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Conditional Cooperation and the Effect of Punishment

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Conditional Cooperation and the Effect of Punishment

Abstract

We study how punishment influences conditional cooperation. We ask two questions: 1) how does conditional cooperation change if a subject can be punished and 2) how does conditional cooperation change if a subject has the power to punish others. In particular, we disentangle the decision to be a conditional cooperator at all from the strength of conditional cooperation. We find that the possibility of being punished increases the strength of conditional cooperation. At the same time the possibility of being punished increases the number of free riders. In our study the net effect on cooperation still is positive. The possibility of punishing others has two effects: Substitution and responsibility. Players substitute conditional cooperation with punishment which leads to a decrease in conditional cooperation. The power to punish means more responsibility which leads to an increase in conditional cooperation. In our design the overall effect of responsibility is stronger than the effect of substitution. We conclude that the threat of being punished and the power to punish changes conditional cooperation behavior in several, unexpected, ways.

JEL-Codes: C910, C720, H410.

Keywords: punishment, conditional cooperation, experiment, substitution, responsibility.

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1 Introduction

In this paper, we study how punishment influences conditional cooperation behavior. In particular, we ask how conditional cooperation changes (1) if a subject can be punished and (2) if a subject has the power to punish.

Social dilemmas, i.e. conflicts between self-interest and collective interest (Van Lange et al., 2014, Chaudhuri, 2010, Kollock, 1998), are a key issue in public economics. Social dilemmas can be found in many domains (e.g. environmental protection, overpopulation, team work). In many experiments we find that humans behave not only selfishly. At least to some degree, human behaviour is also cooperative (see the seminal paper by Isaac et al., 1984).¹

Conditional cooperation is one possible explanation for the existence of cooperation. Humans contribute and expect others to contribute as long as others contribute, too. Fischbacher et al. (2001) classify 50% of their participants as conditional cooperators while only 30% are found to be free riders. Since then similar findings has been replicated in different cultures (Herrmann and Thöni, 2009, Kocher et al., 2008). Conditional cooperation also plays a role in repeated games. Many studies in repeated games find cooperation decreasing over time (Isaac et al., 1984, Ledyard, 1994, Chaudhuri, 2010). Fischbacher and Gächter (2010) provide empirical evidence that conditional cooperation can explain the decline of cooperation in repeated public good games.² All in all, conditional behaviour seems to be a very strong element in human behaviour. Humans behave conditionally even when it is bad for the group. Abbink et al. (2010) find that subjects are punished if they do not contribute to a group conflict even if this results in an overall worse outcome. Furthermore, Abbink et al. (2017) show that subjects are punished if they do not engage in the destruction of a public good.

Punishment is another factor which is relevant to understanding cooperation. Punishment can increase and stabilize contribution significantly in many settings, in particular in peer-punishment, third-party punishment and centralized punishment settings.³ However, punishment can have negative effects, too: Gneezy and Rustichini (2000) study the effect of fines in day-care centers. They find that fining parents for picking up their children late increases, paradoxically, the number of parents which are late. Crowding out intrinsic motivation has been discussed since several years. Ellingsen and Johannesson (2008) argue that control systems may erode morale. Frey and Reto (2001) and Gneezy et al. (2011) summarise several studies on crowding out of incentives through punishment.

Punishment can change the behaviour of two decision makers: The punisher and the punished. The punisher has a power to punish. The punished experiences a threat of punishment. In this paper we want to study how the threat of being punished and the power to punish

¹See Chaudhuri (2010), Ledyard (1994) for two surveys of the literature.

²One alternative explanations for the decline in cooperation is given by Andreoni (1988) who argues that free riding is learned during a repeated game. Other authors relate a decline in cooperation in repeated games to other-regarding preferences (Houser and Kurzban, 2002, Goeree et al., 2002, Brandts and Schram, 2001, Palfrey and Prisbrey, 1997, Fischbacher et al., 2001).

³See Andreoni and Gee, 2012, Boyd et al., 2010, Cheung, 2014, De Silva et al., 2010, Dickson et al., 2015, Faillo et al., 2013, Fehr and Gächter, 2000, Fehr and Gächter, 2002, Herrmann et al., 2008, Kamei, 2014, Kamijo et al., 2014, Nosenzo and Sefton, 2012, OGorman et al., 2009, Schoenmakers et al., 2014. For an overview see Chaudhuri, 2010, Balliet et al., 2011.

changes conditional cooperation. To our knowledge, there is no study investigating how punishment influences conditional cooperation.

Even though we know from the literature that the threat of punishment might increase cooperation, we do not know how punishment impacts conditional cooperation. We do not know whether punishment mainly affects the number of cooperators or whether punishment affects the strength of conditional cooperation. We also do not know how the power to punish interacts with conditional cooperation. In this paper, we explore several possible mechanisms. In particular, we study whether the power to punish is mitigated by substitution, responsibility, or entitlement.

Both punishment and conditional cooperation are conditional responses to the behavior of others. In this sense punishment and conditional cooperation can be seen as substitutes. A decision maker in a situation where both options, punishment and conditional cooperation, are available might choose smaller amounts of both as compared to a situation where only one of them is available.

Responsibility might be affected by the availability of punishment. Subjects with the power to punish might feel more responsible and act more as benevolent leaders, and hence might contribute more. A number of experiments⁴ have shown that a position of power may lead to more prosocial behavior.

Entitlement is another mechanism which could affect conditional cooperation and punishment. In two recent studies [Hoefl and Mill \(2017a,b\)](#) show that subjects in a position of power use this power to enforce behavior which the enforcers themselves are not complying with. A decision maker with the power to punish might, hence, feel entitled to provide smaller contributions.⁵

To understand how punishment influences conditional cooperation we use three treatments. Treatment *Base* is a replication of [Fischbacher et al. \(2001\)](#). In this treatment all subjects have two tasks: One task is an unconditional contribution, the other task is a conditional contribution. Groups consist of four players. The unconditional decision is implemented for three players in each group. Only for one player in each group the decision conditional on the behavior of the others is implemented.

In treatments *CPun* and *UCPun*, subjects still make an unconditional and a conditional decision. In addition, they make a punishment decision conditional on the contribution of others. In the treatment *CPun* only the punishment of the conditional contributor was implemented and one of the unconditional decision makers was punished. In the treatment *UCPun* only the punishment of one of the unconditional decision makers was implemented and the conditional decision maker was punished. Thus, *UCPun* represents a situation where a conditional decision maker experiences the threat of being punished. *CPun* represents a situation where a conditional decision maker has the power to punish others.

Anticipating our results, we find that the threat of punishment increases conditional cooperation for most participants. However, we also observe a negative effect of the threat of punishment: With punishment the number of free riders increases. Still, in our experiment, the total effect on conditional cooperation is positive.

⁴see [Hamman et al. \(2011\)](#), [Grossman \(2014\)](#), [Brandts et al. \(2015\)](#), [Glöckner et al. \(2011\)](#).

⁵Similarly, [Ball et al. \(2001\)](#) show that high-status subjects derive more rent in markets.

Table 1: Treatments

Treatment	Unconditional Contribution	Conditional Contribution	Punishment	Who punishes	Who is punished
<i>Base</i>	✓	✓	–	–	–
<i>CPun</i>	✓	✓	✓	Conditional decision maker	One of the unconditional decision makers
<i>UCPun</i>	✓	✓	✓	One of the unconditional decision makers	Conditional decision maker

Relating to the power of punishment we find that conditional cooperation and punishment are treated as substitutes. Such a substitution effect could mean that the availability of conditional punishment implies a decrease in conditional cooperation. This effect is, however, compensated by responsibility: Players with the power to punish seem to work harder for the common good.

In conclusion, this paper answers two questions:

1. How does conditional cooperation change if subjects can be punished?
 - The conditional cooperation increases
 - However, the number of free riders also increases
2. How does conditional cooperation change if subjects have the power to punish?
 - Conditional cooperation and punishment are treated as substitutes
 - But subjects with more power behave responsibly by contributing more to the common good.

The remainder of the paper is structured as follows: Section 2 will explain the design of the experiment. Section 3 presents our Hypotheses. In Section 4 we show the results of the experiment. Section 5 concludes.

2 Design

We implement three treatments in order to study the questions how conditional cooperation changes if 1) conditional cooperators might be punished and if 2) conditional cooperators have the power to punish.

In our *Base* treatment we try to be as close to the original paper of [Fischbacher et al. \(2001\)](#) as possible. Participants are matched in groups of four. They are instructed to divide 20 tokens between a private and public account (1 token = 0.30€). The public account (c_i) had a MPCR of 0.4, i.e. each group member receives 0.4 times the total contribution to the public account plus what they keep in the private account. Each participant i has, hence, the following payoff ϕ_i :

$$\phi_i = 20 - c_i + 0.4 \cdot \sum_{j \in \{1, \dots, 4\}} c_j \quad (1)$$

Instructions are provided on the computer. As in [Fischbacher et al. \(2001\)](#), participants answer 10 control questions before moving to the decision task.

To elicit choices, we use the strategy vector method ([Selten, 1967](#)). Participants make decisions for different situations. Only later they learn which choice is relevant. As in [Fischbacher et al. \(2001\)](#), participants can have one of two possible roles: In each group of four one randomly selected player is a conditional decision maker (CDM). The other three are unconditional decision makers. As in [Fischbacher et al. \(2001\)](#), players only learn which role they have after they have made all their decisions.

