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Self-Governance in Generalized Exchange. A Laboratory Experiment on the Structural Embeddedness of Peer Punishment

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Abstract: Peer punishment is widely lauded as a decentralized solution to the problem of social cooperation. However, experimental evidence of its effectiveness primarily stems from public good structures. This paper explores peer punishment in another structural setting: a system of generalized exchange. In a laboratory experiment, a repeated four-player prisoner's dilemma is arranged either in a public good structure or in a circular network of generalized exchange. The experimental results demonstrate that the merits of peer punishment do not extend to generalized exchange. In the public good, peer punishment was primarily altruistic, was sensitive to costs, and promoted cooperation. In generalized exchange, peer punishment was also altruistic and relatively frequent, but did not increase cooperation. While the dense punishment network underlying the public good facilitates norm enforcement, generalized exchange decreases control over norm violators and reduces the capacity of peer punishment. I conclude that generalized exchange systems require stronger forms of punishment to sustain social cooperation.

Keywords: generalized exchange; peer punishment; cooperation; social networks; embeddedness; laboratory experiment

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1. Introduction

The explanation of cooperation is one of the most intriguing quests in the social sciences. Its existence seems theoretically puzzling, as cooperation often requires that personal interests are subordinated to collective interests. Laboratory experiments have pointed to peer punishment as an empirical solution to the theoretical puzzle of cooperation [1–3]. Accordingly, groups manage to uphold social cooperation as long as their members are able to monitor each other and sanction norm violations.

Recently, however, scholars have identified various conditions under which peer punishment fails to create beneficial outcomes [4,5]. In particular, the success of peer punishment depends on social factors external to the individual [6], such as the information conditions [7,8], the institutional mechanisms coordinating punishment [9], or the status differentials within a group [10,11]. Against this background, it seems surprising that the accumulated evidence on peer punishment almost exclusively stems from public good structures, whereas cooperation problems arise in various structural forms.

This study examines peer punishment in another prominent structure of social exchange: a system of generalized exchange. A system of generalized exchange is characterized by unilateral and interpersonal flows of resources among its members [12,13]. Instead of providing benefits to a centralized pool, in generalized exchange, individuals send benefits directly to specific members of their network, while being (potentially) reciprocated not by the same person but by a third party. In this article, I specifically deal with a circular network of generalized exchange, in which resources cycle through a chain of network ties such that everyone sends benefits to and receives benefits from exactly one other person [14–16]. In this type of generalized exchange, punishment networks

are less dense than in the public good, and sanctioning is limited to immediate network neighbors. This reduces the capacity of peer punishment such that it might be less effective in supporting cooperation. By the same token, generalized exchange could also support peer punishment, as it eliminates the problem of coordinating sanctions within a group.

I conduct a laboratory experiment to compare peer punishment between a public good and generalized exchange. In the experiment, a repeated four-player version of the prisoner's dilemma is arranged either in a circular network of generalized exchange or in a public good structure. In a second manipulation, I vary the impact of punishment by distinguishing between a costly punishment treatment (2; 1), a costless punishment treatment (2; 0), and a baseline treatment.

The results indicate that generalized exchange offers an unfavorable structure for peer punishment. In the public good, the observed patterns chime with what has been known from prior work: peer punishment was primarily altruistic, was sensitive to costs, and induced cooperation. In generalized exchange, peer punishment remains largely ineffective. Although it was mostly altruistic and relatively frequent, peer punishment did not raise cooperation above the baseline level. I conclude that in public good structures, mild punishment may suffice, since incremental sanctions can accumulate to a sizable threat for defectors. By contrast, generalized exchange systems require stronger forms of punishment to facilitate norm enforcement and maintain social cooperation. In particular, if exchange is not embedded into long-term relationships—as in this experimental setting—self-governance via peer punishment constitutes an unlikely explanation of social cooperation in generalized exchange.

This study helps to narrow down the structural conditions under which punishment fosters cooperation. In doing so, it connects to a handful of experimental studies on sanctioning networks. Leibbrandt et al. [17] found that any deviation from a complete sanctioning network—i.e., a network that contains ties between all group members—lowers contributions to a public good. In their experimental setting, network connections restrict punishment, but not monitoring. Two recent studies conceptualize sanctioning networks as also applying to the availability of information about other group members [18,19]. However, both experiments reveal no striking differences in contributions, efficiency, and punishment frequency between circular and complete sanctioning networks. In these articles, cooperation and exchange is still organized in a public good structure, whereas the present study treats networks as also affecting the initial flow of benefits between individuals. The present paper also speaks to recent work pointing to the importance of the cost–impact ratio of punishment [20,21]. Although my study confirms that the cost–impact ratio crucially affects the effectiveness of punishment, it shifts attention to the structural environment embedding a punishment regime and tests if the identical cost–impact ratio has different implications in different network configurations.

Most importantly, the paper aims to bridge the growing literature about peer punishment with an established tradition researching social exchange forms. Inasmuch as the latter tradition has analyzed social dilemmas [22–24], its approach has examined how different exchange forms facilitate social stability and group solidarity [25]. Generalized exchange systems have taken pride of place in this effort, with laboratory studies revealing their underlying mechanisms [16,26] and field studies attesting to their relevance across various domains [27,28]. However, a paucity of evidence remains concerning their compatibility with peer punishment. This study seeks to fill this void in the growing corpus of research by shedding light on peer punishment in a circular network of generalized exchange.

2. Theoretical Background

The problem of cooperation can be represented by the incentive structure of a repeated prisoner's dilemma [29,30]. In a standard prisoner's dilemma, each individual i faces a binary decision between cooperation—offering a high social benefit and a low private benefit—and defection—yielding a low social benefit and a high private benefit. Mutual

cooperation of players produces the highest total benefit, while the private benefit of defection exceeds the private benefit of cooperation. In its extension to $n > 2$ players, the prisoner's dilemma can be arranged in the structure of a public good. In this case, social benefits are contributed to a common pool and equally divided among group members.

The multiplayer version of the prisoner's dilemma, however, can also be arranged in a generalized exchange system [31]. Generalized exchange systems exist in different structural forms—often categorized as either 'chain' or 'pure' generalized exchange [32,33]. In chain generalized exchange, benefits move through the collective in a circular network, similar to the well-known Kula ring [34]. In pure generalized exchange, the flow of benefits is not restricted to a fixed network structure; instead, individuals direct benefits to group members of their choosing.

