (2008).[8] In the *Rich Punishment* treatment, in contrast, despite the small increase in average earnings in the second half of the experiment relative to the *No Punishment* treatment (24.34 and 22.67, respectively), earnings are still not significantly different even in the second half ($p-$value $= 0.8798$).

One may wonder whether the absence of a significant difference in the earnings in the *Rich Punishment* and *No Punishment* treatments is a result of comparing earnings across the whole second half of the experiment. In order to check whether the small difference observed is significant if we consider a smaller set of periods, Table 4 presents the results of a regression analysis (with group-level random effects) where the 30 periods of the experiment are divided into groups of five periods.[9] The dependent variable is the profit of an individual in a given period. The independent variables include dummies for periods 1-5, 6-10, 11-15, 16-20, and 21-25 (the omitted category is 26-30), as well as interaction terms of the treatment dummies for the *Standard Punishment* (SP) and the *Rich Punishment* (RP) treatments and these period dummies. The period dummies thus measure the differences between blocks of periods in the *No Punishment* treatment, while the interaction effects measure the difference between the respective treatment and the *No Punishment* treatment in the respective block of periods.

The results in Table 4 reveal the following. First, as mentioned, there is a progressive

[8] Despite the shorter time horizon in our experiment, the average difference in earnings across all periods between the *Standard Punishment* and *No Punishment* treatments is similar in our experiment and that in Gächter et al. (2.52 and 2.98, respectively).

[9] We do not model period as a linear effect as this assumption is clearly refuted by the evidence seen in Figure 2.

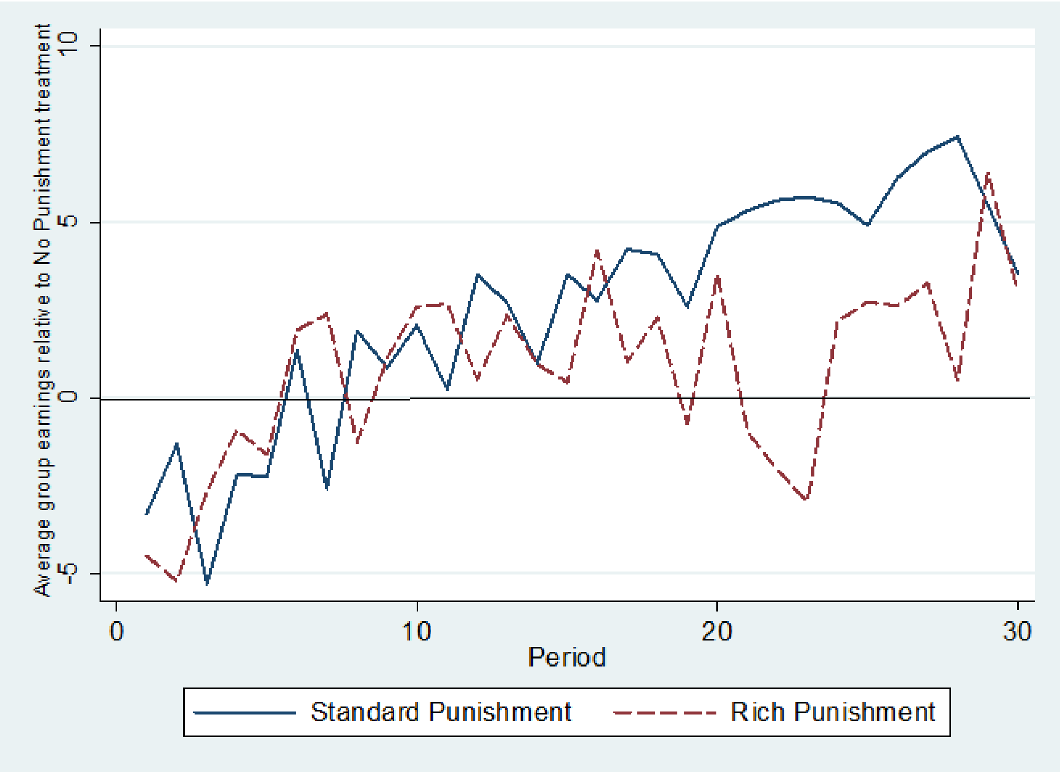

Figure 2: Evolution of earnings across periods relative to the *No Punishment* treatment