As in [Fischbacher et al. \(2001\)](#), subjects make two types of contribution decisions: First they make an “unconditional contribution”, which is relevant if they have the role of an unconditional decision maker, see [Figure 9](#) for the Interface. Here they state how many of their 20 tokens they allocate to the public account.

Then they make a conditional contribution which is only relevant if their role is a CDM, see [Figure 10](#) for the Interface. Here they state their contribution to the public account for all the 21 possible average contributions (rounded to integers) of the other players.

In addition to the *Base* treatment two further treatments add a punishment stage. In the treatment *UCPun* the conditional cooperator can be punished. In the treatment *CPun* the conditional cooperator has the power to punish (see [Figure 11](#) for the Interface). In the punishment stage, participants indicate by how many points another player should be punished conditional on the earlier contribution of this player (0, 1, ..., 20 tokens). Each punishment point reduces the payoff of the punished player by one point. To avoid inequality concerns and welfare concerns punishment is costless and limited to 10 tokens.⁶

CPun and *UCPun* differ in the direction of the punishment. In *UCPun* the CDM experiences the threat of being punished. The punishment table of one randomly selected unconditional decision maker determines the punishment of the CDM. In *CPun* the situation is reversed. Here the CDM has the power to punish others. The punishment decision of the CDM determines the punishment of one randomly selected other player.

Only when all subjects have completed all tasks they learn their role (conditional or unconditional cooperator) and (in the punishment treatments) whether their punishment is implemented. Subjects are also told the overall contribution of their group and the own payoff. See [Figure 12](#) for the Interface.

After completing a socio-demographic questionnaire subjects were paid individually.

⁶Costly punishment would make it difficult to compare *CPun* and *UCPun* with *Base*. The reason is that in *Base* participants have a fixed budget which they can use for contribution. In *CPun* and *UCPun* we introduce an extra task: punishment. If this task is costly and if the budget remains the same as in *Base*, then contributions might drop only because we introduced a second (costly) task. Increasing the budget too much implies that participants have more resources left which they can use for punishment. Setting the price for punishment to exactly zero means that the budget participants have for contributions is the same in *Base*, *CPun* and *UCPun*.

3 Hypotheses

In this paper we want to study how punishment influences conditional cooperation. In particular, we investigate 1) how the threat of punishment influences conditional cooperation and 2) how the possibility to punish others influences the own contribution behavior. Most of our hypotheses are, therefore, about conditional effects, not about average levels of contribution or average levels of punishment.

We suspect that the threat of being punished might work through different mechanisms. The fear of being punished could have a positive effect and work as an incentive. At the same time, potential punishment increases uncertainty and insecurity which could lead to frustration and crowding-out. In this case the possibility of punishment could increase the number of free riders.

We also speculate that having the option to punish others affects conditional cooperation in a number of ways: An effect of substitution of reciprocity, but also responsibility, and entitlement.

In the following, we first present the hypotheses if a CDM may be punished and then we present the hypotheses if a CDM has the power to punish others.

3.1 Threat of punishment

In the *UCPun* treatment the CDM can be punished. As discussed above, several studies support the view that the possibility to be punished changes the behavior of decision makers. To avoid punishment, the CDM might try harder to fulfill the expectations of the punisher. In particular, if subjects believe that most punishers expect conditional cooperation, then we should find either more conditional cooperation of the CDM in *UCPun* or more conditional cooperators in *UCPun*.

Hypothesis 1 (Punishment increases cooperation). *The CDM in UCPun shows more conditional cooperation than CDMs in Base.*

Hypotheses 1 refers to the slope of the conditional decision.

Hypothesis 2 (Punishment leads to more conditional cooperators). *In UCPun more CDMs behave as conditional cooperators than in Base.*

Hypotheses 2 refers to number of conditional cooperators and freeriders.

Thus, we have two hypotheses on how the threat of punishment impacts cooperation behavior. It either increases the slope of conditional cooperation or it just increases the number of conditional cooperators.

However, punishment might also backfire and crowd-out the incentives to cooperate, which is supported by the literature on crowding-out effects (Gneezy and Rustichini, 2000, Ellingsen and Johannesson, 2008, Frey and Reto, 2001, Gneezy et al., 2011). Specifically, Bowles and Polania-Reyes (p. 418, 2012) argue that “the meaning of the fines or subsidies to the target of the incentives” account for crowding out. Thus, if the option of being punished suggests to subjects that freeriding is a “permissible behavior”⁷, then we would expect

⁷Ibid., p. 390.

the opposite effect, and find less cooperation in *UCPun*. Thus, both Hypotheses 1 and 2 might be overturned by the crowding-out effect.

3.2 Power to punish

The power to punish can influence the conditional cooperation in several ways. We will discuss each of them in the following.

3.2.1 Substitution

In [Fischbacher et al. \(2001\)](#) and in our *Base* treatment conditional cooperation is the only possibility for the CDM to behave in a reciprocal way. In our *UCPun* treatment conditional punishment is the only possibility for the other three players to behave in a reciprocal way. In our *CPun* treatment the CDM has both options: She can reciprocate through conditional cooperation. At the same time, the CDM can also reciprocate through conditional punishment. These two options can be seen as substitutes. Players might then choose a smaller amount of each single action when both are available.

If conditional cooperation and conditional punishment are substitutes, we hypothesize the following:

Hypothesis 3 (Substituting conditional cooperation). *We observe less conditional cooperation (a smaller slope) in CPun than in Base.*

Hypothesis 4 (Substituting punishment). *We observe less conditional punishment (a smaller slope) in CPun than in UCPun.*

Both hypotheses refer to the amount of reciprocity, i.e. to the slopes of the conditional decision (see Equation (3) below), not to the absolute level. We should also note that the effect of substitution might be offset by responsibility.

3.2.2 Responsibility

[Bolle and Vogel \(2011\)](#) show that decision makers in a position of power act more responsibly. They act prosocially and not selfishly. Thus, we hypothesize that power leads to more responsible behavior. In our setting the CDM in *CPun* has more powers to reciprocate than the CDM in *Base* and *UCPun*. Therefore, we hypothesize that the CDM in *CPun* behaves more responsible than the CDMs in *Base*. In particular, we hypothesize the following:

Hypothesis 5 (Responsibility increases cooperation). *The CDM in CPun shows more conditional cooperation than CDMs in Base.*

Hypothesis 5 refers to the slope of the conditional decision. Hypothesis 5 predicts the opposite of Hypothesis 3.

Table 2: Hypotheses

		Avg. Contr.	Contr. Slope	# of Cond.Coops	Pun. Slope
Threat of punishment	Hyp. 1	-	$UCPun > Base$	-	-
	Hyp. 2	-	-	$UCPun > Base$	-
Substitution	Hyp. 3	-	$CPun < Base$	-	-
	Hyp. 4	-	-	-	$CPun < UCPun$
Responsibility	Hyp. 5	-	$CPun > Base$	-	-
Entitlement	Hyp. 6	$CPun < Base$	-	-	-

3.2.3 Entitlement

Several papers⁸ show that entitlement (and also social status) influences behavior of decision makers so that they behave in a less prosocial way.

In all our treatments the CDM can cooperate conditionally, but only in $CPun$ the CDM can cooperate conditionally and punish conditionally. This extra power experienced by the CDM in $CPun$ might not only lead to more responsibility but to more entitlement, i.e. the expectation of a higher profit and, thus, the right to behave less prosocial.

If the power to punish is perceived as an entitlement to behave in a less prosocial way, we hypothesize the following:

Hypothesis 6 (Entitlement reduces cooperation). *The CDM in $CPun$ cooperates less than the CDM in $Base$.*

Hypothesis 6 refers to the average amount of cooperation, i.e. the intercepts of the conditional decision. This is different from Hypotheses 1, 3 and 5, which refer to the strength of conditional cooperation, i.e. the slope of the reaction function of the CDM. For Hypothesis 6 we ask whether the CDM is entitled to a smaller contribution, regardless whether the other players contribute a large or a small amount. Since our estimation is based on demeaned data we can, indeed, interpret our treatment effects as effects on the average. A summary of

our hypotheses can be found in Table 2.

4 Results

4.1 Descriptives

4.1.1 Subjects

We conducted the experiments in February 2016 in the laboratory of the school of economics of the University of Jena (Germany). We recruited 144 participants in 9 sessions using the

⁸see Ball and Eckel (1998), Ball et al. (2001), Kimbrough and Sheremeta (2014), Hoffman et al. (1994), Hoefft and Mill (2017a,b), Falk (2017).

online recruiting platform ORSEE (Greiner, 2015). We implemented the experiment using z-Tree (Fischbacher, 2007). We are grateful to Fischbacher et al. (2001) for providing us with the z-Tree code and the instructions for the original experiment. We changed instructions, test-questions, and the program only where necessary to implement our treatments *CPun* and *UCPun*. The entire experiment lasted for about 45 minutes. Participants earned on average 7.97€, which is slightly above the minimum wage in Germany. We had 36% male and 64% female participants with a median age of 24. The average participant was in the third year of studying. As in Fischbacher et al. (2001), we did not invite any students who indicated to be studying economics or economics related topics (business, business-engineering etc.)