The present study looks at a variant that adopts elements of chain and pure generalized exchange. In this specification, the structure of giving is fixed to a chain network in which each player i simultaneously sends benefits directly to player $i + 1$ and receives benefits directly from player $i - 1$. Across periods, each subject moves to a random position in the circular network such that benefits are sent to and received from varying network members. In this circular structure, cooperation represents indirect acts of helping among strangers. The economic literature refers to these circular exchange structures as 'indirect helping game' or 'indirect gift-giving game' [35,36]. Although being only one among several variants of generalized exchange, the circular structure corresponds to the most frequent operationalization in laboratory experiments [14,15].

2.1. Peer Punishment in the Public Good Structure

Peer punishment is integrated into the theoretical setting as a second stage of the repeated n-player prisoner's dilemma [37]. In this second stage, each player i can react to the actions of each group member j, from whom i could potentially receive benefits, either by sanctioning or not sanctioning player j. The implications of sanctioning are defined by the parameters of a punishment regime $(p; c)$ with a penalty p to the punished and a cost c to the punisher. In the public good with peer punishment, the total payoff of each actor amounts to the first-stage payoff, minus the penalties received from group members and the costs paid for sanctioning group members.

The standard game-theoretical prediction for finitely repeated social dilemmas states that no player should be willing to punish if it is costly, and, hence, cooperation should remain unaffected [38]. Nonetheless, regular acts of costly punishment and high levels of cooperation have been documented consistently in public good experiments [39,40]. In particular, the existence of strong reciprocators—players who are willing to conditionally cooperate and to endure costs to sanction defectors—is advanced as an empirical solution to the second-order free-rider problem [41–43]. Drawing on this evidence, Hypothesis 1a states that peer punishment increases cooperation in the public good structure.

Hypothesis 1a (H1a). *Cooperation is higher in a public good structure with peer punishment than in a public good structure without peer punishment.*

While peer punishment is mainly seen as conducive to cooperation, there are conflicting views on its effect on the total revenues of experimental participants. Some studies suggest that punishment increases aggregate payoffs only in certain parameter segments [5,44], whereas other studies indicate that, over a longer time horizon, the benefits of sustained social order outweigh the resources destroyed in the initial phase of coordinating decentralized punishment [45].

Besides the voluminous literature on its merits, there are also important limitations to peer punishment. In particular, the influence of strong reciprocators is decisively shaped by the cost–impact ratio of a punishment regime [20,21]. Accordingly, self-governance is most functional in an environment that reduces the cost to the punisher and increases the impact of each punitive act. However, peer punishment is not exclusively about the 'size of the stick'; it also serves to signal disapproval to norm violators. The importance of

this symbolic dimension is demonstrated by prior work showing that punishment may increase cooperation even if the penalty is not sufficiently severe to deter defection [46,47].

Next to the impact on the defector, the effectiveness of peer punishment also hinges on its costs to the punisher. Despite the popularity of low-cost and no-cost sanctions in the field [48], costless punishment has received only limited attention in the laboratory. If punishers are not required to endure a monetary cost to sanction norm transgressors, peer punishment no longer relies on strong reciprocity [49]. In the absence of costs, the willingness to enforce social norms and, consequently, the effectiveness of peer punishment are considered to rise [50–52].

Hypothesis 1b (H1b). *Cooperation is higher in a public good structure with costless peer punishment than in a public good structure with costly peer punishment.*

Punishment—both costly and costless—may not necessarily follow defection but can also be directed to cooperative group members [53–56]. From a normative perspective, antisocial punishment penalizes non-conformist behavior even if this behavior benefits the punisher, as in the case of over-contribution [57–59]. Thereby, it endangers social order and may lead to inefficient loops of retaliation [60]. In the public good structure, however, antisocial punishment is observably less frequent than altruistic punishment. For instance, Cinyabuguma et al. [61] report that only around 20 percent of all punishment decisions are 'perverse', going from defectors to cooperators.

Nevertheless, antisocial punishment carries instrumental and normative implications for those addressed by the punishment. On the one hand, it increases the opportunity costs of compliance and tilts the balance between cooperation and defection in favor of the latter. On the other hand, antisocial punishment signals an uncooperative norm and conveys the adverse behavioral expectations of the punisher. Against this backdrop, Hypothesis 1c posits that antisocial punishment induces defective behavior, whereas altruistic punishment encourages cooperative behavior.

Hypothesis 1c (H1c). *In a public good structure, receiving altruistic punishment increases the willingness to cooperate, whereas receiving antisocial punishment decreases the willingness to cooperate.*

2.2. Self-Governance in Generalized Exchange

In the public good structure, group members provide benefits to others indirectly and impersonally by contributing to a common pool. By contrast, in generalized exchange, group members send benefits directly to others in decentralized interactions. If network ties restrict not only exchange but also sanctions, exchange partners can punish only immediate network neighbors from whom they could potentially receive benefits. Accordingly, self-governance in generalized exchange does not correspond to a coordinated group activity as it does in the public good structure, but to punitive acts reflecting the coercive power of a recipient over his or her sender [62,63]. The public good allows an individual to punish each group member, which, conversely, implies that each individual may receive punishment by all fellow group members. The circular network of generalized exchange has a lower density such that each participant can direct sanctions only to the potential sender of one's benefits.

Adapting peer punishment to generalized exchange eliminates the problem of coordinating sanctions within a group. More importantly, however, it reduces the capacity of peer punishment such that a defector may receive a lower aggregate penalty. If incremental penalties cannot accumulate to a sizable loss, the punitive threat to a norm violator decreases. At the same cost–impact ratio, the effectiveness of peer punishment is expected to be lower in generalized exchange than in the public good.

Hypothesis 2a (H2a). *The effect of peer punishment on cooperation is lower in the generalized exchange system than in the public good structure.*

As generalized exchange restricts the capacity of punishment, norm violators can be less effectively deterred and strong reciprocators are discouraged. Additionally, the circular network of generalized exchange hampers mutual observability and thereby undermines norm enforcement further, since punishers cannot signal cooperative values to third parties beyond the exchange relation. Social stabilization through others, however, turns out to be decisive for peer punishment [64,65].