	Coefficient	Standard Error	$p-$value
First 5	3.792	0.6853	0.000
Second 5	1.482	0.6853	0.031
Third 5	1.356	0.6853	0.048
Fourth 5	2.382	0.6853	0.001
Fifth 5	1.659	0.6853	0.015
SP × First 5	−2.862	2.1969	0.193
SP × Second 5	0.722	2.1969	0.742
SP × Third 5	2.186	2.1969	0.320
SP × Fourth 5	3.708	2.1969	0.091
SP × Fifth 5	5.42	2.1969	0.014
SP × Sixth 5	5.944	2.1969	0.007
RP × First 5	−2.98	2.1969	0.175
RP × Second 5	1.357	2.1969	0.537
RP × Third 5	1.387	2.1969	0.528
RP × Fourth 5	2.057	2.1969	0.349
RP × Fifth 5	−0.213	2.1969	0.923
RP × Sixth 5	3.157	2.1969	0.151
Constant	21.323	1.5534	0.000

Table 4: Regression of earnings over time, with random effects at the group level. "First 5" refers to periods 1-5, "Second 5" refers to periods "6-10" and so on. The dependent variable is the earnings of an individual in a given period. Number of observations: 3600.

reduction in earnings in the *No Punishment* treatment over time due to the declining contributions. Second, earnings are significantly higher (at least at the 10% level) in the *Standard Punishment* treatment than in the *No Punishment* treatment from periods 16-20 onwards. Third and most importantly, we do not find any evidence of an increasing tendency in earnings in the *Rich Punishment* treatment relative to the *No Punishment* treatment. In particular, the interaction terms of the *Rich Punishment* treatment and period dummies are always insignificant and often change signs. To further our understanding of the comparison of earnings, we take a closer look at punishment behavior.

Result 3: *The total number of punishment points assigned in the Rich Punishment and Standard Punishment treatments is not significantly different. However, while punishment declines substantially and significantly over time in the Standard Punishment treatment, this is not the case in the Rich Punishment treatment where punishment remains at substantial levels even in the second half of the experiment.*

SUPPORT: Table 5 presents the number of punishment points assigned across all stages

Treatment	All Periods	Periods 1-15	Periods 16-30
Standard Punishment (SP)	0.63	0.96	0.29
Rich Punishment (RP) (Total number of points across stages)	0.92	1.05	0.80
First-stage punishment (RP)	0.54	0.60	0.48
Higher-stage punishment (RP)	0.38	0.44	0.31

Table 5: Punishment points assigned across treatments

in the first and second half of the experiment in each treatment. As can be seen, the average number of points across periods and stages is 39.7% higher in the *Rich Punishment* treatment. Nevertheless, this difference is not statistically significant due to the high variance across groups (Mann-Whitney, two-sided, $p-$value $= 0.9698$). Figure 3 presents the evolution of the average number of punishment points assigned over the course of the experiment in the two treatments with punishment opportunities.[10] The figure illustrates that the extent of punishment is similar in the early rounds across the two treatments. However, while punishment declines considerably over time in the *Standard Punishment* treatment (Spearman, $\rho = -0.7078$, $p-$value < 0.0001), it remains at fairly high levels in the *Rich Punishment* treatment (Spearman, $\rho = -0.2961$, $p-$value < 0.1121).[11, 12]

In summary, the data indicates that a long time horizon does not guarantee that peer punishment will improve efficiency in an environment with rich punishment strategies. Most importantly, we find no evidence of earnings increasing over time in the *Rich Punishment* treatment relative to the *No Punishment* treatment, implying that this finding is likely to hold up in experiments with even longer time horizons. The fact that there is a substantial

[10] Figure 3 graphs the total number of points assigned across stages in the *Rich Punishment* treatment as well as the number of points assigned in the first punishment stage of this treatment. The reason is that first-stage punishment is typically aimed towards below-average contributors, while higher-order punishment is often used to retaliate punishment (Nikiforakis and Engelmann, 2011). This allows the reader to evaluate the relative extent to which higher-order punishment is observed. (Remember that there is only one punishment stage in the *Standard Punishment* treatment.)

[11] While the average number of points is nearly 3 times greater in the second half of the experiment in the *Rich Punishment* than in the *Standard Punishment* treatment, the difference remains statistically insignificant (Mann-Whitney, two-sided, $p-$value $= 0.6182$). This indicates that a small subset of groups is investing heavily in punishment in the *Rich Punishment* treatment.