4.1.2 Contributions

To classify participants we follow the definition of Fischbacher et al. (2001). In particular, subjects are classified as *free riders* – subjects with a constant contribution of zero – *conditional cooperators* – subjects who cooperate conditionally on the contribution of others – *hump-shaped contributors* – subjects who conditionally contribute up to a certain point and reverse their conditional contribution from that point on forward – and *others* – subjects not classified in the three mentioned categories. We find 78% conditional cooperators, 8% free riders, 3% hump-shaped contributors, as well as 10% *others*. This distribution of types seems to be similar to the distribution Kocher et al. (2008) find for the U.S.A. with 80.6% conditional cooperators, 8.3% free riders and 0% hump-shape contributors. The distribution of types is different from Fischbacher et al. (2001) who identify about 50% conditional cooperators, 30% free riders, and 14% hump-shaped contributors.

However, the behavior of conditional cooperators we found in our experiment is very similar to Fischbacher et al. (2001) (see Figure 1). As in several other studies (Fischbacher et al., 2001, Burlando and Guala, 2005, Herrmann and Thöni, 2009, Kocher et al., 2008) conditional cooperators contribute slightly below perfect conditional cooperation.

4.1.3 Punishment

The pattern of punishment we find is similar to Fehr and Gächter (2002) (see Figure 2). Fehr and Gächter (2002) observe punishment in particular for players who contribute less than the mean contribution of the other group members. The fewer a player contributes to the public good compared to the average the more this player is punished. Similarly, we observe that our participants punish in particular those players who contribute less than the own unconditional contribution. The fewer a player contributes compared to the unconditional contribution of the punisher the more this player will be punished.

4.2 Estimation strategy:

To investigate the contribution behavior as well as the punishment behavior of subjects we use a hurdle model with mixed effects. We include a random effect (for each individual participant) since we observe for the same participant several conditional contributions levels. We use a hurdle model to allow for free riders and conditional cooperators in the population.

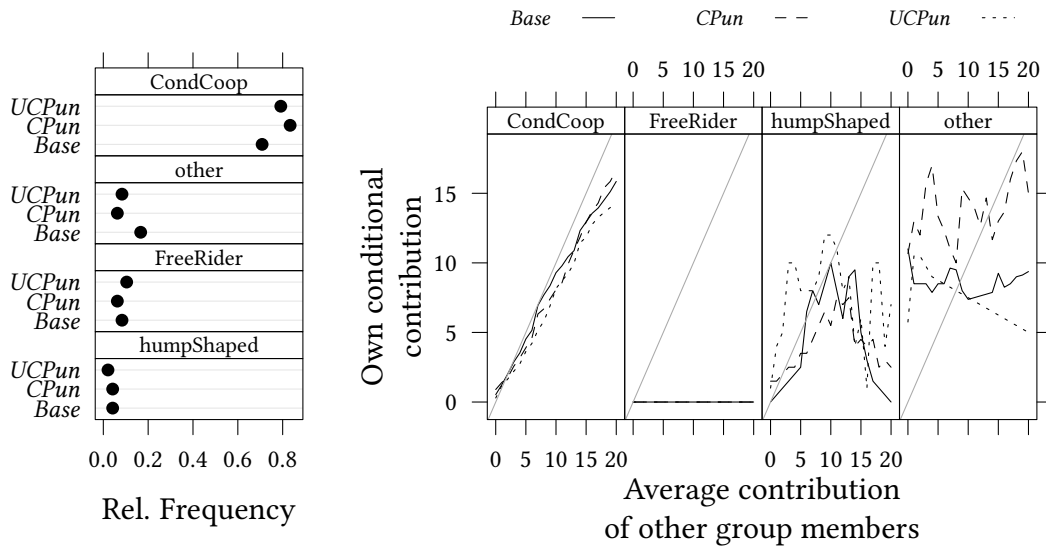


Figure 1: Frequency of types and average contribution of types.

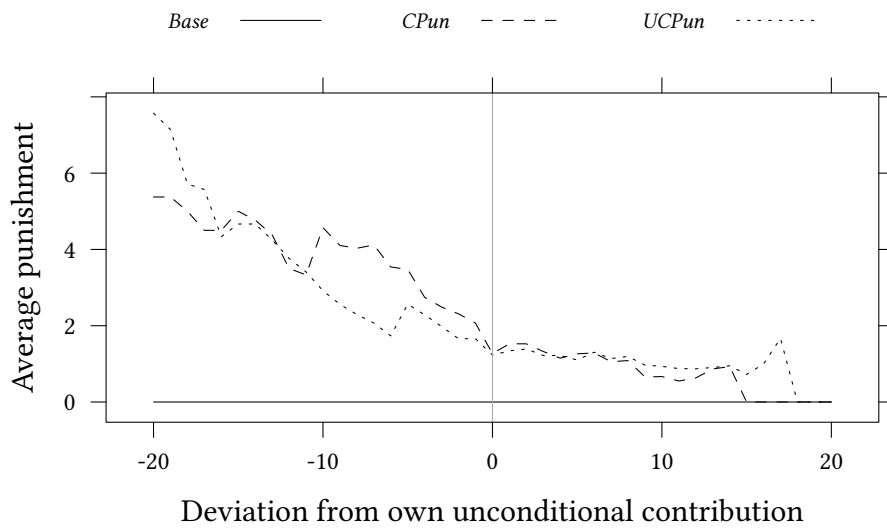


Figure 2: Punishment behavior

	<i>Base</i>	<i>CPun</i>	<i>UCPun</i>
Cond. Cooperator	34	40	38
Free rider	4	3	5
Hump shaped	2	2	1
Other	8	3	4

Table 3: Distribution of player types for the three treatments

We do not focus on unconditional cooperators as this is a rather rare type.⁹ In our model, the hurdle separates the free riders from the cooperators. For cooperators, cooperation is a linear function of the contribution of the others. This approach allows us to distinguish whether punishment changes subjects' types or their conditional behavior.

As we find only 10% free riders, we also estimate a standard mixed effects model without the hurdle.

The variable $\mathbb{1}_{CC,i}$ is one for participants i which are conditional cooperators and zero for free riders. \mathcal{L} denotes the logistic distribution. The probability to be a conditional cooperator is given by the following equation:

$$\Pr(\mathbb{1}_{CC,i} = 1) = \mathcal{L}(\gamma_1^C + \gamma_{CPun}^C \mathbb{1}_{CPun} + \gamma_{UCPun}^C \mathbb{1}_{UCPun}) \quad (2)$$

The conditional contribution $c_i(c_{-i})$ of player i conditional on the average contribution of the others c_{-i} is given by (3):

$$c_i(c_{-i}) = \mathbb{1}_{CC,i} \cdot (\beta_1^C + \beta_{CPun}^C \mathbb{1}_{CPun} + \beta_{UCPun}^C \mathbb{1}_{UCPun} + (\beta_{c_{-i}}^C + \beta_{CPun \times c_{-i}}^C \mathbb{1}_{CPun} + \beta_{UCPun \times c_{-i}}^C \mathbb{1}_{UCPun})c_{-i}) + \epsilon_i^{C'} + \epsilon_{i,c_{-i}}^C \quad (3)$$

$\mathbb{1}_{CPun}$, resp. $\mathbb{1}_{UCPun}$, are dummy variables which are one for treatments $CPun$ and $UCPun$, respectively, and zero otherwise. To account for the nested structure of the data we include a random effect $\epsilon^{C'}$.¹⁰ The residual is $\epsilon_{i,c_{-i}}^C$.

To model punishment, we, again, use a hurdle model with mixed effects. We know from the literature on punishment behavior that punishment has a substantial amount of zeros (no punishment). Hence, we use a hurdle model. We also include a random effect for each individual participant to account for the nested structure of the data

The probability to be a conditional punisher is given by the following equation:

$$\Pr(\mathbb{1}_{CP} = 1) = \mathcal{L}(\gamma_1^P + \gamma_{UCPun}^P \mathbb{1}_{UCPun}) \quad (4)$$

The punishment $p_i(c_{-i})$ meted out by subject i conditional on the contribution c_{-i} of an other subject is given by (5):

$$p_i(c_{-i}) = \mathbb{1}_{CP} \cdot (\beta_1^P + \beta_{UCPun}^P \mathbb{1}_{UCPun} + (\beta_{c_{-i}}^P + \beta_{UCPun \times c_{-i}}^P \mathbb{1}_{UCPun})c_{-i}) + \epsilon_i^{P'} + \epsilon_{i,c_{-i}}^P \quad (5)$$

The random effect $\epsilon_i^{P'}$ takes into account the nested structure of the data.¹¹ $\epsilon_{i,c_{-i}}^P$ is the residual.

⁹Moreover, it is not obvious why unconditional cooperators should change their behavior under either the threat of punishment or the power to punish as they seem to have a fixed contribution scheme at heart.

¹⁰We also estimate a model with two random effects: one for the intercept and one for the slope. Results are shown in Table 7 in the Appendix.

¹¹As with cooperation we also estimate a hurdle model for punishment where we include two mixed effects: one mixed effect for the intercept and a second mixed effect for the slope. Results can be found in Table 10 in the Appendix.

As we are not aware of any package in R to estimate the giving model¹² we use a Bayesian approach. We also estimate the standard mixed effects model (without a hurdle) using frequentist methods and Bayesian methods. Results are reported in Tables 6 and 11 in the Appendix for the Bayesian and for the frequentist estimation, respectively. Results on conditional cooperation are similar to the results from the Bayesian hurdle approach.