In line with the above, prior experimental work indicates that the private nature of generalized exchange renders peer punishment scarce. In an indirect helping game, Ule et al. [66] found that peer punishment opportunities are rarely used and exert only a negligible effect on cooperation. In their experimental setting, punishment was chosen only in around three percent of all cases, if it was associated with a monetary penalty. However, the authors designed the punishment option as an action alternative to cooperation and defection in the first-stage decision, whereas in public good games, peer punishment is typically conceptualized as a second-stage decision, succeeding the choice between cooperation and defection. Nonetheless, their conclusion coincides with earlier computer-simulated experiments by Molm [62], who equivocally states that peer punishment in reciprocal exchange is consistently harmless due to its infrequent usage.

In tandem with the maximum impact, the aggregate costs to a punisher also diminish in generalized exchange. Consequently, the cooperation-enhancing effect of reducing punishment costs tends to decrease in generalized exchange. Hypothesis 2b posits that the difference between costless and costly punishment is lower in generalized exchange than in the public good structure.

Hypothesis 2b (H2b). *The difference in cooperation between costless and costly peer punishment is higher in the public good structure than in the generalized exchange system.*

Little is known about the frequency of altruistic and antisocial punishment in forms of social exchange other than the public good. By consulting classical exchange theorists, we learn that mutual punishment in interpersonal forms of exchange may be attributed a rather antagonistic character. Homans [67], for instance, was convinced that punishment tends to be perceived primarily as hostile and coincides with experienced pain and revenge. Similarly, Blau [68] reasoned that punishment 'arouses emotional reactions that have undesirable consequences for behavior other than the one it is intended to affect' and would more likely result in avoidance, withdrawal, and the discontinuation of the social relationship rather than in compliance. As the public function of sanctions recedes, private acts of retaliation are more likely to provoke anger and repugnance, hinting that peer punishment in generalized exchange might be less altruistic.

On the one hand, generalized exchange reduces the impact of punishment on the tradeoff between cooperation and defection. On the other hand, in generalized exchange, punishment is more likely to be interpreted as private information about the punisher than as a public signal about an underlying social norm. For these reasons, we may assume that, in generalized exchange, altruistic and antisocial punishment are less powerful in inducing behavioral changes in the predicted direction.

Hypothesis 2c (H2c). *The positive (negative) effect of altruistic (antisocial) punishment on the willingness to cooperate is lower in the generalized exchange system than in the public good structure.*

3. Methods

In line with previous research on peer punishment and on generalized exchange, I tested the hypotheses in a controlled laboratory experiment. The experiment immersed subjects into a scenario in which they repeatedly interacted in a four-person prisoner's dilemma. Across groups, the network structure (generalized exchange/public good) and the presence of punishment (baseline/costly/costless) were manipulated in a 2×3 design.

3.1. Participants and Procedures

The experiments were implemented at the laboratories of the Vienna Center for Experimental Economics (VCEE), using the software z-Tree for programming [69] and ORSEE for the recruitment of participants [70]. Twelve experimental sessions hosted a total of 260 participants in two phases in April to June 2016 and June 2017 (See Documentation in the supplementary materials). The majority of participants (192) took part in the generalized exchange treatments, reflecting the main emphasis of the study. The remaining participants (68) were assigned to the public good structure with the intention of replicating the established patterns from the literature. Participants were undergraduates enrolled in a wide variety of academic disciplines. They were only rarely in full-time employment and mostly aged between 20 and 27 years. Furthermore, 57 percent (148/260) of the participants were female. All subjects received monetary payment according to their decisions and the decisions of their co-players. Final payments, including a 5 EUR show-up fee, were, on average, 19.5 EUR and ranged from 7 EUR to 31 EUR.

Upon arrival, participants were seated in front of computers in three-sided cubicles and received a copy of written instructions. After they correctly responded to a set of control questions and took part in a short task to assess their willingness to take risks, subjects were randomly assigned to groups of four. The group composition stayed the same throughout the experiment. Interactions among participants were computerized and anonymized to prevent the influence of personal characteristics in the exchange process. In the main experiment, the prisoner's dilemma was implemented for 16 periods. Participants were not informed about the exact number of repetitions in order to preclude endgame effects. A session lasted approximately 90 min and—in addition to the main experiment—comprised the collection of various control variables and a dictator game, which was conducted after the main experiments (the results of which are not reported herein). At the end of a session, participants were called to the experimenter desk separately to collect their payment privately and in cash.

3.2. Manipulations and Parameters

In each round, participants simultaneously decided between cooperation and defection, in the experiment framed as 'Option 1' and 'Option 2'. Cooperation produced a social benefit of 10 MU and a private benefit of 0 MU, while defection resulted in a social benefit of 0 MU and a private benefit of 3 MU.

Network Structure: Across network structures, the 4-player prisoner's dilemma was arranged to mirror either a public good structure (Figure 1, left) or a generalized exchange system (Figure 1, right).

In the public good structure, cooperation implied a transfer of social benefits to a joint account. The benefits sent to the joint account were equally divided among the remaining three group members, irrespective of their decision. The income gained in each period amounted to the sum of social benefits provided to the joint account by one's fellow group members—which ranged from 0 MU to 10 MU depending on the co-players' decisions—plus the private benefits kept—which was either 0 MU or 3 MU depending on the player's decision.

In the generalized exchange system, each participant was involved in two exchange relations. In one exchange relation, the participant decided between sending social benefits to a recipient or keeping private benefits. In the other exchange relation, the participant was affected by another player's decision between sending social benefits or keeping private benefits. The income gained in each period amounted to the social benefits received from one's sender—which was either 0 MU or 10 MU depending on the co-player's decision—plus the private benefits kept—which was either 0 MU or 3 MU depending on the player's decision.