[12] Note that the number of punishment points declines by approximately 70% in the second half of the experiment in the *Standard Punishment* treatment. This reduction is marginally statistically significant (Wilcoxon signrank, two-sided, $p-$value=0.0593). While the reduction of overall punishment in the *Rich Punishment* treatment is statistically significant (Wilcoxon signrank, two-sided, $p-$value=0.0367), it is substantially smaller (approximately 25%) than the decline in the *Standard Punishment* treatment. Moreover, the significance of this reduction relies critically on the cut-off point. For example, if we compare the average number of points in periods 1-16 and 17-30 the difference is far from being significant (Wilcoxon signrank, two-sided, $p-$value=0.3329). Similarly, if we compare the average number of points in periods 1-20 and 21-30 the difference is also stastistically insignificant (Wilcoxon signrank, two-sided, $p-$value=0.7213).

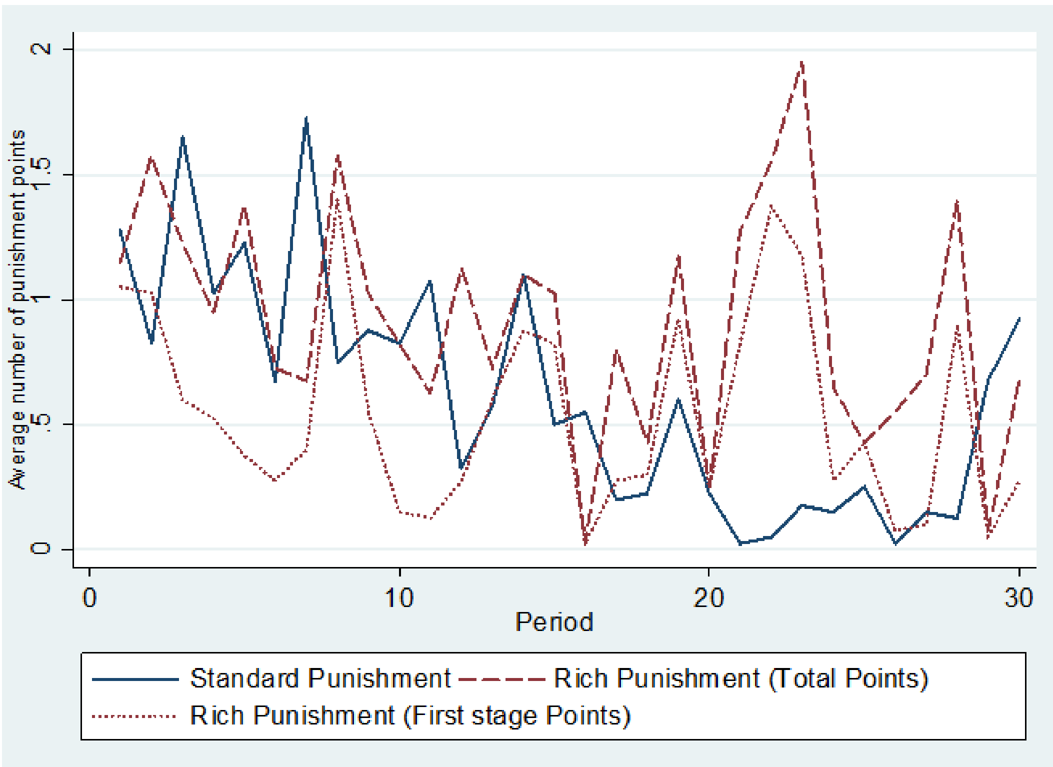

Figure 3: Evolution of average number of punishment points assigned across periods

amount of punishment cannot be attributed to different levels of cooperation, as can be seen in Figure 1. Instead, the high levels of punishment are attributable mostly to two groups engaged in feuding. To keep our paper focused on our main research question, we refrain from presenting a more detailed analysis of punishment behavior here. However, we note, that the punishment patterns we observe in the present experiment are similar to those reported in Nikiforakis and Engelmann (2011). For example, free riders are significantly less punished in the first stage of punishment in the *Rich Punishment* treatment than in the *Standard Punishment* treatment. One difference is that in the present study we do observe some feuds occurring over an extended period of time in two groups in the *Rich Punishment* treatment. Individuals in these groups invest significant amounts of money in punishing others as can be seen by the peaks in periods 20-23 in Figure 3. As a result, although the number of points assigned in the first punishment stage in the *Rich Punishment* treatment is higher than the number of points assigned in later punishment stages (Table 5: 0.54 vs. 0.38), the difference is not statistically significant (Wilcoxon signrank, two-sided, $p-$value $= 0.1394$). The greater incidence of feuds in the present study may be related to the longer-time horizon.