We use JAGS 4.3.0 (2017). We demean data to improve convergence of the sampler. Demeaning also allows us to conveniently interpret our treatment effects as effects on the average. For each model, we use 4 MCMC chains. For each chain, we use a thinning interval of 10, we discard 5000 samples for adaptation and burnin and keep 10000 samples to estimate the posterior.¹³ For each model we have, hence, 40000 samples (based on, actually, 4×10^5 samples before thinning). We use vague priors as given by (6)-(10).

$$\beta_{\{1,2,\dots,5,6\}}^{\{C,P\}} \sim \mathcal{N}(0, 10^{-4}) \quad (6)$$

$$\gamma_{\{1,2,\dots,3\}}^{\{C,P\}} \sim \mathcal{N}(0, 10^{-4}) \quad (7)$$

$$\epsilon^T \sim \mathcal{N}(0, \tau^T) \quad (8)$$

$$\tau^T \sim \Gamma((\mathbf{m}^T)^2 / (\mathbf{s}^T)^2, \mathbf{m}^T / (\mathbf{s}^T)^2) \quad (9)$$

$$\mathbf{m}^T \sim \text{Exp}(1) \text{ and } \mathbf{s}^T \sim \text{Exp}(1) \text{ with } T \in \{C', C, P', P\} \quad (10)$$

4.3 Estimation results

Figure 3 shows estimation results for Equations (2) and (3). Detailed results are given in Table 5 in Appendix A. Table 6 resp. Table 11 present results for a simpler model without a hurdle with a Bayesian approach and a frequentist estimation, respectively.¹⁴

Figure 4 shows estimation results for Equations (5) and (4). Detailed results are given in Table 8 in Appendix B. Table 9 resp. Table 12 present results for a simpler model without a hurdle with a Bayesian approach and a frequentist estimation, respectively.¹⁵

4.3.1 Threat of punishment

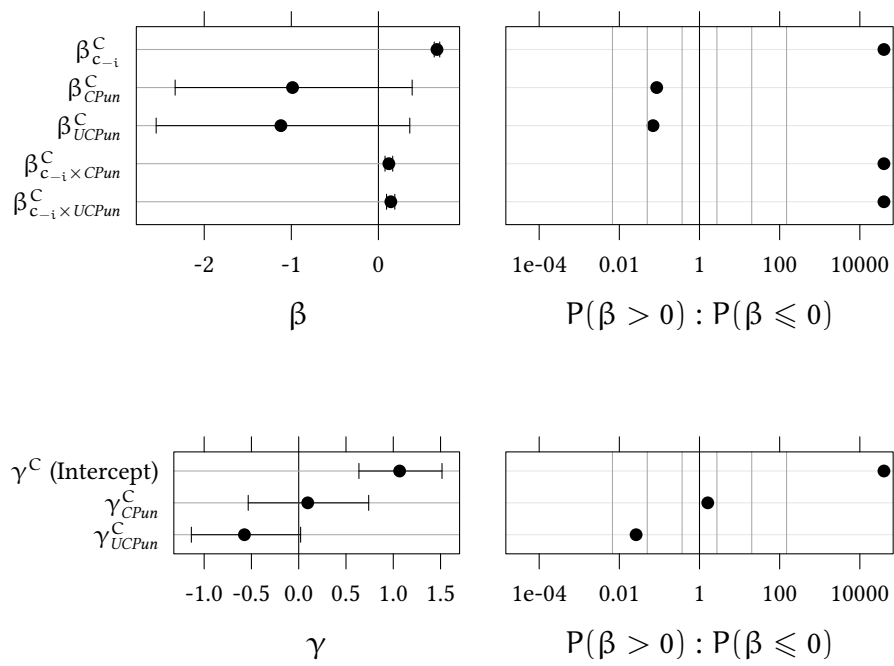
Punishment increases cooperation Hypotheses 1 and 2 predict a change in the cooperation behavior of CDMs in *UCPun* compared to *Base*. Hypothesis 1 predicts a steeper slope of the conditional cooperation function in *UCPun* than in *Base*. Hypothesis 2 predicts a higher probability to be a conditional cooperation in *UCPun* than in *Base*.

¹²g1mmADMB estimates the hurdle models in a two-step regression: First estimating a linear mixed effects model for contributors only and second estimating a binomial logistic regression of contributing at all. In doing so the mixed effects hurdle model does not control for dependencies. The two-step regression, hence, is prone to underestimating the standard errors. Using a Bayesian version allows us to simultaneously estimate the conditional as well as the binary decision.

¹³With a thinning interval of 10 we calculate 10^5 samples for each chain. We then use thinning to keep the data manageable, keeping 10000 samples from each of the 4 MCMC chains.

¹⁴Table 7 shows results for a model with hurdle and two random effects, one for the intercept and one for the slope.

¹⁵Table 10 shows results for a model with hurdle and two random effects, one for the intercept and one for the slope.



The graphs show the 95%-credible intervals for the Bayesian estimated coefficients on the left hand side and the odds of the posterior to be larger than zero on the right hand side. Detailed results are given in Table 5 in the Appendix.

Figure 3: Estimation results for Equations (3), (2)

We find that the odds that $\beta_{c_{-i} \times UCPun}^C > 0$ are 40000 : 1, i.e., we have very strong evidence in support of more cooperation in *UCPun* than in *Base*. Thus, we confirm Hypothesis 1.¹⁶

Turning to the probability to be a conditional cooperator, we find the odds that $\gamma_{UCPun}^C < 0$ are 38.1 : 1, i.e., we have strong evidence for a smaller (not larger) probability to be a conditional cooperator in *UCPun*. Thus, we reject Hypothesis 2 and show a converse relationship.

Hence, we see two opposing effects: When a CDM anticipates punishment in *UCPun*, the slope of conditional cooperation increases. At the same time the probability to be a conditional cooperator decreases. To assess which effect dominates we estimate Equation (3) with $\mathbb{1}_{CC,i} = 1$, i.e. we assume that all participants belong to the group of conditional cooperators. Estimation results are shown in Table 6 in Appendix A. For this (simplified) model we find the odds that $\beta_{c_{-i} \times UCPun}^C > 0$ are 5.34 : 1, i.e., we have positive evidence for an overall increase in conditional cooperation.

Result 1.1. *Threat of punishment increases the slope of conditional cooperators.*

Result 1.2. *Threat of punishment reduces the probability to be a conditional cooperator.*

4.3.2 Power to punish

Next, we come to the effect of being able to punish on conditional cooperation. We hypothesized that a CDM may be impacted in his decisions making in several ways if he has the option to punish others.¹⁷

4.3.2.1 Substitution

Substituting conditional cooperation Hypothesis 3 predicts that the slope for conditional cooperation is smaller in *CPun* than in *Base*. On the contrary, we find odds that $\beta_{c_{-i} \times CPun}^C > 0$ are 40000 : 1, i.e., we have very strong evidence for more, not less, conditional cooperation in *CPun* than in *Base*.

Result 2.1. *On the level of cooperation we find no substantial evidence for a substitution effect.*

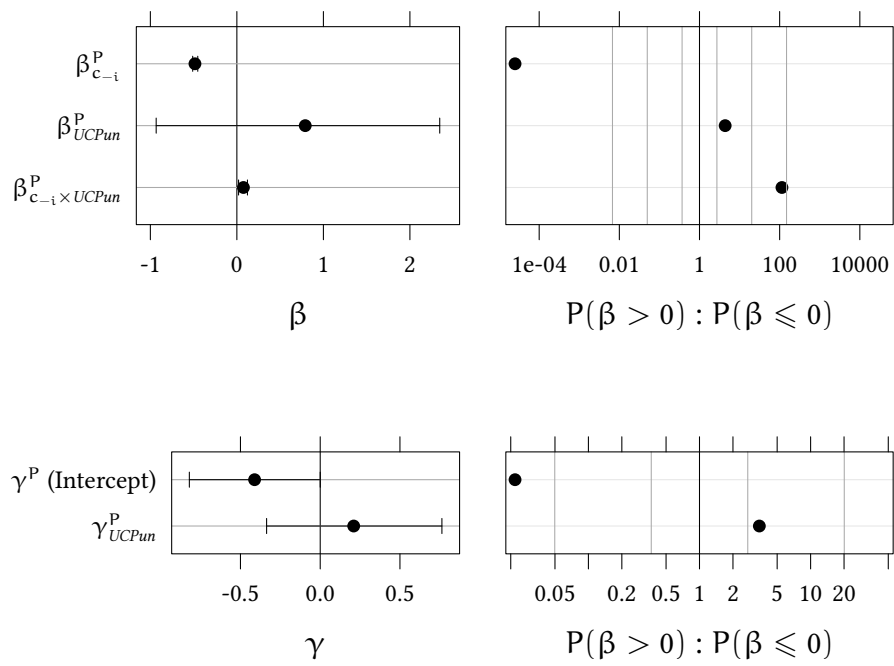
Substituting punishment Hypothesis 4 predicts a more sensitive reaction of punishment to contributions in *UCPun*, i.e. a higher slope of the punishment function. Indeed, we find the odds that $\beta_{c_{-i} \times UCPun}^P > 0$ are 114 : 1, i.e., we have strong evidence that punishment reacts more sensitively to contributions in *UCPun* than in *CPun*.

Result 3.1. *On the level of punishment we find strong evidence for a substitution effect.*

Hence, we do find evidence for a substitution effect, however only when substitution is not in conflict with responsibility, i.e. only for Hypothesis 4, and not for Hypothesis 3.

¹⁶We follow the terminology of Kass and Raftery (1995) to assess posterior odds.

