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When punishers might be loved: fourth-party choices and third-party punishment in a delegation game

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Abstract

Third-party punishment (TPP) has been shown to be an effective mechanism for maintaining human cooperation. However, it is puzzling how third-party punishment can be maintained, as punishers take on personal costs to punish defectors. Although there is evidence that punishers are preferred as partners because third-party punishment is regarded by bystanders as a costly signal of trustworthiness, other studies show that this signaling value of punishment can be severely attenuated because third-party helping is viewed as a stronger signal of trustworthiness than third-party punishment. Third-party helpers donate their payoffs to victims of defection in games instead of punishing defectors as third-party punishers do. Then, under what circumstances can third-party punishment be maintained by costly signaling when helping is also present? We show that punishers are preferred over helpers by fourth-party individuals as their delegates to deter potential exploitation. This suggests that costly signaling can facilitate the maintenance of third-party punishment in partner choice with delegation interactions.

Keywords Third-party punishment · Costly signaling · Delegation game

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1 Introduction

Third-party punishment (TPP), whereby unaffected individuals punish selfishness at a cost to themselves, has been proposed as an important mechanism through which human cooperation can be maintained. Experimental evidence has shown that third-party punishment can effectively enforce cooperation among anonymous individuals (Fehr and Fischbacher 2003, 2004a, 2004b; Fehr and Gachter 2002; Fehr et al. 2002). However, third-party punishment itself is costly in that punishers take on personal costs to punish defectors without receiving any direct benefit from it. In addition, punishment might risk retaliation from defectors (Janssen and Bushman 2008). These issues raise the following question: although TPP supports cooperation, what mechanisms support TPP?

Experimental evidence suggests that one mechanism might work well: third-party punishers are preferred as cooperative partners or rewarded by bystanders who regard TPP as a costly signal of prosociality (Barclay 2006; Horita 2010; Nelissen 2008). However, third-party players can also choose alternative ways to signal their prosociality. For example, they can donate part of their endowment to help victims of defection rather than punishing defectors. Experimental evidence shows that bystanders, or receivers of a costly signal of prosociality, are more likely to choose third-party helpers rather than punishers as their cooperative partners (Jordan et al. 2016; Peysakhovich et al. 2014; Raihani and Bshary 2015a). If helpers "grab" most cooperative opportunities from punishers, then it remains unknown whether costly signaling can be the mechanism that supports TPP. Therefore, it is important to investigate the mechanisms that support TPP when both third-party helping and punishment are options for signaling prosociality and gaining cooperative partners.

This paper provides experimental evidence that costly signaling in a delegation interaction can maintain TPP when both helping and punishment are options for signaling prosociality. Previous studies focus on two-player interactions in which bystanders choose with whom to interact ("play *with* me"), but in delegation interactions, bystanders choose a delegate to interact with others on their behalf ("play *for* me"). In such a delegation interaction, we also call the one who chooses the partner the 'Principal' and the one chosen the 'Delegate'.

In our main experiment (Experiment 3), we compare the cooperation opportunities received by punishers and helpers in a delegation game in which bystanders (fourth-party players) choose either punishers or helpers as their delegates to play with others in the ultimatum game. We show that punishers receive more delegation opportunities than helpers. We propose that punishers gain this advantage because bystanders expect to deter potential defectors (among the "others") by choosing partners who have previously sent deterrence signals through punishment. This relies on the prerequisite that TPP can indeed signal deterrence more saliently than helping. We examine the prerequisite in Experiment 2. Prior to Experiments 2 and 3, we first examined whether helpers "grab" most of the cooperative opportunities from punishers when both helping and punishment are available options for third-party players (Experiment 1).

This study contributes to the literature in two ways. First, we determine the circumstances under which costly signaling can maintain third-party punishment when both punishment and helping are options for third-party players. It is worth noting that previous studies show only that costly signaling can maintain TPP when it is the only costly signaling option (Barclay 2006; Horita 2010; Nelissen 2008). Our results extend this explanation to a more general case in which third-party helping and punishment simultaneously exist in social interactions. Second, our results show how delegation relationships, which are common in social networks and organizations, can affect the maintenance of TPP and cooperation. This is important because, in the real world, face-to-face interaction and bargaining usually occur between delegates rather than between principals (Schotter et al. 2000). In addition, delegated punishment, placing enforcement in the hands of a delegate (e.g., leader, police, and government), is regarded as an effective way of promoting cooperation (Andreoni and Gee 2012; Liu et al. 2020).

The remainder of this paper proceeds as follows: Sect. 2 describes the research background, the conceptual framework of the experiments, and the hypotheses. Sections 3–6 present the experimental design and the results. Section 7 discusses some concerns and future research.

2 Literature review, conceptual framework, and hypotheses

2.1 Literature review

Maintaining cooperation has been the subject of an impressive body of research. Several mechanisms, including kin selection (Hamilton 1964), direct reciprocity (Axelrod and Hamilton 1981; Trivers 1971), reputation or indirect reciprocity (Alexander 1987; Nowak and Sigmund 1998a, 1998b), and costly signaling (Bird and Smith 2005; Gintis et al. 2001; Smith and Bird 2000; Smith et al. 2003; Zahavi 1995), have been proposed.

Third-party punishment is also proposed as an important mechanism, and there is experimental evidence that it effectively facilitates cooperation (Fehr and Fischbacher 2003, 2004a, 2004b; Fehr and Gachter 2002; Fehr et al. 2002). As third parties might punish a stranger who violates prosocial norms, TPP is regarded as a mechanism that can promote large-scale cooperation. A cross-cultural study shows that people in small-scale societies engage in less TPP than people in larger societies (Marlowe et al. 2008). However, punishing defectors is costly and likely to induce counter-punishment or revenge (Balafoutas et al. 2014). Then, it is important to investigate the mechanisms that can maintain third-party punishment. Two approaches explore this question. One approach studies various strategies of punishers per se, including abstaining from joint endeavors if exploited (Hauert et al. 2007), coordinating collective punishment by signaling a willingness to punish (Boyd et al. 2010), setting sanction institutions before engaging in the joint enterprise (Gurerk et al. 2006; Zhang et al. 2014), etc. The other focuses on the attitude and behavior of bystanders (fourth-party individuals) toward third-party punishers. The second approach has investigated two mechanisms.

The first mechanism is indirect reciprocity, in which third-party punishers are rewarded by uninvolved fourth-party individuals. Although a computational simulation shows that fourth-party rewards can maintain the evolution of altruistic punishment (Ye et al. 2011), experimental evidence suggests that the reward will be significantly reduced if third-party players are allowed to choose to either punish defectors or help victims of unfair distributions (Raihani and Bshary 2015a, 2015b). In addition, a theoretical model finds that indirect reciprocity provides only a narrow margin of efficiency for costly punishment (Ohtsuki et al. 2009).