A possible concern for the assessment of the welfare effects of punishment is the *non-material* benefits and costs of punishment. Following revealed-preference arguments, participants who punish others do so because this gives them higher utility than not punishing. At the same time, being punished (counter-punished) may be more costly than just the material losses involved, because one may feel abused. The literature has largely adopted the simplifying convention of only considering the material outcomes of the game and ignoring any utility derived from punishment, payoff comparisons and other social motivations. We follow this approach here in order for our analysis to be comparable to the literature, and because trying to assess actual overall utility levels would require making assumptions about the specific forms of the utility functions of participants, which at this point would probably be gross simplifications.

4 Conclusion

We have investigated whether peer punishment is an efficient mechanism for promoting cooperation in an environment that imposes minimal restrictions on the set of punishment strategies available to individuals. In line with recent theoretical models (Boyd et al., 2010; Janssen and Bushman, 2008; Rand et al., 2010; Rand and Nowak, 2011), we find no evidence of peer punishment increasing group earnings over time in such an environment, despite allowing for interactions to occur over a long time horizon. Although the threat of peer punishment helps maintain the initial levels of cooperation, the benefits of higher cooperation are offset by the costs of punishment which remain high until the end of the experiment, partly due to the ongoing feuds between group members.

The inefficacy of peer punishment to increase group earnings in our environment relative to the treatment without punishment opportunities raises questions about whether and under what conditions peer punishment can be an efficient mechanism for upholding cooperation in daily life. In many respects, the environment studied in our experiment is a favorable one for the success of peer punishment. Individuals interact in small groups in which monitoring and coordination of actions should be easier than in larger groups. Furthermore, there is no uncertainty about the contributions of others (Ambrus and Greiner, 2012; Grechenig et al., 2010). In our experiment, group members are symmetric, a factor that minimizes the problem of normative conflict, which increases the cost of punishing free riders (Nikiforakis et al., 2012; Reuben and Riedl, 2013). In addition, individuals interact for an extended period of time which has been shown to make them more forward looking (Gächter et al., 2008; Isaac et al., 1994).

In spite of these favorable conditions, peer punishment is not very effective at increasing group earnings in our setting that is more general and, arguably, more realistic than the typical setting, which allows for a very limited set of punishment strategies. Our findings therefore may help explain why groups in daily life often adopt some form of hierarchy and delegate the power to punish to a small number of group members (e.g., police, Head of Department, senior partner in a firm, head of the family). This is not to imply that there are no conditions under which peer punishment can be an efficient mechanism for promoting cooperation. Factors such as communication (Bochet and Putterman, 2009; Masclet et al., *forthcoming*; Ostrom et al., 1992), punishment that is costless for the victim (Masclet et al., 2003), endogenous selection of group members (Masclet, 2003; Putterman, 2005) and adoption of rules that govern group behavior (e.g., Putterman et al., 2011) are likely to promote efficiency. However, these factors may also interact with others. For example, the ability to communicate and adopt common rules will be limited in larger or asymmetric groups. Even if different factors can help make peer punishment effective in the long run, the time horizon may be too long. As Keynes suggested, people care about their current state of affairs and not only what will happen in the long run. Hence, they may favor delegation of punishment. We believe that these are all topics worthy of future investigation.

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APPENDIX (FOR ONLINE PUBLICATION)

Instructions for the Rich Punishment Treatment

You are now taking part in an economic experiment. If you read the following instructions carefully, you can, depending on your decisions, earn a considerable amount of money. It is therefore important that you take your time to understand the instructions.

The instructions which we have distributed to you are for your private information. **Please do not communicate with the other participants during the experiment.** Should you have any questions please raise your hand.

During the experiment we shall not speak of Dollars, but of Experimental Currency Units (ECU). Your entire earnings will be calculated in ECUs. At the end of the experiment the total amount of ECUs you have earned will be converted to Dollars at the rate of **1 ECU = 6 cents** and will be immediately paid to you in cash. In addition, we will give you a one-off payment of 150 ECU (**$9.00**).