¹⁷Note, that all our hypotheses in this section are referring either to the slope or the average level. The hypotheses do not refer to the proportion of conditional cooperators and free riders. Thus, we also do not report these proportion here. However, the proportion still can be found in the respective tables and figures. It is evident that they do not change the results.



The graphs show the 95%-credible intervals for the Bayesian estimated coefficients on the left hand side and the odds of the posterior to be larger than zero on the right hand side. Detailed results are given in Table 8 in the Appendix.

Figure 4: Estimation results for Equations (5), (4)

Table 4: Summary of tested hypotheses

		Avg. Contr.	Contr. Slope	# of Cond.Coops	Pun. Slope
Threat of punishment	Hyp. 1	-	$UCPun > Base; \uparrow *; \checkmark$	-	-
	Hyp. 2	-	-	$UCPun > Base; \downarrow *; \times$	-
Substitution	Hyp. 3	-	$CPun < Base; \uparrow *; \times$	-	-
	Hyp. 4	-	-	-	$CPun < UCPun; \uparrow +; \checkmark$
Responsibility	Hyp. 5	-	$CPun > Base; \uparrow *; \checkmark$	-	-
Entitlement	Hyp. 6	$CPun < Base; \downarrow +; \checkmark$	-	-	-

* denotes strong or very strong evidence. + denotes positive evidence. \uparrow indicates a positive effect while \downarrow indicates a negative effect. \checkmark indicates that the result goes in the anticipated direction and \times indicates that the result goes in the opposite direction.

4.3.2.2 Responsibility

Responsibility increases cooperation Hypotheses 5 predicts more conditional cooperation in $CPun$ than in $Base$, i.e. a steeper slope of the conditional cooperation function. Indeed, we find that the odds that $\beta_{c_{-i} \times CPun}^C > 0$ are 40000 : 1, i.e., we have very strong evidence in favour of more conditional cooperation (a steeper slope) in $CPun$ than in $Base$.

Result 4.1. *We find very strong support for an effect of responsibility.*

4.3.2.3 Entitlement

Entitlement reduces cooperation Hypothesis 6 predicts less conditional cooperation in $CPun$ than in $Base$, i.e. smaller average levels of cooperation (Equation (2)).

Since the estimation of Equation (2) is based on demeaned data, we can interpret our treatment effects as effects on the average. The odds that $\beta_{CPun}^C < 0$ are 11.7 : 1, i.e., we have positive evidence for less cooperation in $CPun$ than in $Base$.

Result 5.1. *We find positive evidence for an entitlement effect.*

A summary of all the tested hypotheses and the corresponding results can be found in Table 4.

5 Discussion and Conclusion

In our experiment, we study how punishment influences conditional cooperation behavior.

To do this, we compare in a one-shot public good game three different situations: one standard situation with no punishment and two different situations with punishment. The two punishment situations differ in who is punishing and who is punished. In treatment $UCPun$ it is the punishment decisions of just one of the unconditional decision makers which is implemented and it is the conditional decision maker who is punished. In our treatment $CPun$, only the conditional decision maker may punish and one unconditional decision maker will be punished. This allows us to understand how punishment changes conditional cooperation (two of the most studied issues in cooperation literature). In particular, we can examine how

the threat of punishment (in the *UCPun* treatment) and the power to punish (in the *CPun* treatment) changes the behavior of the conditional decision maker.

We hypothesize that the threat of punishment can change cooperation through two mechanisms. On the one hand, conditional cooperators might get more cooperative – by having a more sensitive contribution slope – and on the other hand, the proportion of conditional cooperators might increase as free riders opt for behaving as conditional cooperators.

Also, the power of punishment can change the behavior of the conditional decision maker in several ways. CDMs may consider conditional cooperation and punishment as substitutes. Alternatively, power can lead to more cooperative behavior by triggering responsibility, but it can also go in the opposite direction and result in less cooperative behavior by inducing entitlement.

We use a mixed effects hurdle model specification to estimate the behavior of contribution and of punishment. In line with [Fischbacher et al. \(2001\)](#), we find that most subjects are conditional cooperators. We find the expected effect of the threat of punishment. When decision makers can be punished, conditional cooperation increases for most players. However, we also find a discouraging effect of punishment. The anticipation of punishment leads to a strong increase in the number of free riders. These could be decision makers who expect to be punished anyway and who try to make up for the lost earning by free riding. A possible explanation is a crowding out effect ([Bè nabou and Tirole, 2006](#), [Berg et al., 2017](#), [Frey, 1997](#)). This effect describes situations where rewards and punishment have an adverse effect on prosocial behavior. In our context, it might be that the positive intention of some conditional cooperators is crowded out by punishment. The overall net effect of punishment is however positive. This is perfectly in line with the literature on punishment which shows that punishment increases contribution behavior.

In the context of the power of punishment, we find support for substitution and responsibility. When substitution and responsibility make opposite predictions, responsibility has the stronger effect. Conditional cooperation is stronger in *CPun* than in *Base*. This observation is in line with responsibility, it is not in line with substitution. When substitution is unhampered by responsibility (as in punishment in *UCPun*) we have also strong support for substitution. Our evidence for entitlement is, if at all, quite limited. We do not observe more punishment when players have more power.

Thus, if subjects have the power to punish they behave more prosocially. They are also less sensitive in their punishment. This behavior suggests that power leads to more responsible behavior. It also suggests that there is some substitution of reciprocal behavior if subjects have two ways to behave reciprocal.

In conclusion, we find that punishment influences conditional cooperation behavior in a variety of ways. If subjects can be punished overall contribution behavior increases but this is mainly due to the increased slope of conditional cooperators which outweighs a crowding out effect resulting in a smaller proportion of conditional cooperators. If subjects have the power to punish they also behave more prosocial (as suggested by the responsibility hypothesis). Overall, we give a first mechanism how punishment works. In particular, we show how punishment influences conditional cooperation.

The key insights of these results are twofold. First, the threat of punishment may have an adverse effect on the proportion of cooperators with the upside that the fewer conditional cooperators cooperate more which ultimately results in a positive contribution effect. Second, the power to punish also increases cooperation behavior.

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Table 5: Contribution: Results of the main model ((2), (3))

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSeff	psrf
β_{c-i}^C	0.673	0.641	0.704	40000 : 1	40313	1.0000
β_{CPun}^C	-0.986	-2.334	0.388	1 : 11.7	39845	1.0000
β_{UCPun}^C	-1.120	-2.552	0.360	1 : 14.4	38669	1.0002
$\beta_{c-i \times CPun}^C$	0.120	0.076	0.164	40000 : 1	42577	1.0000
$\beta_{c-i \times UCPun}^C$	0.143	0.093	0.188	40000 : 1	31792	1.0004
γ^C (Intercept)	1.067	0.637	1.516	40000 : 1	32579	1.0000
γ_{CPun}^C	0.096	-0.534	0.740	1.61 : 1	35856	1.0001
γ_{UCPun}^C	-0.574	-1.135	0.020	1 : 38.1	33039	1.0000
τ_C	0.123	0.117	0.130		30332	1.0033
$\tau_{C'}$	0.118	0.091	0.148		34381	1.0005

A graph for the credible intervals and for odds is shown in Figure 3.

Table 6: Contribution: Standard mixed effects model (3) without hurdle ($\mathbb{1}_{CC,i} = 1$)

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSeff	psrf
β_{c-i}^C	0.556	0.522	0.591	40000 : 1	40000	1.0000
β_{CPun}^C	-1.153	-2.845	0.566	1 : 10.2	39035	1.0000
β_{UCPun}^C	-1.132	-2.873	0.544	1 : 9.48	40343	1.0000
$\beta_{c-i \times CPun}^C$	0.148	0.099	0.197	40000 : 1	39644	1.0001
$\beta_{c-i \times UCPun}^C$	0.025	-0.023	0.074	5.34 : 1	40000	1.0000
τ_C	0.088	0.084	0.093		40000	1.0000

A Estimation of Equations (2) and (3)

Table 5 reports the detailed results of the main model of contribution. Results for a standard mixed effects model (no hurdle) are reported in Table 6 and Figure 5. Table 7 and Figure 6 show results for a model with hurdle and two random effects, one for the intercept and one for the slope.

Tables show for each case the estimated median of the parameter, the 95%-credible interval ($Q_{.025}$, $Q_{.975}$), the odds that the parameter is larger than zero ($o(> 0)$), the effective sample size (SSeff), and the potential scale reduction factor (psrf).