Another mechanism is signaling trustworthiness to potential partners through third-party punishment. If bystanders trust third-party punishers more than nonpunishers and prefer the former as partners, greater access to cooperative ventures might recoup the cost of altruistic punishment (Barclay 2013; Jordan and Rand 2017). Experimental studies suggest that when punishing selfishness is the only way to signal prosociality, punishers are more trusted than nonpunishers and preferred as partners (Barclay 2006; Horita 2010; Nelissen 2008).

However, the signaling value of punishment is severely attenuated if there is also an opportunity to signal trustworthiness by helping (Jordan et al. 2016; Raihani and Bshary 2015a). One experiment even shows that TPP is uncorrelated with trustworthiness when helping is also an option for third-party players (Peysakhovich et al. 2014). This is not surprising if we consider several issues punishment might induce, including wasting resources, causing conflicts (Yang et al. 2018), promoting enforcement of bad social norms (Abbink et al. 2017), punishing socially efficient allocations (Leibbrandt and López-Pérez 2011), using punishment to seek self-advantageous inequality (Houser and Xiao 2010), over-punishment (Kamei 2020), etc. In contrast, social reward can promote cooperation while avoiding the issues above (Yang et al. 2018). Compensating or helping is similar to rewarding in that it maintains cooperation without resorting to punishment. Studies show that third parties prefer positive sanctioning (rewarding, compensating) to punishing (Chavez and Bicchieri 2013; Nikiforakis and Mitchell 2014; Sutter et al. 2010), and bystanders prefer third-party helpers to punishers as cooperative partners (Jordan et al. 2016; Raihani and Bshary 2015a).

The experimental studies above, comparing the signal values of punishment and helping, use the trust game (TG) as the interaction between bystanders and third-party players. This approach fails to consider the possibility that punishment might signal information other than trustworthiness, such as deterrence (Tan and Xiao 2018). In fact, third-party punishment can gain punisher advantages by deterring potential defectors in two-player interactions (Delton and Krasnow 2017; dos Santos et al. 2011; Krasnow et al. 2016).

However, even if punishers can effectively protect themselves from potential exploits in two-player ventures, this advantage alone does not guarantee the maintenance of TPP. This is because punishers may have less opportunity than helpers to be chosen in two-player ventures if individuals can freely choose whom to interact with; thus, there will be fewer opportunities for punishers to gain potential payoffs.

Hence, the deterrence effect in two-player interactions is not sufficient to explain the maintenance of third-party punishment. Instead, it is necessary to further explore

when and why third-party players might be preferred as partners and what role the signal of deterrence plays in multi-individual interactions. To address these questions, we extend interactions between bystanders and third-party players to include multi-individual interactions by introducing delegation interactions (Fershtman et al. 1991; Schelling 1960). In a delegation game, players send delegates who play the game on their behalf, and delegation can serve as a commitment device or signal. We apply a delegation game in which a principal chooses a partner as their delegate to play with another player in the ultimatum game (Fershtman and Gneezy 2001). While classical delegation interactions mainly focus on how varied contracts between principals and delegates and informed conditions can influence commitment and bargaining results (Choy et al. 2016; Dalmia 2019; Katz 1991; Kockesen and Ok 2004), we investigate whether principals distinguish between types of delegates according to their choices in cooperation.

2.2 Conceptual framework

Our research is based on the framework of costly signaling theory (CST), which has been established in both economics (Spence 1973; Veblen 1899) and evolutionary biology (Grafen 1990; Johnstone 1995; Zahavi 1995; Zahavi and Zahavi 1997). We particularly draw on the CST framework that emphasizes the role of partner choice in maintaining cooperation (Gintis et al. 2001; Jordan et al. 2016; Smith and Bird 2005).

Costly signaling theory proposes that the "Signaler" conveys information about her hidden qualities to the "Receiver" by sending costly signals. For example, high-quality employees distinguish themselves from low-quality ones by rigorous higher education. Employers regard higher education as a signal of productivity, as only high-quality workers can afford to put effort into high-level education (Spence 1973).

In the literature on cooperation, the hidden quality of the "Signaler" is her cooperativeness or her quality of being a cooperative partner. High-quality cooperative partners exhibit costly prosocial behaviors as costly signals, and the "Receiver" or the "Chooser" chooses her partner based on these signals (Gintis et al. 2001; Smith and Bird 2005). Jordan et al. (2016) established a CST framework in which individuals choose cooperative partners from among third-party players based on signals sent by the latter. Third-party players convey information about their type by sending costly prosocial signals, and choosers benefit from partnering with cooperative signalers. The cost to signalers will be compensated by gaining more access to cooperation relationships. There are two types of costly prosocial signals in Jordan et al. (2016): third-party punishment and third-party helping. While third-party punishers take on personal costs to punish defectors, third-party helpers donate part of their endowments to victims of defection instead of punishing defectors.

Our research introduces the delegation relationship into the conceptual framework of Jordan et al. (2016). In our framework, bystanders, rather than choosing partners to interact directly, choose partners as their delegates to interact with others. Choosing and attracting partners depends on the costly signals (third-party punishment or helping) sent by candidate delegates.

2.3 Hypotheses

Based on the conceptual frameworks above, our experiments will be used to test three hypotheses as follows:

Several experimental studies have verified that third-party punishers can gain more access to cooperative relationships by sending costly signals so that third-party punishment can be maintained; in previous studies, punishment was mainly seen as a signal of trustworthiness (Barclay 2006; Horita 2010; Nelissen 2008).

However, if there are alternative prosocial signals that can better convey trustworthiness, then the effect of the mechanism maintaining TPP might be attenuated. That is why we need to examine the circumstances under which TPP can be maintained when third-party players can choose either to punish or to help. Indeed, evidence shows that helping is a better signal for trustworthiness than punishment (Jordan et al. 2016; Peysakhovich et al. 2014; Raihani and Bshary 2015a). However, there are several detailed differences in experimental design between the previous studies on the topic and our research (e.g., in Jordan et al. (2016), the helpers are not technically third-party helpers). Therefore, we first test Hypothesis 1 in Experiment 1, which is consistent with the condition and design of our main experiment.

Hypothesis 1 When cooperative opportunities are allocated based on signals of trustworthiness, the advantage of helpers is greater than that of punishers.

Next, we consider TPP to be a mixed costly signal. There is evidence that punishment is a signal of trustworthiness (Barclay 2006; Horita 2010; Nelissen 2008; Peysakhovich et al. 2014; Raihani and Bshary 2015a). Meanwhile, experimental studies show that punishment can be used as a signal of deterrence against potential exploitation (Delton and Krasnow 2017; Krasnow et al. 2016).

We consider how such a deterrence signal affects partner choice and the maintenance of TPP. Then, we first need to verify the basic premise that punishment is regarded by bystanders as a deterrence signal to potential exploitations. If this basic premise is true, then we should expect third-party punishers to be less likely to receive an unfair distribution in the ultimatum game than helpers and noncooperative individuals (who neither help nor punish) when bystanders are distributors in the game. This yields our second hypothesis:

Hypothesis 2 Third-party punishers are less likely to receive an unfair distribution than helpers when the distributors are fourth-party bystanders.