At the beginning of the experiment the participants will be randomly divided into groups of four. You will therefore be in a group with 3 other participants. **The composition of each group will remain the same throughout the experiment.**

The experiment will last 30 periods. In the beginning of the experiment, after you are randomly divided into groups, **each participant in your group will be randomly given a number for identification** (i.e. Player 1, Player 2, Player 3, and Player 4). **Each participant will keep this number throughout the experiment.** Once the experiment is over the identities of each participant will be kept anonymous.

Each of the 30 periods is divided into a number of stages.

The first stage

At the beginning of each of the 30 periods each participant will receive 20 ECU. In the following, we shall refer to this amount as the “endowment”. Your task in the first stage is to decide how to use your endowment. **You have to decide how many of the 20 ECUs you want to contribute to a project** (from 0 to 20) **and how many of them to keep for yourself**. The consequences of your decision are explained in detail below.

Once all the players have chosen their contribution to the project you will be informed about the group’s total contribution, your earnings from the project and your earnings at the end of the first stage. Your earnings at the end of the first stage are calculated using the following formula. If you have any difficulties do not hesitate to ask us.

Earnings at the end of stage 1 = Endowment of ECUs - Your contribution to the Project + 0.4*Total contribution to the Project

This formula shows that your earnings at the end of the first stage consists of two parts:

1) The ECUs which you have kept for yourself (endowment – contribution)
2) The earnings from the project, which equals to the 40% of the group's total contribution.

The earnings of each group member from the project is calculated in the same way. This means that each group member receives the same earnings from the project. Suppose the sum of the contributions of all group members are 60 ECUs. In this case, each member of the group receives earnings from the project of: 0.4*60=24 ECUs. If the total contribution to the project is 9 ECUs, then each member of the group receives earnings of: 0.4*9=3.6 ECUs from the project.

You always have the option of keeping the ECUs for yourself or contributing them to the project. Each ECU that you keep raises your end of period earnings by 1 ECU. Supposing you contributed this ECU to the project instead, then the total contribution to the project would rise by 1 ECU. Your earnings from the project would thus rise by 0.4*1=0.4 ECU. However, the earnings of the other group members would also rise by 0.4 ECUs each, so that the total earnings of the group from the project would be increased by 1.6 ECUs. Your contribution to the project therefore also raises the earnings of the other group members. On the other hand you also gain earnings for each ECU contributed by the other members to the project. In particular, for each ECU contributed by any member you earn 0.4 ECUs.

The second stage

At the second stage you will be informed about how much each group member contributed individually to the project at the first stage. At this stage you can **reduce or leave equal the earnings of each member of your group by distributing points**. The other group members can also reduce your earnings if they wish to.

To reduce another player's earnings you will have to distribute points. Each point you distribute will cost you 1 ECU and will reduce the earnings of the person you assign it to by 3 ECU. If you choose 0 points for a particular group member, you do not change his or her earnings.

Example: Suppose that you give 2 points to player 1. This costs you 2 ECU and reduces player 1's earnings by 6 ECU.

Your total earnings from the two stages is therefore calculated as follows:

Total earnings (in ECUs) at the end of stage 2 =

= Earnings from the 1st stage – 3*Points you receive – Points you give

Please note that your earnings in ECUs after the second stage can be negative. If your earnings are negative at the end of the period, this will be covered by the 150 ECU that we gave you in the beginning in order to pay this off.

If none of the members of your group distributes points then the period finishes and the next period begins again with stage one. The period also finishes if none of the members of your group is allowed to assign further points. This will be explained below. Otherwise, a third stage will follow.

<u>The third stage</u>

In the third stage, you will be informed of the points that each person in your group assigned to you and the other members in your group. Similarly, the other members of your group will be informed about how many points you assigned to each of them. Then you can again **reduce or leave equal the earnings of each member of your group by distributing points**. The other group members can also again reduce your earnings if they wish to.

Note that in order for someone to be able to assign points at this stage he or she must have at least 1 ECU (i.e. the cost of one point). Additionally, if one member has earnings, the others will not be able to reduce her earnings further. However, they will be able to reduce her earnings if at the beginning of the third stage her earnings are equal to zero.