B Estimation of Equations (4) and (5)

Table 8 show estimation results of the main model of the punishment behavior, Equation (4) and (5). We also estimate a standard mixed effects model which is reported in detail in Table

Figure 5: Contribution: Standard mixed effects model without hurdle

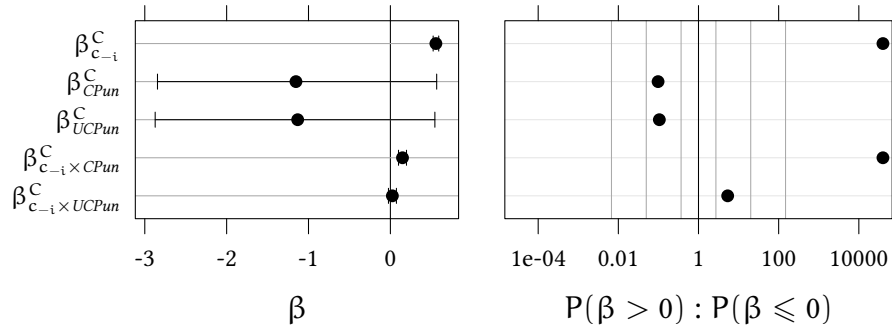


Table 7: Contribution: Mixed effects random slope hurdle model

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSEff	psrf
β_{c-i}^C	0.638	0.504	0.764	40000 : 1	38884	1.0001
β_{CPun}^C	-1.311	-3.493	0.880	1 : 7.1	39569	1.0000
β_{UCPun}^C	-0.887	-3.257	1.375	1 : 3.41	40000	1.0000
$\beta_{c-i \times CPun}^C$	0.154	-0.025	0.342	19.2 : 1	39514	1.0002
$\beta_{c-i \times UCPun}^C$	0.124	-0.067	0.321	8.39 : 1	40000	1.0000
γ^C (Intercept)	1.160	0.716	1.631	40000 : 1	30723	1.0002
γ_{CPun}^C	-0.001	-0.651	0.647	1 : 1	33304	1.0001
γ_{UCPun}^C	-0.611	-1.216	-0.036	1 : 48.5	31278	1.0001
τ_C	0.250	0.237	0.263		40000	1.0000
$\tau_{C'}$	0.133	0.102	0.166		40472	1.0000
$\tau_{C''}$	5.674	4.225	7.249		38744	1.0000

Figure 6: Contribution: Mixed effects random slope hurdle model (Table 7)

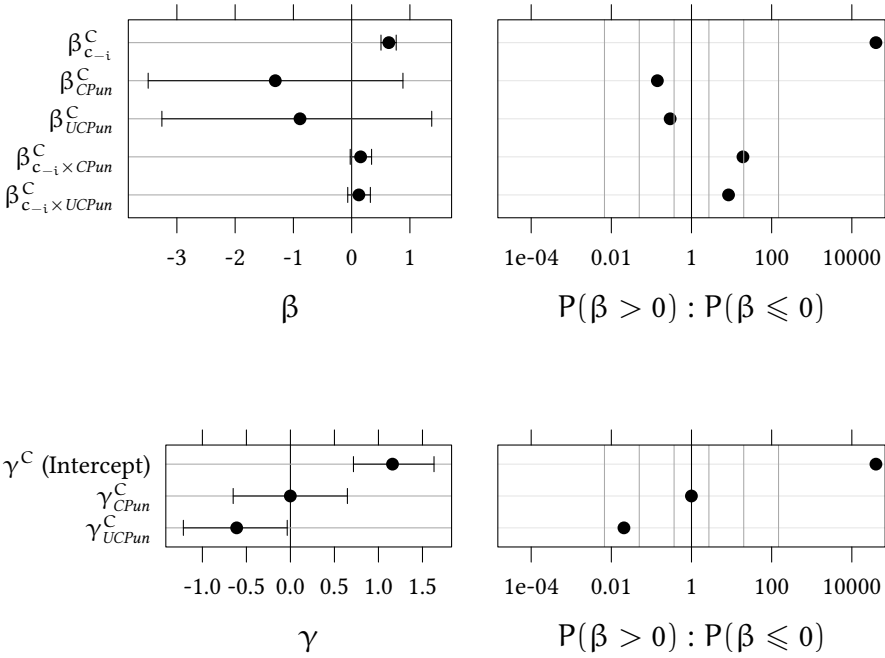


Table 8: Punishment: Results of the main model ((4), (5))

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSeff	psrf
β_{c-i}^P	-0.485	-0.511	-0.452	1 : 40000	3881	1.0372
β_{UCPun}^P	0.790	-0.933	2.345	4.37 : 1	11805	1.4089
$\beta_{c-i \times UCPun}^P$	0.076	0.020	0.122	114 : 1	1923	1.6251
γ^P (Intercept)	-0.411	-0.821	0.000	1 : 45.7	20552	1.1842
γ_{UCPun}^P	0.210	-0.336	0.763	3.46 : 1	19646	1.0983
τ_P	0.444	0.414	0.474		11314	1.0516
$\tau_{P,l}$	0.275	0.193	0.364		16850	1.0500

A graph with credible intervals and odds ratios is shown in Figure 4.

Table 9: Punishment: Standard mixed effects model (5) without hurdle ($\mathbb{1}_{CC,i} = 1$).

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSeff	psrf
β_{c-i}^P	-0.208	-0.228	-0.186	1 : 40000	40000	1.0000
β_{UCPun}^P	1.216	0.240	2.205	130 : 1	39027	1.0001
$\beta_{c-i \times UCPun}^P$	0.081	0.051	0.110	40000 : 1	39461	1.0001
τ_P	0.244	0.228	0.259		39449	1.0000
$\tau_{P,l}$	0.189	0.135	0.247		41245	1.0000

9 and Figure 7. A hurdle model with two random effects, one for the intercept and one for the slope is reported in Table 10 and Figure 8.

C Frequentist results

We also estimate a frequentist mixed effects models for the contribution behavior, comparable to the estimation results presented in Table 6

Table 11 shows estimation results for Equation (3) using lme4 (Bates et al., 2015) (version 1.1-12). All results from Section 4.3 are also present in this simple regression.

We also estimated a frequentist mixed effects models for the punishment behavior, comparable to the Bayesian model presented in Table 9.

Table 12 shows the estimation results of Equation (5) estimated in a frequentist context using lme4. Again the results are very similar to the results reported in 4.3.

Figure 7: Punishment: Standard mixed effects model without hurdle (Table 9).

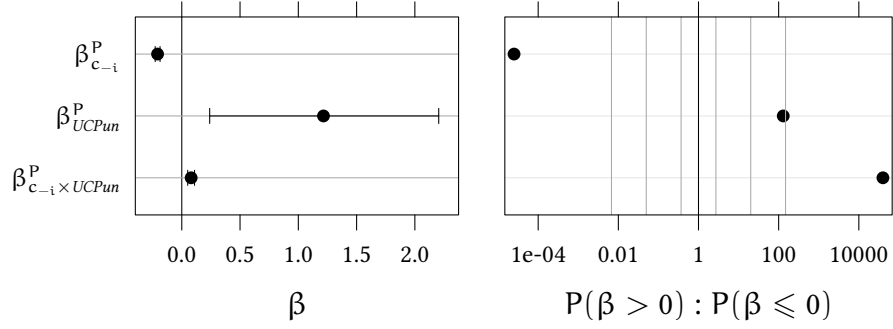


Table 10: Punishment: Mixed effects random slope hurdle model.

	Median	Q _{.025}	Q _{.975}	o(> 0)	SSeff	psrf
β_{c-i}^P	-0.341	-0.484	-0.202	1 : 20000	41105	1.0150
β_{UCPun}^P	1.492	-0.782	3.879	8.54 : 1	41191	1.0654
$\beta_{c-i \times UCPun}^P$	0.124	-0.085	0.334	7.37 : 1	40378	1.0209
γ^P (Intercept)	-0.080	-0.487	0.334	1 : 1.81	39322	1.3188
γ_{UCPun}^P	0.224	-0.328	0.792	3.61 : 1	38392	1.2166
τ_P	0.667	0.611	0.722		39594	1.6549
$\tau_{P/}$	0.422	0.299	0.569		39106	1.1749
$\tau_{P//}$	7.806	4.617	11.523		33699	1.0224

Figure 8: Punishment: Mixed effects random slope hurdle model (Table 10).

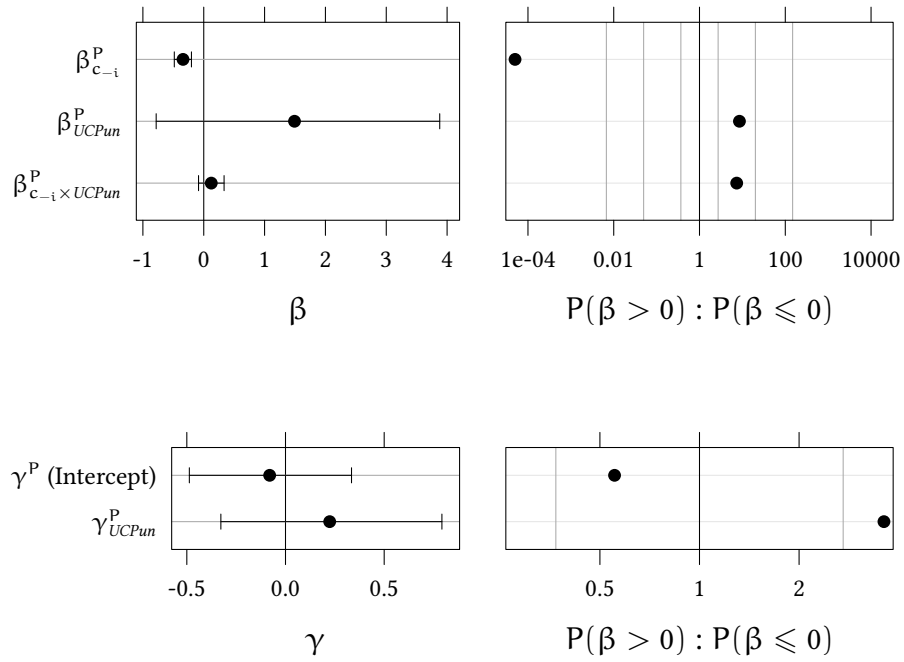


Table 11: Contribution: Frequentist estimation (no hurdle)

Frequentist Mixed Effects Model	
Constant	2.18*** (0.98, 3.38)
CondOn	0.56*** (0.52, 0.59)
Treat2	-1.16 (-2.86, 0.54)
Treat3	-1.14 (-2.84, 0.56)
Treat2:CondOn	0.15*** (0.10, 0.20)
Treat3:CondOn	0.03 (-0.02, 0.07)
Observations	3,024
Log Likelihood	-8,217.92
Akaike Inf. Crit.	16,451.84
Bayesian Inf. Crit.	16,499.95

Notes: p : *** < .001 ** < .01 * < .05

Table 12: Punishment: Frequentist estimation (no hurdle)

Frequentist Mixed Effects Model	
Constant	4.33*** (3.63, 5.03)
CondOn	-0.21*** (-0.23, -0.19)
Treat3	-1.22* (-2.20, -0.23)
Treat3:CondOn	0.08*** (0.05, 0.11)
Observations	2,016
Log Likelihood	-4,450.54
Akaike Inf. Crit.	8,913.07
Bayesian Inf. Crit.	8,946.72

Notes: p : *** < .001 ** < .01* < .05

Period:
1 of 1

Your unconditional contribution to the project:

Help:
Please enter your unconditional contribution to the project. Press "OK" when you are finished.