If bystanders regard TPP as a deterrence signal, then some of them might choose third-party punishers as partners to deter potential exploitation from others. We consider this under the framework of a delegation game in which bystanders choose a third-party individual to play as a receiver on their behalf in the ultimatum game. Intuitively, we expect bystanders who act as distributors to be less likely to exploit punishers because they expect punishers to be more likely to punish exploitive distribution by refusing the proposal. We, therefore, expect fourth-party individuals to prefer third-party punishers over helpers and noncooperative individuals as

partners in the delegation game to deter potential exploitation. This allows us to formulate our third hypothesis:

Hypothesis 3 Third-party punishers are more frequently selected as delegates than helpers and noncooperative individuals.

3 General experimental design

There are typically two stages in experiments that aim to explore how bystanders interact with third-party players: in the first stage, the third-party players choose how to deal with an unfair distribution in a dictator game. They can choose to punish selfish dictators, to help victims, or to do nothing. In the second stage, the bystanders, who are informed of the choice the third-party players made in the first stage, choose how to treat the third-party players. For instance, in Experiment 1, the bystanders choose how much money they invest in third-party players in the trust game according to their behavior in the first stage. In Experiment 2, the bystanders choose the distribution to the third-party players in the ultimatum game based on the choices of the latter in the first stage.

In previous experimental designs, the interaction between third-party players and bystanders in the second stage was typically a two-player format. In Experiment 3, we replaced the two-player interaction with an n-person interaction by introducing the delegation game as the second stage.

Across three experiments, 405 subjects were recruited. All experiments were run in the laboratory at Zhejiang University of Finance and Economics. Each participant could participate in only one experiment. The participants were randomly assigned roles and were randomly matched in the experiments. Each experiment took approximately one hour. Subjects were paid 10 RMB yuan for participating, plus an additional bonus based on their decisions in the experiment. The average income of the participants was 20.669 RMB yuan (approximately 2.914 US dollars, S.D.= 12.185).

4 Study 1 third-party punishment as a signal of trustworthiness

In Study 1, we wanted to detect which behavior is perceived by society as a better signal of trustworthiness when third-party punishment coexists with third-party helping.

4.1 Study 1 methods

The first stage of Experiment 1 is a third-party punishment game. The third-party punishment game involves three roles: dictator, recipient, and third-party individual. First, the dictator and the recipient are endowed with 20 RMB yuan in total (Forsythe et al. 1994), and the dictator can choose to split the endowment. The dictator chooses between two options: (1) keep 10 RMB yuan and give 10 RMB yuan to the recipient; or (2) keep 20 RMB yuan and give 0 RMB yuan to the recipient. Then, the third-

party individual is endowed with 25 RMB yuan. If the dictator decides to be selfish (monopolizing all the money), the third-party individual has 3 options: (1) pay 5 RMB yuan to reduce the dictator's money by 5 RMB yuan (thus becoming a punisher); (2) pay 5 RMB yuan to increase the recipient's money by 5 RMB yuan (thus becoming a helper); or (3) do nothing (no cost). To make the punishment and help choices work in the same way, both helping and punishing involve zero transfers of money (i.e., it costs 1 unit to increase/reduce by 1 unit) in the third-party punishment game.

In the second stage, the fourth-party players join the game. Each fourth-party player forms a group with a third-party player and plays a trust game with that third-party player. In the trust game, the fourth-party player starts with 40 RMB yuan and chooses how much to send to the three types of third-party players (punisher/helper/player who did nothing) in a random order, without knowing what type of third-party player he or she was paired with (the 'strategy method'). Any amount sent is tripled. Then, the third-party player chooses how much to return to the fourth-party player (Fig. 1).

The third-party player decides what percentage of the amount he or she receives to return, without knowing how much the specific fourth-party player he or she was paired with decided to send (the 'strategy method')(Jordan et al. 2016). When making third-party punishment game decisions, third-party players are aware of the complete experimental process (including the trust game that follows). Experiment 2 and Experiment 3 used the same settings.

In summary, we plan to test hypothesis 1 through this two-stage experiment. In the first stage (third-party punishment game), the third-party participants can send a signal, and in the second stage (trust game), the fourth-party participants can make choices. That is, the third-party punishment decision is a signal released to the fourth-party player. Based on previous research (Jordan et al. 2016; Peysakhovich et al. 2014; Raihani and Bshary 2015a, 2015b), we expected that helpers would gain greater trust among the three types of third-party players.

The amount of money received by the third-party player in the trust game is determined by a combination of the decisions of the fourth-party player in the trust game and the player's decision in the third-party punishment game.[1] The system randomly selects one of the incomes between the first stage (third-party punishment game) and the second stage (trust game) of the experiment as the third-party players' final experiment income. The starting amount in the dictator and fee-to-impact ratios of punishment were chosen to ensure that disadvantageous inequity aversion could be ruled out as a possible motive for the decisions of both the third-party and fourth-party players (Raihani and Bshary, 2015b).

After the experiment, all participants were asked to fill out a questionnaire. Specifically, the fourth-party players were asked (1) how much they trusted the punisher/helper/player who did nothing and (2) what type of third-party players they preferred to play trust games with (as trusters). The third-party players were asked (1) if they were fourth-party players, what type of third-party players they preferred to

[1] For example, Player 4 decides to send Player 3 (who chooses to punish) X RMB yuan, send Player 3 (who chooses to help) Y RMB yuan, and send Player 3 (who chooses to do nothing) Z RMB yuan. If Player 4 is paired with Player 3, who chose to punish, then Player 3 will get 3X RMB yuan.