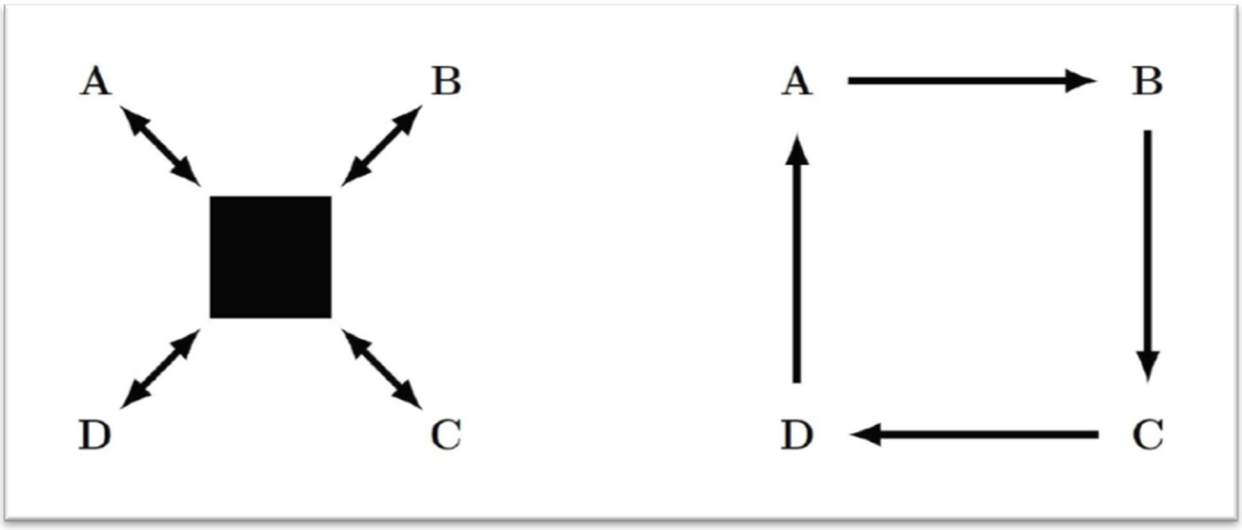

Figure 1. The two network structures. The letters indicate group members. The arrows represent a decision between cooperation and defection.

The parameters of the social and private benefits were selected to generate cooperation rates around 50 percent in the baseline setting [36,66] and permitted treatment effects of punishment in both directions. The payoff range is the same in the two network structures. In both treatments, mutual defection resulted in a payment of 3 MU and mutual cooperation resulted in a payment of 10 MU. A subject could receive a maximum of 13 MU if the player defected and received social benefits from one's sender or all other group members, respectively. A subject could receive a minimum of 0 MU if the player cooperated and received no social benefits from one's sender or the other group members, respectively.

In generalized exchange, the positions in the chain network and the identifiers of participants were randomly reshuffled in each period to prevent the emergence of personal ties between group members. Thus, the participants did not know to which group members they sent benefits and from which group member they could receive benefits. In the same manner, identifiers were randomized in each period in the public good. Information about the decisions of group members was provided according to the same rule in the two network structures. Thus, individuals were only informed about the outcome of the exchanges that were relevant to their income. In the public good, participants observed the (randomly reshuffled) identifiers of group members and their decisions. In generalized exchange, they only learned about the decision of one's sender.

Punishment: Punishment was manipulated between a baseline treatment containing no second-stage decision, a punishment regime of (2; 1), and a punishment regime of (2; 0). The loss of 2 MU from receiving punishment was the same across punishment treatments, but the costs were varied between a costly (1 MU) and a costless (0 MU) option. The experimental design kept the loss that a player could inflict on another below the possible gain from defection, such that each individual possessed only limited power over each other group member. The parameters mirror the specifications of punishment in the related literature. The cost–impact ratio of (2; 1) compares to the effective specification in Carpenter et al. [52]. However, in the survey of different punishment regimes by Nikiforakis and Normann [21], this ratio proves to be only mildly effective. In the punishment treatments, participants could receive negative income from a round. In order to prevent participants from falling below accumulated earnings of zero, players in all treatments received 10 MU endowment at the beginning of the experiment.

Peer punishment differs between the two exchange structures with regard to three aspects. First, the sanctioning network in the public good treatment is denser than in the generalized exchange system. In the public good, every player can punish multiple group members and, in return, receive punishment by multiple group members, whereas in

generalized exchange, an individual can only punish one's sender and receive punishment from one's recipient. Second, although the information about the punishment behavior of other players was comparable across the two treatments, insofar as participants only learned about the punishments that had consequences for their own income, the public good made it easier to infer if group members adapted their behavior because of punishment. Thus, in the public good, players were informed about all exchange decisions in each period and could notice changes in average cooperation, whereas in generalized exchange, they received MUs from alternating group members over consecutive periods and could not be certain that they observed the cooperation decision of the person they punished before. Third, the dense sanctioning network in the public good inflates the aggregate penalty that each individual may receive to a range between 0 MU and 6 MU. The sanctioning network in generalized exchange creates an aggregate penalty between 0 MU and 2 MU. In the public good, the coordination of incremental sanctions could build up to a loss that exceeded the potential gain from defection (3 MU), whereas in generalized exchange, singular acts of punishment did not suffice to deter a purely egoistic defector. Conversely, in the costly punishment treatment, the aggregate costs to punishers ranged between 0 MU and 3 MU in the public good and 0 MU and 1 MU in generalized exchange.

4. Results

The results of the experiment are reported in two parts. The first part presents the findings for the public good structure (Hypotheses 1a–1c), which square with the established knowledge from the literature. The second part outlines the findings for the generalized exchange system (Hypotheses 2a–2c) and expounds the structural differences.

4.1. The Public Good Structure

Figure 2 illustrates the cooperation averages by treatment over the course of the experiment. Table 1 presents the supporting statistical tests on the differences in group averages.

Table 1. Cooperation and earnings by treatment.

	GROUPS	COOPERATION	EARNINGS
PUBLIC GOOD			
BASELINE	6	0.52	6.63
PUNISHMENT (COSTLY)	6	0.59 ($p = 0.67$)	5.69 ($p = 0.53$)
PUNISHMENT (COSTLESS)	5	0.92 ($p < 0.01$)	8.77 ($p = 0.053$)
GENERALIZED EXCHANGE			
BASELINE	18	0.59	7.16
PUNISHMENT (COSTLY)	18	0.66 ($p = 0.51$)	7.32 ($p = 0.32$)
PUNISHMENT (COSTLESS)	12	0.59 ($p = 0.97$)	6.54 ($p = 0.46$)

Notes: The p-values correspond to two-tailed t-tests on group averages in comparison to the baseline manipulation. Earnings are measured by the average MUs earned per period. The difference between the two punishment treatments is weakly significant in the public good ($p = 0.06$) and insignificant in generalized exchange ($p = 0.67$) for cooperation, and weakly significant in the public good ($p = 0.07$) and insignificant in generalized exchange ($p = 0.30$) for earnings.