Figure 9: Unconditional contribution Decision

D Interface, data and methods

The experiment was conducted in German. A translation of the interface for the unconditional contribution, the conditional contribution, the conditional punishment and for the feedback can be found in Figures 9, 10, 11, 12.

Data and methods can be found at <https://www.kirchkamp.de/research/condCoopPun.html>

E Instructions

The experiment was conducted in German. All participants obtained the following handout (translated into English). Participants also read instructions on the computer screen (see E.2).

E.1 Handout

The decision situation You are a member of a group of size 4. Each member of this group has to decide how to spend 20 points. You can put the 20 points into a private account or

Period:
1 of 1

Your conditional contribution to the project (Contribution table)

0	<input type="text"/>	7	<input type="text"/>	14	<input type="text"/>
1	<input type="text"/>	8	<input type="text"/>	15	<input type="text"/>
2	<input type="text"/>	9	<input type="text"/>	16	<input type="text"/>
3	<input type="text"/>	10	<input type="text"/>	17	<input type="text"/>
4	<input type="text"/>	11	<input type="text"/>	18	<input type="text"/>
5	<input type="text"/>	12	<input type="text"/>	19	<input type="text"/>
6	<input type="text"/>	13	<input type="text"/>	20	<input type="text"/>

Help:
In each field enter which contribution to the project you provide, if on average the others make a contribution to the project as denoted by the number to the left of each field.
When you have entered everything, press "OK".

Figure 10: Conditional contribution Decision

Period:
1 of 1

Your conditional reduction of payment of the others (Reduction table)

0	<input type="text"/>	7	<input type="text"/>	14	<input type="text"/>
1	<input type="text"/>	8	<input type="text"/>	15	<input type="text"/>
2	<input type="text"/>	9	<input type="text"/>	16	<input type="text"/>
3	<input type="text"/>	10	<input type="text"/>	17	<input type="text"/>
4	<input type="text"/>	11	<input type="text"/>	18	<input type="text"/>
5	<input type="text"/>	12	<input type="text"/>	19	<input type="text"/>
6	<input type="text"/>	13	<input type="text"/>	20	<input type="text"/>

Help:
In each field enter by which amount your want to reduce the payoff of the others when they contribute to the project an amount as denoted by the number to the left of each field.
The reduction is only implemented if you are randomly selected as a conditional player.
When you have entered everything, press "OK".

Figure 11: Conditional punishment Decision

Period:	
1 of 1	
Random number	2
Your number	1
For you the unconditional amount is relevant	
Your contribution to the project	10
Sum of all contributions	50
Income from the project	20.0
Income from private account	10.0
Reduction by player 2	5
Total income	25.0
Additional income from estimation	0

Figure 12: Feedback of unconditional decision maker

you can put all points or some of the points into a project. Each point not invested into the project goes automatically into the private account.

Total income You total income is the sum of your income from the private account plus the income from the project:

Income from private account (= 20–contribution to project)
+ income from project (= 0.4 × sum of contributions to project)
Total income

Each member of the group has to make two decisions: the unconditional contribution and the contribution table.

With the unconditional contribution, you state simply how many of the 20 points you invest into the project.

With the contribution table, you state, for each (rounded) average contribution of the others to the project, how much you want to contribute to the project.

Random choice Each member of the group has a membership number between 1 and 4. The participant in cubicle 1 will (with a four sided die) determine a random number between 1 and 4 and enter this number into the computer. If your number is chosen, then you are the randomly selected member.

For this randomly selected member, only the contribution table is relevant for the own contribution and for the payoff. For the other three members, who are not randomly selected members, only the unconditional contribution is relevant.

[[The following is only shown in CPun and UCPun]]:

Reduction decision In addition to the two contribution choices you also make a reduction decision. For this decision, you have to decide for each possible contribution of another player to the project by how many points the payoff of this player is reduced. This decision does not affect your own payoff.

[[in CPun]]

Only the reduction decision of the person whose contribution table is relevant for the decision will be implemented.

[[in UCPun]]

Only the reduction decision of one of the people whose contribution table is not relevant for the decision will be implemented.

I.e. if you are not a randomly selected member, i.e. if you unconditional contribution was relevant,

[[in CPun]]

then your reduction decision will not be implemented.

When you are a randomly selected member, i.e. your contribution table was relevant, then your reduction decision will be implemented.

[[in UCPun]]

then your reduction decision, or the decision of one of the other unconditional contributors, is implemented. Which of the three reduction tables of the three players who make an unconditional contribution is implemented, will be chosen by the computer. You will learn this choice at the end.

If you are a randomly selected member, i.e. your contribution table was relevant, then your reduction decision will be implemented.

E.2 Screen Instructions

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. At the end of the experiment, your earned money will be added up and paid to you immediately in cash.

The instructions which we have distributed to you are solely for your private information. It is prohibited to communicate with the other participants during the experiment. Should you have any questions please ask us. If you violate this rule, we shall have to exclude you from the experiment and from all payments. If you have any questions please put your hand up. A member of the student team will come to you and answer your question privately.

During the experiment, we will not speak of Euros but rather of points. During the experiment, your entire earnings will be calculated in points. At the end of the experiment the total amount of points you have earned will be converted to Euros at the following rate:

1 point= 30 Eurocent

All participants will be divided into groups of four members. Except us, the experimenters, nobody knows who is in which group.

On the next pages, we will describe the exact procedure of the experiment.

The decision situation

You will learn later on how the experiment will be conducted. We first introduce you to the basic decision situation. At the end of the description of the decision, you will find control questions that help you to gain an understanding of the decision situation.

You will be a member of a group of 4 people. Each member has to decide on the division of 20 tokens. You can put these 20 tokens on a private account or you can invest them fully or partially into a project. Each token you do not invest into the project will automatically be transferred to your private account.

Your income from the private account:

For each token you put on your private account you will earn exactly one point. For example, if you put twenty tokens on your private account (which implies that you do not invest anything into the project) you will earn exactly twenty tokens from the private account. If you put 6 tokens into the private account, you will receive an income of 6 tokens from the private account. Nobody except you earns something from your private account.

Your income from the project

From the token amount you invest into the project, each group member will get the same payoff. Of course, you will also get a payoff from the tokens the other group members invest into the project. For each group member the income from the project will be determined as follows:

$$\text{Income from project} = \text{sum of contributions to the project} \times 0.4$$

For example, if the sum of all contributions to the project is 60 tokens, then you and all other group members will get a payoff of $60 \times .4 = 24$ points from the project. If the four group members together contribute 10 tokens to the project, you and all others will get a payoff of $10 \times .4 = 4$ points from the project.

Your total income:

Your total income results from the summation of your income from the private account and your income from the project.

Income from private account (= 20—contribution to project) + income from project (= 0.4× sum of contributions to project)
Total income

The Experiment

The experiment contains the decision situation that we have just described to you. At the end of the experiment, you will get paid according to the decisions you make in this experiment. The experiment will only be conducted once.

As you know you will have 20 tokens at your disposal. You can put them into a private account or you can invest them into a project. In this experiment, each subject has to make two types of decisions. In the following, we will call them "unconditional contribution" and "contribution table".

- With the unconditional contribution to the project you have to decide how many of the 20 tokens you want to invest into the project. You will enter this amount into the following computer screen: *[[Insert Figure 9]]*
- Your second task is to fill out a "contribution table". In the contribution table, you have to indicate for each possible average contribution of the other group members (rounded to the next integer) how many tokens you want to contribute to the project. You can condition your contribution on the contribution of the other group members. This will be immediately clear to you if you take a look at the following screen. This screen will show up immediately after you have determined your unconditional contribution. *[[Insert Figure 10]]*

The numbers next to the input boxes are the possible (rounded) average contributions of the other group members to the project. You simply have to insert into each input box how many tokens you will contribute to the project - conditional on the indicated average contribution. You have to make an entry into each input box. For example, you will have to indicate how much you contribute to the project if the others contribute 0 tokens to the project, how much you contribute if the others contribute 1, 2, or 3 tokens etc. In each input box, you can insert all integer numbers from 0 to 20.

After all participants of the experiment have made an unconditional contribution and have filled out their contribution table, in each group a random mechanism will select a group member. For the randomly determined subject, only the contribution table will be the payoff-relevant decision. For the other three group members that are not selected by the random mechanism, only the unconditional contribution will be the payoff-relevant decision. When you make your unconditional contribution and when you fill out the contribution table you, of course, do not know whether you will be selected by the random mechanism. You will, therefore, have to think carefully about both types of decisions because both can become relevant for you. Two examples should make that clear.