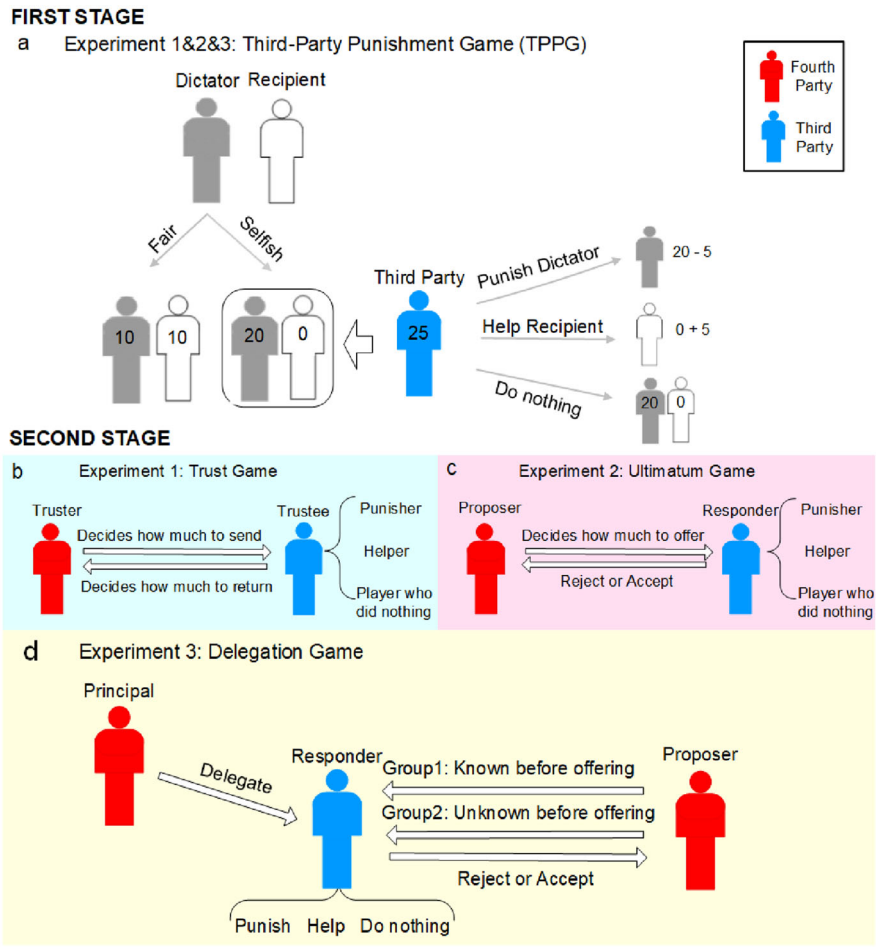

Fig. 1 Experimental design. **a** The first stage of Experiments 1, 2, and 3: The third-party player participates in a third-party punishment game. A dictator decides whether to share with a recipient, and then, a third-party player makes a choice to punish, help, or do nothing if the dictator was selfish. **b** The second stage of Experiment 1: the fourth-party player plays a trust game with the third-party player. **c** The second stage of Experiment 2: the second-stage game is an ultimatum game. The first stage of Experiment 2 is also a third-party punishment game (same as Experiment 1). **d** The second stage of Experiment 3: the second-stage game is a delegation game. The first stage of Experiment 3 is also a third-party punishment game. In the delegation game, the fourth-party player chooses a third-party player (as the responder) to make the accept/reject decision on his or her behalf, and then, the fourth-party principal and the chosen third-party player (delegate) split the amount equally. In particular, the proposer is asked to make a proposal to the responder and his or her principal. Thereafter, the responder decides whether to accept or reject the proposal. The participants in this experiment were divided into two groups, and there were differences in the information settings, especially for the proposers. In the known group, the proposer is first informed of the delegate's first-stage choice before he or she makes the offer. In the unknown group, the proposer is not informed of the delegate's first-stage choice before he or she makes the offer. The principal knows the specific information setting before choosing the delegate

play trust games with (as trusters) and (2) if they were fourth-party players, how much money they were willing to send to the punisher/helper/player who did nothing.

Since our interest was to test the extent to which third-party punishment was perceived as a signal of trustworthiness or retaliation, we analyzed only the behavior of the fourth- and third-party participants. The dictator game was not truly implemented, and every third-party player was told that the dictator he or she faced behaved selfishly. After completing the study, the participants were thanked and debriefed. Experiment 2 and Experiment 3 used the same settings.

4.2 Study 1 results

Eighty-six subjects (19 males, mean age=20.29) participated in Experiment 1, including 43 third-party players and 43 fourth-party players. The sample size was estimated using G*Power (Faul et al. 2007). With a sample size of 43 subjects, the study had a power of 0.8 to detect a small-to-medium effect at an alpha level of 0.05.

The experimental results show that the fourth-party players entrusted the most money to the helpers, followed by the punishers and the players who did nothing in the third-party punishment game. A Friedman test[2] showed that the amount sent was significantly different (χ^2 (2)=39.562, p<0.001, Kendall's W effect size=0.46). Post hoc analysis (pairwise comparisons) revealed that the fourth-party players sent 9.59 percentage points more to the helpers than to the punishers (95% CI=4.94% to 15.12%, FDR-adjusted p=0.011). Then, the fourth-party players sent 15.12 percentage points more to the punishers than to the players who did nothing (95% CI=6.69% to 24.42%, FDR-adjusted p=0.027) (Fig. 2). Furthermore, the Likert scale questionnaire also showed that the fourth-party individuals trusted the helpers more than the punishers and the players who did nothing (χ^2 (2)=41.097, p<0.001, effect size=0.623, see Appendix B1(1)).

After the experiment, we investigated what type of third party the subjects were willing to choose as trustees to interact with when they were trusters. In addition, the third-party players indicated how much money they would send to different kinds of third-party players if they were fourth parties. The results showed that both the third party and the fourth party had significant preferences for helpers (Appendix B1(2) and B1(3)). The above results indicate that as we expected in Hypothesis 1, the fourth-party players trusted the helpers the most, followed by the punishers and players who did nothing. This means that when only trusted signals are involved, the advantage of helpers is greater than that of punishers.

We also analyzed the decisions of the third-party players in the third-party punishment game. Most of the third-party players chose to become helpers. Of the 43 third-party participants, 33 chose to help (76.74%), 6 chose to punish (13.95%), and 4 chose to do nothing (9.3%). The Chi-square test indicated that the third-party players made significantly different choices in the third-party punishment game of

[2] The amounts entrusted to the third-party players were not normally distributed, as assessed by Shapiro–Wilk's test (p<0.05). Thus, we performed nonparametric tests to analyze the data. Since the analysis involved multiple comparisons, we also used the FDR correction procedure to avoid inappropriately increasing the number of null hypotheses that are wrongly rejected.

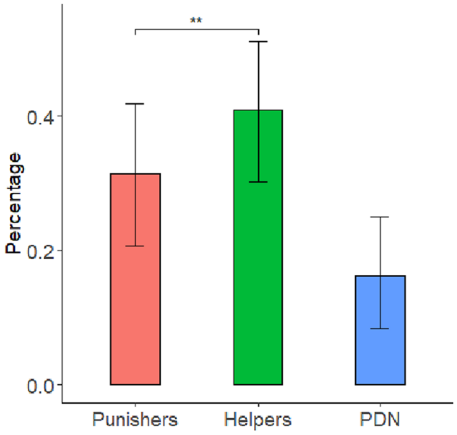

Fig. 2 Helpers gain more trust than punishers. In the trust game, the fourth-party players sent a larger percentage (of their initial 40 RMB yuan) to the helpers than to the punishers. Both the punishers and helpers were sent more money than the players who did nothing (PDN) in response to selfish dictators. *$p<$ 0.1, **$p<0.05$, ***$p<0.01$, error bars indicate 95% confidence intervals

Experiment 1 (χ^2 (2)=36.605, $p<0.001$, effect size=0.652). In addition, although the trusters showed a higher level of trust in the helpers, the return data showed no significant difference in the level of trustworthiness between the helpers and punishers, and the helpers did not return more in the trust game than the punishers. In fact, there appears to be a pattern where the punishers are more trustworthy than the helpers and players who did nothing; given the limited sample size, this effect did not reach significance ($p=0.231$, effect size=0.07, see Appendix B1(4)).

In Study 1, we examined the degree of trust that the fourth-party players had in different types of third-party players. The critical interaction revealed that, as predicted by Hypothesis 1, in the trust game, the fourth-party players gave more money to the helpers than to the punishers. In other words, the helpers gained more trust than the punishers.