As can be seen from Figure 2, in the public good, the pattern of the baseline treatment closely mirrors what is typically observed in reference studies [71]. Cooperation starts relatively high, at more than 70 percent, and gradually decreases throughout the experiment, eventually reaching less than 40 percent in the final rounds. Costly punishment slightly mitigates this decay towards the end of the game, yet remains statistically indistinguishable from the baseline. By contrast, free punishment reveals a drastically different pattern. It starts only marginally above the other two conditions, yet approaches almost uniform cooperation as the experiment progresses.

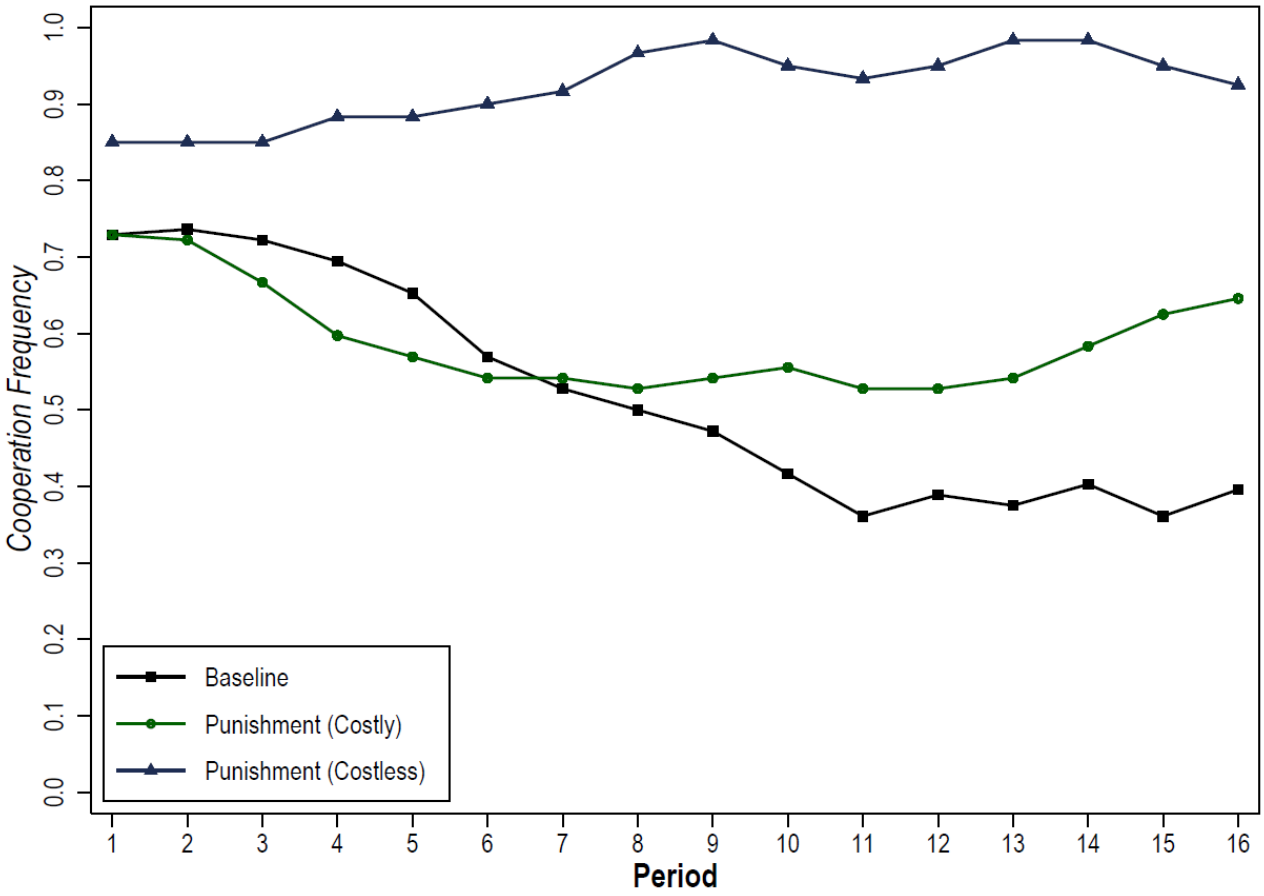

Figure 2. Cooperation frequency in the public good structure. Lines and dots correspond to three-period moving averages.

These findings provide direct evidence for Hypothesis 1a and Hypothesis 1b and chime with the established insights from the related literature [20,21]. In the public good structure, peer punishment maintains high rates of cooperation; however, the positive effect is strongly contingent on the cost of punishment. In particular, costly punishment does not increase cooperation compared to the baseline treatment ($t(10) = 0.44$, $p = 0.67$), whereas costless punishment increases cooperation compared to the baseline treatment ($t(9) = 3.35$, $p < 0.01$).

The final column of Table 1 reports the average earnings of each treatment in experimental currency. In the costless punishment condition, the gains from sustained cooperation outweigh the damage inflicted by mutual punishment and earnings exceed those of the baseline treatment, however, significantly only for the second half of the experiment ($t(9) = 3.06$, $p = 0.014$). By contrast, earnings in the costly punishment condition were not statistically different from the baseline treatment.

In order to shed further light on the nature of peer punishment, the analysis explored how often peer punishment was employed and how subjects reacted to it. Overall, 75 percent of the subjects used punishment at least once if it was costly (18/24) and free (15/20). Reference studies report similar rates in the range of 70 to 85 percent in the public good [51,71]. Looking at the absolute frequency, costly punishment was exerted in 16.1 percent (185/1152) and free punishment in 11.3 percent (109/960) of all punishment opportunities.

Figure 3 presents punishment frequencies, conditional on whether the preceding action was defection (altruistic punishment) or cooperation (antisocial punishment), and, therefore, controls for the different cooperation frequencies of treatments. For punishment following a defection, the impact of costs is clearly discernable. In the presence of costs, roughly every fourth defection is punished, while in the absence of costs, this number

increases to more than 75 percent. In both scenarios, it was markedly more likely to receive punishment after a defection than a cooperation. The observation that the majority of punitive acts were altruistic squares with the conclusions of the literature [43,61].