Example 1: Assume that you have been selected by the random mechanism. This implies that your relevant decision will be your contribution table. For the other three group members, the unconditional contribution is the relevant decision. Assume they have made unconditional contributions of 0, 2, and 4 tokens. The average contribution of these three group members, therefore, is 2 tokens. If you have indicated in your contribution table that you will contribute 1 token if the others contribute 2 tokens on average, then the total contribution to the project is given by $0 + 2 + 4 + 1 = 7$ tokens. All group members, therefore, earn $.4 \times 7 = 2.8$ points from the project plus their respective income from the private account. If you have instead indicated in your contribution table that you will contribute 19 tokens if the others contribute two tokens on average, then the total contribution of the group to the project is given by $0 + 2 + 4 + 19 = 25$. All group members, therefore, earn $.4 \times 25 = 10$ points from the project plus their respective income from the private account.

Example 2: Assume that you have not been selected by the random mechanism which implies that for you and two other group members the unconditional contribution is taken as the payoff-relevant decision. Assume your unconditional contribution is 16 tokens and those of the other two group members is 18 and 20 tokens. The average unconditional contribution of you and the two other group members, therefore, is 18 tokens. If the group member who has been selected by the random mechanism indicates in her contribution table that she will contribute 1 token if the other three group members contribute on average 18 tokens, then the total contribution of the group to the project is given by $16 + 18 + 20 + 1 = 55$ tokens. All group members will, therefore, earn $.4 \times 55 = 22$ points from the project plus their respective income from the private account. If instead, the randomly selected group member indicates in her contribution table that she contributes 19 if the others contribute on average 18 tokens, then the total contribution of that group to the project is $16 + 18 + 20 + 19 = 73$ tokens. All group members will, therefore, earn $.4 \times 73 = 29.2$ points from the project plus their respective income from the private account.

[[The following is only shown in CPun and UCPun]]:

In addition to both contribution decisions, you have to make a reduction decision. In the reduction decision, you have to indicate for every possible contribution decision of a player to the project, by how many points you want to reduce the payoff of this player. Hence, you can decide how much you want to reduce the payoff of the others conditional on their contribution.

This decision will not impact your payoff.

[[Insert Figure 11]]

The numbers next to the input boxes are the possible (rounded) contributions of the other group members. You simply have to insert into each input box by how many tokens you want to reduce the payoff of another player- conditional on his indicated contribution. You have to make an entry into each input box. For example, you will have to indicate by how many points you want to reduce the payoff of another player if he contributes 0 tokens to the project, by how many tokens you want to reduce his payoff if he contributes 1, 2, or 3 tokens etc. In each input box, you can insert all integer numbers from 0 to 10.

[[in CPun]]

Only the reduction decision of the person whose contribution table is payoff relevant will be implemented. I.e. if you have not been randomly determined, i.e. the unconditional contribution is payoff-relevant for you, then your reduction decision will not be implemented. If you are the randomly determined subjects, i.e. the contribution table is payoff-relevant for you, then your reduction decision will be implemented.

[[in UCPun]]

Only the reduction decision of one of the persons, who were not randomly determined, will be implemented. I.e. if you have not been randomly determined, i.e. the unconditional contribution is payoff-relevant for you, then your reduction decision (or the reduction decision of one of the other unconditional contributors) will be implemented. Which of the three reduction decision, of the unconditional contributions, will be implemented, will be determined randomly by the computer and announced at the end of the experiment.

If you are the randomly determined subjects, i.e. the contribution table is payoff-relevant for you, then your reduction decision will not be implemented.

[[The following is only shown in CPun]]:

Example 1: Assume that you have been selected by the random mechanism. This implies that your relevant decision will be your contribution table. This also implies that your reduction decision will be implemented. For the other three group members the unconditional contribution is the relevant decision and hence, their reduction decision will not be implemented.

Assume they have made unconditional contributions of 0, 2, and 4 tokens.

If you have indicated in your reduction decision that the payoff of a subject will be reduced by 2 tokens, if this subjects contributed 0, and that the payoff of a subject will be reduced by 1 token, if this subjects contributed 2, and that the payoff of a subject will be reduced by 1 tokens, if this subjects contributed 4, then the payoff of the first subject (who happen to contribute 0) will be reduced by 2, the payoff of the second subject (who happen to contribute 2) will be reduced by 1, and the payoff of the third subject (who happen to contribute 4) will be reduced by 1.

If instead you have indicated in your reduction decision that the payoff of a subject will be reduced by 4 tokens, if this subjects contributed 0, and that the payoff of a subject will be reduced by 6 tokens, if this subjects contributed 2, and that the payoff of a subject will be reduced by 8 tokens, if this subjects contributed 4, then the payoff of the first subject (who happen to contribute 0) will be reduced by 4, the payoff of the second subject (who happen

to contribute 2) will be reduced by 6, and the payoff of the third subject (who happen to contribute 4) will be reduced by 8.

Example 2: Assume that you have not been selected by the random mechanism which implies that for you and two other group members the unconditional contribution is taken as the payoff-relevant decision. Hence, your reduction decision will not be payoff-relevant.

Assume your unconditional contribution is 16.

If the randomly determined subject indicated that the payoff of a subject should be reduced by 2, if this subject contributed 16, then your payoff will be reduced by 2.

If instead, the randomly determined subject indicated that the payoff of a subject should be reduced by 0, if this subject contributed 16, then your payoff will be reduced by 0.

[[The following is only shown in UCPun]]:

Example 1: Assume that you have been selected by the random mechanism. This implies that your relevant decision will be your contribution table. This also implies that your reduction decision will not be implemented. For the other three group members the unconditional contribution is the relevant decision and hence, their reduction decision of one of the three members (determined randomly by the computer) will be implemented. This subject is reduction-relevant.

Assume your conditional contribution is 16.

If the reduction-relevant subject indicated in the reduction decision that the payoff of a subject should be reduced by 2, if this subject contributed 16, then your payoff will be reduced by 2.

If instead, the reduction-relevant subject indicated in the reduction decision that the payoff of a subject should be reduced by 0, if this subject contributed 16, then your payoff will be reduced by 0.

Example 2: Assume that you have not been selected by the random mechanism which implies that for you and two other group members the unconditional contribution is taken as the payoff-relevant decision. Assume that you are reduction-relevant.

Assume further that the unconditional contributions of the other two are given by 0 and 2 and the conditional contribution of the third subjects is 4 tokens.

If you have indicated in your reduction decision that the payoff of a subject will be reduced by 2 tokens, if this subjects contributed 0, and that the payoff of a subject will be reduced

by 1 token, if this subjects contributed 2, and that the payoff of a subject will be reduced by 1 tokens, if this subjects contributed 4, then the payoff of the first subject (who happen to contribute 0) will be reduced by 2, the payoff of the second subject (who happen to contribute 2) will be reduced by 1, and the payoff of the third subject (who happen to contribute 4) will be reduced by 1.

If instead you have indicated in your reduction decision that the payoff of a subject will be reduced by 4 tokens, if this subjects contributed 0, and that the payoff of a subject will be reduced by 6 tokens, if this subjects contributed 2, and that the payoff of a subject will be reduced by 8 tokens, if this subjects contributed 4, then the payoff of the first subject (who happen to contribute 0) will be reduced by 4, the payoff of the second subject (who happen to contribute 2) will be reduced by 6, and the payoff of the third subject (who happen to contribute 4) will be reduced by 8.

[[The following is shown in all treatments]]:

The random selection of the participants will be implemented as follows. Each group member is assigned a number between 1 and 4. The participant in the first cubicle will, after all participants have made their unconditional contribution and have filled out their contribution table [In *CPun* and *UCPun*: and have filled out their reduction table], throw a 4-sided die. The number that shows up will be entered into the computer. If the thrown number equals the membership number that has been assigned to you, then for you your contribution table will be relevant [In *CPun*: and your reduction decision will be implemented] and for the other group members the unconditional contribution will be the payoff-relevant decision [In *UCPun*: and his reduction decision will be implemented]. Otherwise, your unconditional contribution is the relevant decision [In *CPun*: and your reduction decision will not be implemented] [In *UCPun*: and your reduction decision will be implemented, if you are randomly selected by the computer].

E.3 Control questions

1. Each group member has 20 tokens at his or her disposal. Assume that none of the four group members (including you) contributes anything to the project. What will your total income be? What is the total income of the other group members?
2. Each group member has 20 tokens at his or her disposal. Assume that you invest 20 tokens into the project and each of the other group members also invests 20 tokens. What will be your total income? What is the total income of the other group members?
- 3 Each group member has 20 tokens at his or her disposal. Assume that the other three group members together contribute 30 tokens to the project.
What is your total income if you - in addition to the 30 tokens - contribute 0 tokens to the project?
What is your income if you - in addition to the 30 tokens - contribute 8 tokens to the project?

What is your income if you - in addition to the 30 tokens - contribute 15 tokens to the project?

4 Each group member has 20 tokens at his or her disposal. Assume that you invest 8 tokens to the project.

What is your total income if the other group members - in addition to your 8 tokens - together contribute 7 tokens to the project?

What is your total income if the other group members - in addition to your 8 tokens - together contribute 12 tokens to the project?

What is your income if the other group members - in addition to your 8 tokens contribute 22 tokens to the project?