5 Study 2 third-party punishment as a signal to deter defection

Third-party punishment is a mixed signal of both trustworthiness and deterrence (Barclay 2006; Delton and Krasnow 2017; Krasnow et al. 2016; Raihani and Bshary 2015a). In Study 1, we found that helping is a more dominant trustworthiness signal, but we speculated that punishment should be a more dominant deterrence signal. We test this hypothesis with Study 2.

5.1 Study 2 methods

The first stage of Experiment 2 was the same as that of Experiment 1, a third-party punishment game. A dictator decides whether to share with a recipient, and then, a third-party player makes a choice to punish, help, or do nothing if the dictator was selfish.

In the second stage, the fourth-party players joined the game. Each fourth-party player forms a group with a third-party player and plays an ultimatum game with that third-party player. The ultimatum game included a fourth-party player as the proposer

and a third-party player as the responder. The fourth-party player and the third-party player were endowed with 40 RMB yuan in total. The fourth-party player was first informed of the previous third-party punishment game decision of the third-party player in the same group and then chose how much to offer to the third-party player. Then, the third-party player chose whether to accept or reject the offer. If the third-party player accepted, the third-party player obtained the offered amount, and the fourth-party player kept the rest. However, if the third-party player rejected the offer, neither the third-party player nor the fourth-party player received anything (Fig. 1).

After the experiment, all participants were asked to fill out a questionnaire about the type of player with whom they preferred to play the ultimatum game and how much money they would send to different types of third-party players.

5.2 Study 2 results

In Experiment 2, we included 214 subjects (59 males, mean age=20.16). Two subjects were excluded because of data that were not recorded during the experiment. The final data were collected from 212 subjects (fourth parties, N=106; third parties, N=106). With a sample size of 106 subjects, the study had a power of 0.8 to detect a medium-to-large effect at an alpha level of 0.05.

While the results of Experiment 1 suggest that helpers have a greater advantage in the trust game, the punishers tended to earn more in the ultimatum game because of the deterrent signals they released. A Kruskal–Wallis H test[3] revealed that there were differences in the amounts offered between the three types of third-party players (χ^2 (2)=11.395, p=0.003, epsilon-squared effect size=0.108) (Fig. 3a). The fourth-party players offered 6.22 percentage points more to the punishers than to the helpers (95% CI=5.30% to 7.219%, FDR-adjusted p=0.033). In addition, the supplemental survey in the questionnaire showed that the fourth-party players were willing to offer the most money to punishers, followed by the helpers and the players who did nothing (Appendix B2(1)). This shows that punishment is an effective deterrent signal for proposers in the ultimatum game.

After the experiment, we investigated the type of third party the subjects preferred to interact with as responders when they were proposers. The results indicated that either the third or fourth parties preferred the helper the most and wanted to interact with the punisher the least (Appendix B2(2)). This further suggests that bystanders are affected by the deterrent signals of punishers in the ultimatum game.

Of the 106 third-party participants, 19 chose to punish (17.92%), 37 chose to help (34.91%), and 50 chose to do nothing (47.17%; χ^2 (2)=13.717, p=0.001, Cramer's V effect size=0.399, see Appendix B2(3)). There was a significant decrease in the proportion of helpers in Experiment 2 relative to Experiment 1 (76.74 vs. 34.91%; FDR-adjusted p<0.001), suggesting that the type of subsequent game affected third-party decision-making in the third-party punishment game. Previous studies have shown that third-party decision-making is usually affected by a variety of factors, including personal social preferences, third-party punishment game decision-making

[3] The amounts offered to the third-party players were not normally distributed, as assessed by Shapiro–Wilk's test (p<0.05). Thus, we performed nonparametric tests to analyze the data.

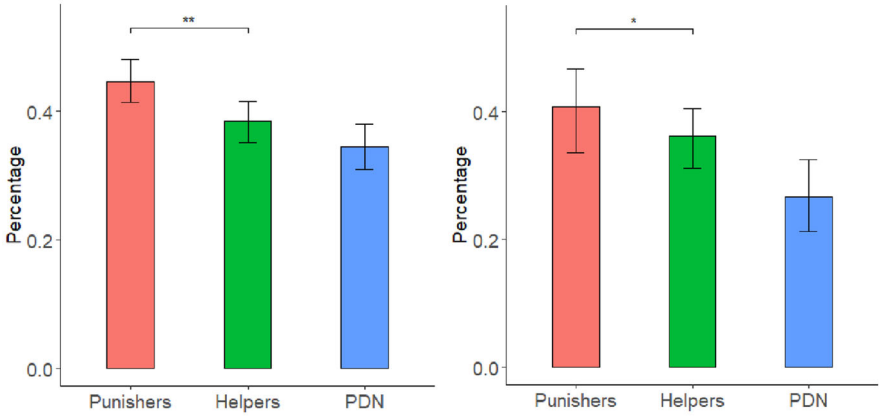

Fig. 3 **a** Punishers are the most deterrent. In the ultimatum game, the fourth-party players offered a larger percentage (of their initial 40 RMB yuan) to the punishers than to the helpers. Both the punishers and helpers were offered more than the players who did nothing (PDN). In the ultimatum game, the punishers benefitted from their reputation of deterrence. **b** Real payoffs of the third-party players in the ultimatum game. The actual average income of the punishers was higher than that of the helpers and the players who did nothing. *$p<0.1$, **$p<0.05$, ***$p<0.01$, error bars indicate 95% confidence intervals.

costs, and the type of subsequent experiments (Barclay 2006; Horita 2010; Jordan et al. 2016).

In the third-party punishment game, the third-party punishment/help cost was 5 RMB yuan, and the cost of doing nothing was 0. The fourth-party players' average offer value to punishers was 4.095 RMB yuan higher than that for the players who did nothing (95% CI=3.742 to 4.458, FDR-adjusted $p=0.002$). It seems that the punishers did not receive enough compensation in subsequent games by releasing costly retaliation signals. However, the third-party player could reject the offer, and if the third-party player rejected it, neither the third-party player nor the fourth-party player received anything. Considering the rejection data, the actual average income of the punishers was 5.879 RMB yuan higher than that of the players who did nothing (95% CI=5.222 to 6.531, FDR-adjusted $p=0.004$, see Appendix B2(4)), which means that the cost of the punishers' signaling was compensated (Fig. 3b).

The fourth-party players' offers for different types of third-party players varied because the fourth party expected the third party's refusal of unfair offers to vary. Furthermore, we used logistic regression to model third-party players' rejections of unfair offers (0–15 RMB yuan) as a function of the third-party player type (the baseline category: helpers) and their offered amounts in the ultimatum game (Table 1).