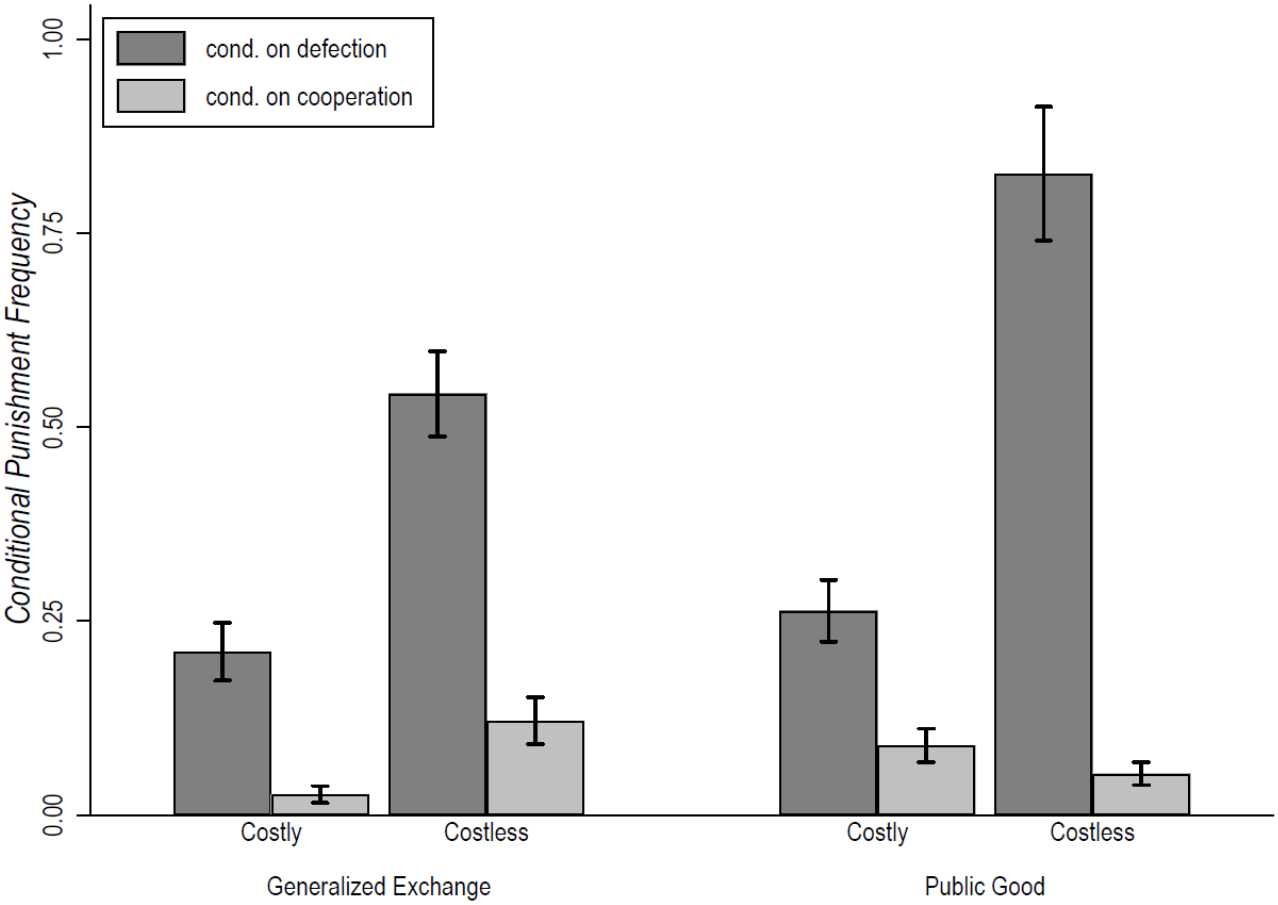

Figure 3. Conditional punishment frequency by treatment. Error bars show 95% confidence intervals.

To examine individual reactions to punishment, Table 2 reports the results of a logistic regression analysis on cooperation in period $[t]$. In order to account for the nested structure of the data, which were generated by repeated interactions in groups, standard errors are clustered at the group level. To check for potential confounding by time-invariant factors, specifically unmeasured characteristics of individuals, two robustness tests were conducted. First, I added fixed effects at the group level. Second, I split up the sample according to cooperation $[t-1]$ and analyzed the impact of receiving punishment in two distinct regressions. The two analyses do not reveal substantially different outcomes to Table 2.

Model (1) contains indicator variables for the punishment treatments and supports the statistical significance of the treatment differences. Model (3) reports the effects of receiving punishment in period $[t-1]$ on cooperation in period $[t]$ conditional on cooperation in period $[t-1]$. The coefficients suggest that punishment indeed induced a behavioral adaption, stimulating cooperation if it sanctioned defection, and provoking defection if it was targeted at cooperation. More precisely, the average marginal effects of the coefficients state that, on average, receiving punishment after defection increases the chances of cooperation in the next period by 0.17 percentage points, whereas receiving punishment after cooperation decreases the chances of cooperation in the next period by 0.11 percentage points. Supporting Hypothesis 1c, altruistic punishment increases the inclination to cooperate, whereas antisocial punishment decreases the inclination to cooperate.

Table 2. Logistic regression on cooperation [t].

Variables	(1)	(2)	(3)	(4)
Costly Punishment	0.250	0.291		
	(0.598)	(0.605)		
Costless Punishment	2.348 **	2.414 **		
	(0.824)	(0.731)		
Generalized Exchange		0.211		0.104
		(0.492)		(0.318)
Generalized Exchange × Costly Punishment		0.0137		
		(0.721)		
Generalized Exchange × Costless Punishment		−2.231 **		
		(0.856)		
Cooperation [$t-1$]			3.844 **	3.911 **
			(0.441)	(0.432)
Punishment Received [$t-1$]			0.965 **	0.981 **
			(0.284)	(0.254)
Cooperation [$t-1$] × Punishment Received [$t-1$]			−1.986 **	−1.955 **
			(0.484)	(0.455)
Generalized Exchange × Cooperation [$t-1$]				−0.423
				(0.549)
Generalized Exchange × Punishment Received [$t-1$]				−0.585
				(0.350)
Generalized Exchange × Cooperation [$t-1$] × Punishment Received [$t-1$]				1.414 *
				(0.669)
Observations	1088	4544	660	2604
Subjects (Groups)	68 (17)	260 (65)	44 (11)	164 (41)
Wald Chi^2	15.86 *	21.35 *	311.83 **	358.53 **
Pseudo R^2	0.129	0.043	0.333	0.366
Log Pseudolikelihood	−606.125	−2894.40	−253.237	−1066.937

Notes: Logistic Regression with group-clustered standard errors. Controls: economics dummy, gender, age, risk index. Not reported: Constant. (1) and (3) use only the observations from public good; (3) and (4) use only the observations from costly punishment and costless punishment. Costly punishment, costless punishment, generalized exchange are treatment dummies. Cooperation [$t-1$] and punishment received [$t-1$] are binary variables indicating if the subject cooperated or received punishment in the previous period. ** $p < 0.01$, * $p < 0.05$.