The costs of assigning points, as well as the earnings reduction caused by each point remain the same as before i.e. it costs you 1 ECU to assign a point and it reduces the recipient's earnings by 3 ECU.

Since a group member can only assign points if her current earnings are at least 1 ECU, the period ends when the earnings of all members of the group has been reduced to less than 1 ECU. Furthermore, since it is not allowed to assign points to a member who already has negative earnings, the period ends if three players have negative earnings, because the fourth player cannot assign points to them to reduce their earnings further. Hence the third stage will only be entered if after the second stage at least one player has 1 ECU left and at least one other player has at least retained earnings of 0 (non-negative earnings)

<u>Fourth stage and beyond</u>

Your **task** in the forth stage and beyond is the **same as in stage 3**. **After being informed of the points distributed in your group you will be able to assign further points.** The costs of assigning points, as well as the earnings reduction caused by each point remain the same as before. The fourth, fifth, or any further stage will only be entered if at least one player assigned points in the previous stage *and* if at least one player can assign further points.

<u>When does a period end?</u>

A period ends and a new one begins when one of the following occurs.

- No points are distributed in a given stage.
- Points are distributed, but no player would be allowed to assign any more points if another stage followed. This can happen if no player has at least 1 ECU left or if three players have negative earnings.

Example: Assume that at the after the third stage, the earnings are as follows:
Player 1: 2 ECU
Player 2: 10 ECU
Player 3: 3 ECU
Player 4: 2 ECU

Assume that in the fourth stage player 4 assigns 2 points to player 3 and no other player assigns points. Hence the earnings are
Player 1: 2 ECU
Player 2: 10 ECU
Player 3: -3ECU (= 3 ECU – 2*3 ECU)
Player 4: 0 ECU (= 2 ECU – 2 ECU)

Since points were assigned in stage four and two players have positive earnings, a fifth stage follows. If in the fifth stage player 2 assign 4 points to player 1 and 1 point to player 4, the earnings are

Player 1: -10 ECU (= 2 ECU – 4*3 ECU)
Player 2: 5ECU (= 10 ECU - 4 ECU – 1 ECU)
Player 3: -3ECU
Player 4: -3 ECU (= 0 ECU – 3*1 ECU)

The period now ends, because only player 2 could assign more points, but because all other players have negative earnings, player 2 is not allowed to assign points to any of them.

If you have any further questions please raise your hand and one of the supervisors will come to help you.

Control Questionnaire

1. Each group member has an endowment of 20 ECUs. Nobody (including you) contributes any ECUs to the project. How high is:
    a. Your earnings after the first stage? ………
    b. The earnings of the other group members………

2. Each group member has an endowment of 20 ECUs. You contribute 20 ECUs to the project. All other group members contribute 20 ECUs each to the project. What is:
    a. Your earnings after the first stage? ………
    b. The earnings of the other group members?………

3. Each group member has an endowment of 20 ECUs. The other three group members contribute together a total of 30 ECUs to the project. What is:
    a. Your earnings after the first stage if you contribute 0 ECUs to the project? ……….
    b. Your earnings at the end of the period if you contribute 15 ECUs to the project? ……….

4. Each group member has an endowment of 20 ECUs. You contribute 8 ECUs to the project. What is:
    a. Your earnings after the first stage if the other group members together contribute a further total of 7 ECUs to the project?...............
    b. Your earnings after the first stage if the other group members together contribute a further total of 22 ECUs to the project?...............

5. Your earnings from the first period is 25 ECU. How much will your earnings at the end of the second stage be if:
    a. You receive 2 points, but do not assign any yourself? …………..
    b. You receive 2 points and assign 3 points yourself?..............

6. *True or false:* Each participant will be given an identification number which will allow others in their group to follow their actions in the experiment.

    ☐ True ☐ False

7. Assume you assign 2 points to another group member, no one else in your group assigns any points and all members in your group have a positive earnings. Will another stage follow?

……………………………………………………………………………………………..

8. **8.** Assume no member of your group assigns points including you. Will another stage follow?

……………………………………………………………………………………………..

Control Questionnaire Answers

1. a) 20 ECU b) 20 ECU

2. a) 32 ECU b) 32 ECU

3. a) 32 ECU b) 23 ECU

4. a) 18 ECU b) 24 ECU

5. a) 19 ECU b) 16 ECU

6. Yes.

7. Yes

8. No.