In all regression models in Table 1, the rejection behavior of the third-party player is the dependent variable, which is 1 if the third-party player rejects the offer and 0 otherwise. Model (1) shows that the amount of money offered has a significant impact on rejection. The higher the offer made by the fourth party, the less likely it is to be rejected. Model (2) further suggests that both the punishers and players who did nothing were more likely to reject unfair offers than the helpers. Model (3) shows

Table 1 Experiment 2: third-party refusal of unfair offers in logistic regression

Dep. variable: rejection (dummy)	(1)	(2)	(3)
Offer	− 0.568***	− 0.608***	− 0.615***
	(0.102)	(0.114)	(0.153)
Punishers		2.030*	1.866*
		(1.070)	(1.026)
Players who did nothing		1.409*	1.362*
		(0.792)	(0.741)
Female			− 1.125
			(0.745)
Economics			− 0.295
			(0.762)
Intercept	6.111***	5.546***	6.639***
	(1.244)	(1.496)	(2.264)
N	43	43	43
Pseudo R^2	0.495	0.532	0.553

Punishers=1 means the subject is a punisher in the third-party punishment game, 0 otherwise. Players who did nothing=1 means the subject is a person who did nothing in the third-party punishment game, 0 otherwise. Female=1 means the subject's gender is female, 0 otherwise. Economics=1 means the subject's major is economics, 0 otherwise

Robust standard errors in parentheses *p<0.1, **p<0.05, ***p<0.01

that the above results are still robust after controlling for the gender and major of the subjects.

In Experiment 2, we examined whether the punishers would be treated less unfairly than the helpers and players who did nothing in subsequent games. Concretely speaking, we analyzed the amount that three types of third-party players were offered in the ultimatum game. As predicted by hypothesis 2, in the ultimatum game, the fourth-party players gave more to the punishers than to the helpers. It can, therefore, be concluded that the punishers signaled deterrence more effectively than the helpers.

6 Study 3 third-party punishment and partner choice in a delegation game

Studies 1 and 2 show that although punishers do not gain as much trust as helpers, punishers have a stronger deterrent effect. That is, bystanders regard third-party punishment as a deterrence signal. This provides the possibility that punishers may be picked as partners to deter potential exploitation from others because of this deterrent effect. In Study 3, we consider this under the framework of a delegation game in which bystanders choose a third-party individual to play as a responder on their behalf in the ultimatum game.

6.1 Study 3 methods

The first stage of Experiment 3 was the same as that of Experiment 1 (a third-party punishment game), and the second stage was a delegation game (Fershtman et al. 1991). In the second stage, the fourth-party players joined the game. The fourth-party player chose a third-party player (as the responder) to make the accept/reject decision on his or her behalf. In particular, the fourth-party principal first chose one type of third-party individual (punisher/helper/player who did nothing) as his delegate. Then, the fourth-party principal, the third-party player (the delegate, also the "responder agent" selected by the fourth-party principal), and the fourth-party proposer were endowed with 60 RMB yuan.

The proposer was asked to make a proposal to the responder and his or her principal. Thereafter, the responder decided whether to accept or reject the proposal. If the responder accepted, the principal and responder obtained the offered amount (then the principal and delegate split the amount equally), and the proposer kept the rest. If the responder decided to reject the offer, then all three participants received 0 RMB yuan (Fig. 1).

We assume that punishers are preferred in partner selection because of their deterrent signaling role in the ultimatum game. If costly signaling theory holds, it matters whether the interacting parties can receive the signal. For this purpose, we further set up two experimental comparison groups. In the known group, the proposer in the ultimatum game knows the choice of the third party in the third-party punishment game, i.e., the punisher can send deterrence signals. In the unknown group, the proposer is not aware of the third party's choice in the third-party punishment game, i.e., the punisher cannot send a deterrence signal. The principal knows the specific information setting before the delegates make a choice.

Since we analyzed the punishers' retaliation effect in Experiment 2, the subject of Experiment 3 was to study whether the punishers were selected more often as partners, so we focused on the behavior of the fourth-party principal. Thus, Experiment 3 was not truly implemented, as the participants were told that all players were real; however, only the fourth-party principals were real players. At the same time, to minimize the adverse effects of deception, we adopted some compensation measures, including experimental procedures and experimental profit settings. See Appendix B3(1) for details.

6.2 Study 3 results

A total of 105 subjects participated in Experiment 3. In the known group of Experiment 3, we included 54 subjects (15 males, mean age=20.17). Three subjects were excluded because of data that were not recorded during the experiment. In the unknown group of Experiment 3, we included 51 subjects (12 males, mean age= 20.47). A power analysis shows that such sample sizes could provide sufficient power (0.99) for the detection of some of the major effects we were investigating.

We have provided evidence that the TPP signals retaliation; furthermore, punishers can benefit from costly signaling. Based on the previous analysis, we further indicated that the punishers were more frequently selected as partners in

subsequent games than the helpers, thus gaining higher potential benefits. To illustrate this, we analyze the fourth-party players' preferences in choosing the type of third-party player to partner with in the ultimatum game (and split the benefits with at the end).

If punishers can obtain benefits through costly signaling, whether the interactive objects in the subsequent games can receive such a signal will directly affect the punishers' income. Particularly, in our experiment, the fourth-party players chose the third-party players to play the ultimatum game for them. The informed condition directly affected the preferences of the fourth-party individuals, which in turn influenced whether the third-party players were delegated and ultimately affected their payoffs.

First, we analyzed the proportion of fourth-party players' choices under the two information conditions. The preferences of the fourth-party players for choosing partners varied with the information condition. When the proposer was NOT informed of the choice of the third-party player in the third-party punishment game, the fourth-party players chose the helpers over the punishers at a 33.3% higher rate (95% CI=19.94% to 46.72%, p=0.01, Cramer's V effect size=0.302). However, when the proposer was informed of the choice of third-party players in the third-party punishment game, the fourth-party players chose the punishers over the helpers at a 23.6% higher rate (95% CI=11.48% to 35.58%, p<0.001, Cramer's V effect size=0.407) (Fig. 4).

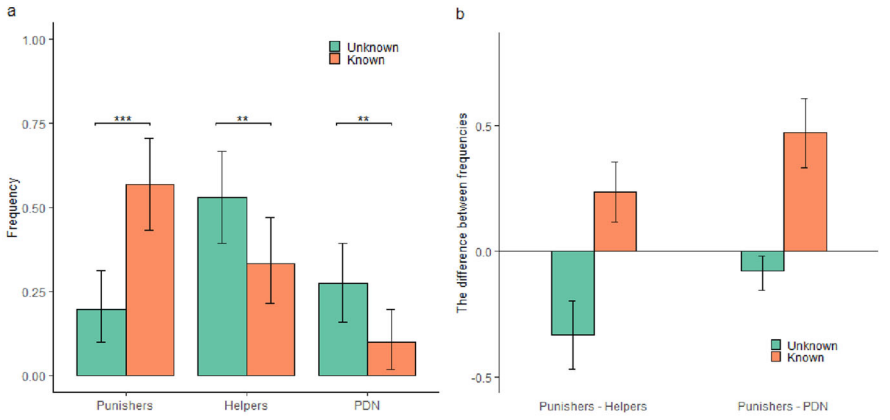

Fig. 4 Punishers can benefit from releasing a deterrence signal in a delegation game. **a** In the delegation game known group, the fourth-party players preferred punishers as partners. In the delegation game unknown group, the fourth-party players preferred helpers as partners. **b** The figure shows the difference between the proportions of the two types of third-party individuals under different conditions (unknown conditions vs. known conditions). In the unknown conditions, the punishers were selected less often than the helpers by 33.3%, whereas the proportion of the punishers selected was 23.6% higher than that of the helpers in the known condition. Similarly, in the unknown condition, the punishers were selected less often than the players who did nothing by 7.9%, while in the known condition, the punishers were selected more often than the players who did nothing (PDN) by 47.1%. Thus, in the delegation game, the punishers gained the highest payoffs from the reputation of deterrence among all three types of individuals. *p<0.1, **p<0.05, ***p<0.01, error bars indicate 95% confidence intervals