4.2. The Generalized Exchange System

The generalized exchange treatments in Figure 4 display a stark contrast to the pattern observed in the public good structure. In generalized exchange, peer punishment was essentially inconsequential to cooperation. None of the punishment treatments significantly furthered cooperation in comparison to the baseline treatment. In all three treatments, the cooperation frequency started at around 60 to 70 percent—in contrast to the public good—and remained relatively constant throughout the exchange phase.

The lower part of Table 1 asserts that neither costly punishment (t(34) = 0.66, $p = 0.51$) nor costless punishment (t(28) = 0.04, $p = 0.97$) increased cooperation compared to the baseline treatment. Regarding Hypothesis 2a, the results imply that the effect of peer punishment is not only reduced, but inexistent in generalized exchange. Model (2) in Table 2 indicates that the interaction term of costless punishment and generalized exchange has a significantly negative coefficient. This confirms Hypothesis 2b that the difference in cooperation between costly and costless punishment diminishes in generalized exchange. The final column of Table 1 reveals no differences in earnings between treatments, although the free punishment option consistently generated lower payments to experimental subjects. These findings highlight that generalized exchange offers a less favorable environment for peer punishment than the public good structure.

Despite its lack of effectiveness, participants were far from reluctant to use peer punishment in generalized exchange. Similar to the public good structure, more than half of the participants used the punishment option at least once when it was costly

(37/72) and 87.5 percent of the participants used it at least once when it was costless (42/48). Furthermore, in absolute terms, the pattern in generalized exchange does not differ markedly from the public good as costly punishment was employed in 9.2 percent (119/1296) and free punishment in 29.4 percent (226/778) of all punishment opportunities.

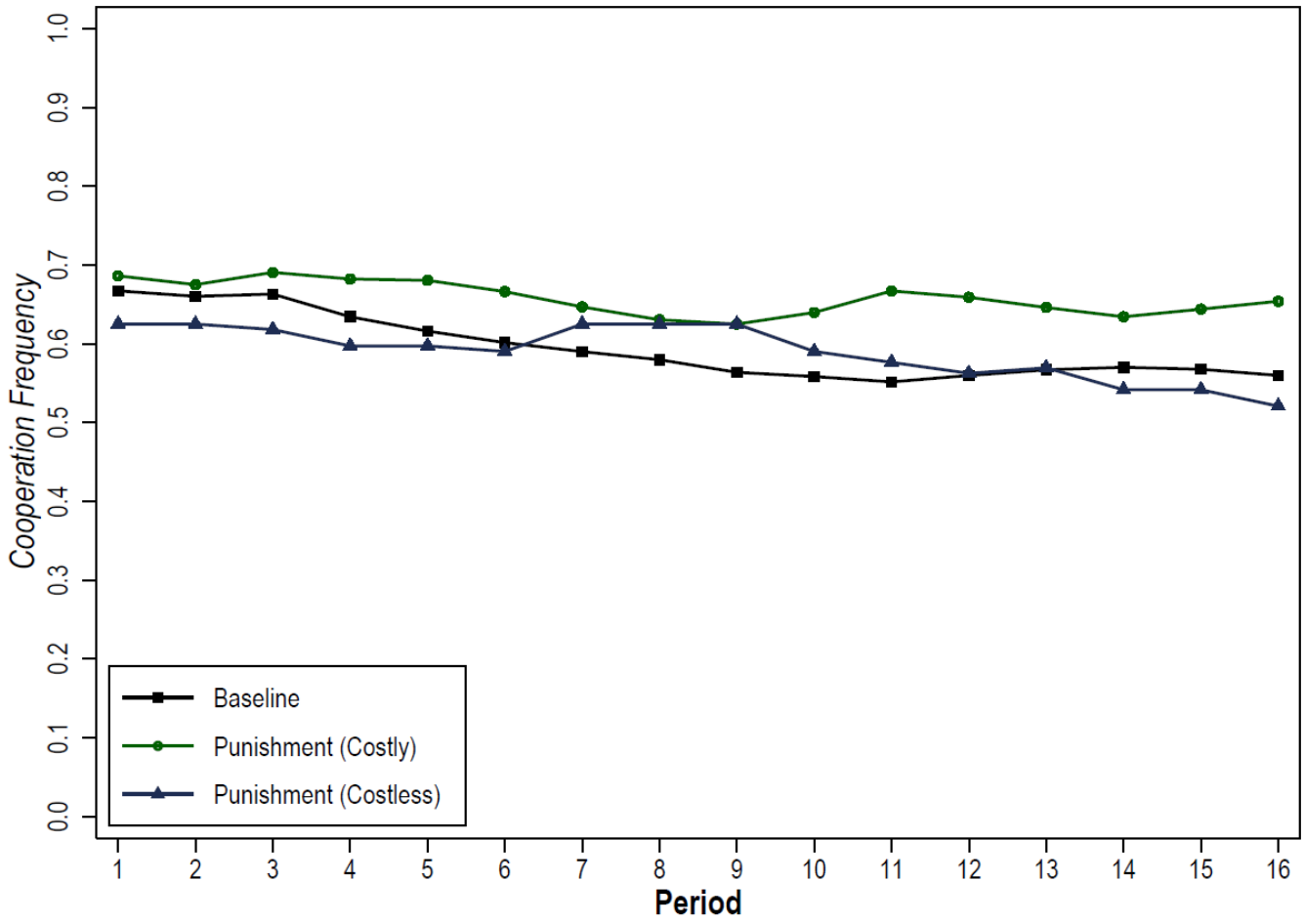

Figure 4. Cooperation frequency in generalized exchange. Lines and dots correspond to three-period moving averages.

The conditional punishment frequencies in Figure 3 are slightly lower in generalized exchange than in the public good structure, as 54 percent and 21 percent of the defections were sanctioned in the costless and costly scenario, respectively. Nevertheless, they display the same tendency across costs, as peer punishment was considerably more frequent following defection than cooperation. These punishment frequencies—both in absolute and conditional terms—remain markedly above the frequencies reported by Ule et al. [66], which implies that generalized exchange itself did not discourage the regular use of peer punishment.

However, from the perspective of a defector, the conditional punishment frequencies have substantially different implications in the two network structures. Based on the parameters of the experiment, a conditional punishment frequency of 21 percent for costly and 54 percent for costless punishment implied an average loss of $0.21 \cdot p = 0.42$ MU and $0.54 \cdot p = 1.08$ MU in generalized exchange. Both values remain below the gain from a defection. By contrast, in the public good, the conditional punishment frequencies of 26 percent and 83 percent translate to an average loss of $0.26 \cdot (n - 1) \cdot p = 1.56$ MU and $0.83 \cdot (n - 1) \cdot p = 4.98$ MU. The latter number clearly surpasses the gain from a defection and thus identifies a reason for why this treatment was the only one promoting cooperation.

Model (4) in Table 2 assesses the difference in the behavioral reactions to altruistic and antisocial punishment between generalized exchange and the public good as formulated

in Hypothesis 2c. The results show that the reactions to receiving punishment did not extend from the public good structure to the generalized exchange system. Receiving altruistic punishment slightly increased the inclination to cooperate in the next period by 0.06 percentage points, but only at a significance level of 0.10 ($p = 0.09$). Receiving antisocial punishment does not significantly change the likelihood of future cooperation. Although peer punishment was similarly frequent in generalized exchange, neither altruistic nor antisocial punishment induced a change in behavior in the punished subject.

5. Discussion and Conclusions

This study explored peer punishment in a public good structure and a generalized exchange system. A laboratory experiment demonstrated that a circular network of generalized exchange provides an unfavorable structure to decentralized punishment. In the public good, peer punishment promoted cooperation, was sensitive to sanctioning costs, and induced the expected behavioral reactions for altruistic and antisocial punishment. These patterns only partly extend to generalized exchange. As in the public good, peer punishment is primarily altruistic and relatively frequent. However, neither costly nor costless punishment led to more cooperation than in the baseline treatment.

The results point to a crucial difference in the two exchange forms. While underlying the public good, a dense web of connections facilitates norm enforcement, generalized exchange reduces the punishment capacity to private acts among network members. In consequence, the same punishment regime may foster cooperation in the public good—where incremental sanctions accumulate to a substantial penalty—and, simultaneously, may fail to do so in generalized exchange—where singular punitive acts fail to deter norm violators. It follows that the evidence on peer punishment in public good does not transfer to circular networks of generalized exchange, which would require more severe punishment regimes to uphold cooperation.

This study adds to a burgeoning body of research emphasizing the social conditions under which peer punishment sustains cooperation [6,72]. In doing so, it relates to a number of existing studies. Its findings echo a study by Leibbrandt et al. [17], who demonstrate that any deviation from the ideal case of a complete punishment network hampers its impact on cooperation. In contrast, the present findings diverge from those of Carpenter et al. [19], who show that incomplete punishment networks do not jeopardize peer punishment as long as the network remains connected, i.e., still connects all group members either directly or indirectly. Likewise, the experimental setting by Boosey and Isaac [18] also documents no adverse implications of restricting sanctioning networks to a circular shape. Going beyond prior work, in my experiment, network connections restrict not only sanctions but also the initial flow of benefits between exchange partners.

The research also relates to previous experiments stressing the importance of the cost–impact ratio of a punishment regime [20,21,50]. My findings confirm that the cost–impact ratio is paramount to the effectiveness of punishment, but they also show that the identical cost–impact ratio might have different ramifications depending on the structural environment embedding punishment.

Finally, the study contributes to our understanding of generalized exchange systems. This experiment focused on a representation of generalized exchange that more closely resembles encounters in large and anonymous collectives rather than in small and intimate groups. Hence, various aspects of generalized exchange as operationalized in this experiment need not apply to other types of generalized exchange.

In small groups, generalized exchange is often embedded in a closely knit web of connections such that group members can observe each other's behavior and punish norm violations of third parties. In this case, sanctions are public information and backed by social support. Fehr and Fischbacher [73] show that many individuals are willing to enforce social norms, even though they are not directly affected by norm violations. This third-party punishment stabilizes exchange forms, in which punishment and observability is not limited to direct network neighbors. Moreover, in many types of generalized

exchange, benefits do not flow in a prescribed cycle, but can be directed deliberately to specific network members. In these conditions, persons are encouraged to build up cooperative reputations [16], and defective group members are threatened with isolation or ostracism [74]. With these social mechanisms, self-governance via peer punishment might have a better chance of sustaining cooperation, and differences to the public good setting might diminish.

By contrast, in large and anonymous collectives, detailed information about exchange partners is often unavailable and the formation of prosocial reputations is often impossible. In the absence of a reputational system, generalized exchange has to rely exclusively on mechanisms of 'generalized reciprocity', where those that receive benefits 'pay it forward' to a third party—for example, out of gratitude [16,75,76]. In these collectives, generalized exchange resembles private encounters that often remain concealed from people beyond the exchanging dyad. In these cases, only the victim of a defection may reprimand the perpetrator, whereas uninvolved parties learn about neither the defection nor the punishment. The present operationalization captures these conditions and suggests that self-governance is difficult to sustain if generalized exchange is not stabilized by additional social mechanisms.

Furthermore, in this study, the cost–impact ratio was held stable when extending peer punishment from the public good to generalized exchange. As a consequence, the punishment capacity—i.e., the total penalty each subject may receive and the total punishment cost each subject may pay—differs between the two exchange structures. Other studies have compared sanctioning networks by keeping the punishment capacity constant and instead inflating the parameters of the punishment regime in less dense networks. Leibbrandt et al. [17] experimentally tested both strategies and concluded that punishment capacities were less important to cooperation than network configurations. In their study, incomplete sanctioning networks produced lower cooperation rates, even if the maximum number of punishment points that a subject could receive was the same as in the complete networks. In any case, the conclusion remains unchanged: self-governance in generalized exchange requires a more powerful punishment regime to enable the cooperation-enhancing effect of strong reciprocators.

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