Furthermore, we analyzed the proportions of the third parties being selected in the unknown and known conditions. The two multinomial probability distributions were not equal among the groups ($\chi^2(2)=15.792$, $p<0.001$; Cramer's V effect size=0.278). The fourth-party players preferred the punishers under the known condition ($N=29$, 56.9%) but not under the unknown condition ($N=10$, 19.6%; FDR-adjusted $p<0.001$). Conversely, the players preferred the helpers under the unknown condition ($N=27$, 52.9%;) but not under the known condition ($N=17$, 33.3%; FDR-adjusted $p=0.046$). There were also significant differences in the proportion of fourth-party individuals who chose players who did nothing under the known conditions ($N=5$, 9.8%) compared with that under the unknown conditions ($N=14$, 27.5%; FDR-adjusted $p=0.033$, see Appendix B3(2)). This suggests that punishers are preferred more when bystanders are looking for delegates. Furthermore, the significant decrease in the bystanders' preference for the punishers under unknown conditions suggests that they prefer punishers due to the deterrent signals released through their previous punishment choices when acting as responders in the ultimatum game.

Through multinomial logistic regression analysis, we intuitively observed the change in the proportion of punishers, helpers and players who did nothing preferred by the bystanders under the two information conditions. In particular, we controlled for gender and whether the subjects' major was economics to investigate the change in the fourth-party players' partner choices from the unknown condition to the known condition (Table 2, Pseudo R-Square=0.094, $p=0.007$). See Appendix B3(3) for the model that does not include controls.

The dependent variable of the model is the type of third party chosen by the fourth party. Known conditions are dummy-coded variables that are set to 1 if the proposer knows the choice of the third party in the third-party punishment game; otherwise, it is 0. The result showed that the average marginal effect of the "informed condition" on the punishers was 34.3%. This means that the probability of choosing punishers was approximately 34 percentage points higher for the known condition than for the

Table 2 Experiment 3: fourth-party choices in multiple logistic regression

Fourth-party choice Baseline category	Punisher Helper	Player who did nothing Helper	Helper Player who did nothing
Known condition	1.572***	− 0.626	0.626
	(0.501)	(0.591)	(0.591)
Female	− 0.068	0.658	− 0.658
	(0.529)	(0.728)	(0.728)
Economics	0.427	− 0.51	0.51
	(0.53)	(0.549)	(0.549)
Intercept	− 1.253*	− 0.861	0.861
	(0.73)	(0.696)	(0.696)
Marginal effect of known condition	34.3%***	− 16.80%	− 17.5%**
	(0.064)	(0.072)	(0.086)

Robust standard errors in parentheses *$p<0.1$, **$p<0.05$, ***$p<0.01$

unknown condition when other factors were the same. The probability of choosing a helper was approximately 18 percentage points lower for the known condition than for the unknown condition, and the probability of choosing a player who did nothing was approximately 17 percentage points lower.

7 Discussion

Since we explained the maintenance of third-party punishment by introducing fourth-party players to the game, it is interesting to consider whether "fifth-party" or "sixth-party" players are needed to explain how fourth-party individuals can be encouraged. What should be noted here are the two mechanisms that explain fourth-party support for TPP: the mechanism of rewards and the mechanism of partner choice with costly signaling. First, for the reward mechanism, fourth-party individuals might spend personal costs rewarding punishers directly (Ohtsuki et al. 2009; Raihani and Bshary 2015a, 2015b; Ye et al. 2011). Indeed, for the costly reward mechanism, the motivation of fourth-party individuals also needs explanation. Because if the reward of fourth-party individuals is costly, then who will compensate them? Will they further be rewarded by any other prosocial individuals? Then, one can continually ask how these "other prosocial individuals" will be compensated? These problems, however, are not faced by the second mechanism in which punishment is seen as costly signaling in partner choosing (Jordan et al. 2016). In this mechanism, third-party punishers gain more cooperation opportunities by sending signals of TPP. Fourth-party bystanders—as signal receivers—also benefit from the mechanism because, with the signal of TPP, they can distinguish cooperators from defectors and choose a third-party punisher as a delegate to deter potential exploitations in future games. Therefore, fourth-party players can be sufficiently motivated by the mechanism of partner choice with costly signaling even without extra incentives from other prosocial individuals.

Importantly, we should consider both proximate and ultimate explanations to properly understand human behavior. Proximate explanations are concerned with the mechanism underlying a certain behavior—how it works—and ultimate explanations are concerned with why a certain behavior resulted from human evolution (Mayr 1963; Scott-Phillips et al. 2011). At the proximate level, in our experiments, it is worth noting that explicit reasoning for third-party punishers to signal their quality as partners is not needed. In other words, third-party punishers may not realize that their punishing behaviors are sending signals and punish strategically. Indeed, affective responses related to unfairness, such as the rush of moral outrage or the pleasure of self-righteousness, can motivate punishing behaviors (Barclay 2012; Nelissen and Zeelenberg 2009). This is supported by several neuroscience studies (Buckholtz et al. 2008; de Quervain et al. 2004).

Although moral emotions can motivate third-party punishment at the proximate level, we should not presume the existence of any prosocial motivation when explaining the emergence of TPP at the ultimate level. This would be tautological considering that we are supposed to use the emergence of TPP to explain why other prosocial behaviors can be maintained in human evolution. In our framework, the

advantage of punishment is not completely supported by prosocial motivation. Each player in our experiment can be self-interested. For example, third-party players can choose to punish or help out of self-interested motivation to send signals. In addition, bystanders may choose punishers or helpers as partners because the choice may increase their payoffs rather than because they appreciate or sympathize with these contributors. At the ultimate level, if fourth-party individuals prefer punishers as partners in certain scenarios, even if this preference is self-interested, it can provide selective pressure for prosocial sentiment conducive to the existence of TPP, such as moral outrage. However, our experiments provide indirect evidence for the conjectures above, and there is no direct evidence by which we can distinguish the two motivations. In addition, we should be cautious of jumping to any conclusion regarding the issue above because the framework we propose is only one of many interaction patterns in human society, though it is common. It would be interesting to investigate the effects of self-interested motivation and prosocial motivation on this costly signaling mechanism of maintaining cooperation.

In our study, the third-party individuals were bystanders, and the fourth-party individuals were bystanders of third-party bystanders. This suggests that we need a very large number of subjects to filter the decision situations of interest. Indeed, this is a problem faced by all experimental studies in the literature that study the interaction between bystanders and third-party punishers. The solutions adopted include scripts (Horita 2010), low stakes (Raihani and Bshary 2015b), and deception (Barclay 2006; Nelissen 2008).[4] We applied some minor deceptions to solve this problem. Deception is commonly used to produce situations in which bystander effects can be studied when the situations are difficult to produce (Hertwig and Ortmann, 2001). The deception we used is unlikely to lead to psychological discomfort. In addition, we used several designs to minimize the potential harm that might be caused to the reputation of experimental methods by deception (see Appendix B3(1)).

In a future study, it would be interesting to determine whether punishers are more preferred when the type of game played in the delegation game is uncertain. For example, we can inform bystanders, in the second stage of Experiment 3, that they will choose a partner to play for them in the delegation game, but the game can be either an ultimatum game or trust game. In this scenario, we could explore whether the deterrence conveyed by TPP would be a more salient costly signal than the trustworthiness conveyed by helping under circumstances that have some degree of uncertainty. This context would be a more general case because we are usually unsure about the type of social interactions we are involved in, even though we do know with whom we interact.

Another important direction for future work would be to conduct neuroimaging studies on the brain reactions of bystanders observing TPP and those observing helping and the differences between them. Studies in neuroscience evidence currently focus on third-party punishers per se (Buckholtz et al. 2008; de Quervain et al. 2004),

[4] A novel solution for conducting such an experiment without deception comes from Jordan et al. (2016), but the cost of such a design is that there are no third-party helpers in the experiment. Since the comparison of third-party helpers and punishers is of interest, we cannot use their method to avoid deception.

and neuroscience studies on bystanders, the potential supporters of TPP, are still rare. The research would help provide an understanding of how bystanders interpret various costly signals from third-party individuals and when and why they would choose third-party punishers or nonpunishing helpers as partners.

This article also complements the literature on biological markets (Barclay 2011, 2013; Noë and Hammerstein 1994, 1995). The theory of biological markets argues that if partner choosing is free, individuals need to compete for access to cooperative relationships through generosity. When individuals can choose whom to interact with, there emerges a biological market where all agents must compete for access to cooperative relationships (Barclay 2013). Thus, choosing and attracting partners can be important for individuals' survival. However, the "product" used to compete for partners, in addition to generous helping, can also be altruistic punishment or other prosocial behavior. Thus, this paper helps explain the circumstances under which various prosocial behaviors, especially TPP, can be competitive in biological markets. The competition among diverse prosocial behaviors in biological markets can also help explain why humans display different "cooperative phenotypes" (Peysakhovich et al. 2014).

As mentioned above, a significant presumption of our study is that individuals are free to choose with whom they partner and with whom they interact. Voluntary choices have been increasingly regarded as important for the emergence of competitive helping (Barclay 2013; Barclay and Willer 2007; Hauert et al. 2002) and altruistic punishment (Hauert et al. 2007). This presumption is supported by studies that suggest hunter-gather societies, in which humans spent most of their species history, featured an egalitarian social structure and a great deal of freedom to choose cooperative partners (Boehm 2012; Johnson and Earle 2000). This structure, as shown in our experiments, is conducive to the emergence of TPP. This perspective might also help provide an understanding of why there is no TPP shown in chimpanzees (Riedl et al. 2012) who have long lived in a highly hierarchical society.

Appendix

A: Experiment instructions

Experiment 1

In experiment 1, the dictator, recipient, third party, and fourth party are labeled as "Player 1", "Player 2", "Player 3", and "Player 4". The third party and the fourth party each receive instructions about the experiment, which is slightly different.

For the fourth party (Player 4):

This is a game in which you might earn a bonus. You are Player 4. You will only play in game B and will NOT be a part of game A. However, we would like you to read about and understand both games.

For the third party (Player 3):

This is a game in which you might earn a bonus. You are Player 3. You will play two games, game A and game B. We would like you to read about and understand both games before you play game A.

For both the third party (Player 3) and the fourth party (Player 4):

Game A

Game A has three players: Player 1, Player 2, and Player 3.

In this game:

A sum of 20 RMB yuan has been provisionally allocated to Player 1 and Player 2.

Player 1 can decide how much of the money each person is to receive.

Player 1 has two choices:

– DO share: give 10 RMB yuan to Player 2 (and keep 10 RMB yuan).

Do NOT share: give 0 RMB yuan to Player 2 (and keep 20 RMB yuan).

Afterwards, Player 3 is given 25 RMB yuan.

If Player 1 chose not to share with Player 2, Player 3 has three choices:

(1) If Player 1 chose not to share, pay 5 RMB yuan to punish Player 1, and Player 1's income is reduced by 5 RMB yuan.

(2) If Player 1 chose not to share, pay 5 RMB yuan to help Player 2, and Player 2's income is increased by 5 RMB yuan.

(3) If Player 1 chose not to share, do nothing.

Game B

Game B has two players: Player 3 and Player 4

In game B:

- Player 4 starts with 40 RMB yuan.
- Player 4 then chooses how much money to send to Player 3.
- Any money Player 4 sends to Player 3 is tripled (If Player 4 sends K, Player 3 will receive 3 K).
- Player 3 then chooses how much money to return to Player 4.

If Player 4 sends K and Player 3 returns M, then Player 4 will earn 40-K+M. Player 3 will earn 3 K-M.

Income structure

Player 3

The system will randomly choose between the experiment A income and the experiment B income as Player 3's experiment income.

Player 4

The income in experiment B.

Please answer the following questions to ensure that you understand this instruction. You MUST answer ALL questions correctly to participate in the games.

Q1

In experiment A, when Player 1 chooses to give Player 1 zero RMB yuan and keeps 20 RMB yuan, Player 3 has three choices.

If Player 3 decides to spend 5 RMB yuan to punish Player 1, the experiment A incomes of Player 1, 2, and 3 are ( ).

If Player 3 decides to spend 5 RMB yuan to help Player 2, the experiment A incomes of Players 1, 2, and 3 are ( ).

If Player 3 decides to do nothing, the experiment A incomes of Players 1, 2, and 3 are ( ).

The following incomes do not include the appearance fee.

(1) Player 1 has 20 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 25 RMB yuan.

(2) Player 1 has 15 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 20 RMB yuan.

(3) Player 1 has 20 RMB yuan, Player 2 has 5 RMB yuan, and Player 3 has 20 RMB yuan.

Q2

If Player 3 is first endowed with 25 RMB yuan in experiment A and has 20 RMB yuan after making the experiment A decision and the experiment B income of Player 3 is 20 RMB yuan, then the final experiment income of Player 3 is _____RMB yuan? (excluding the appearance fee).

Q3

If a Player 3's experiment A income is 20 RMB yuan and experiment B income is 15 RMB yuan, which of the following statements is true about the experiment income of this Player 3? (excluding the appearance fee).

( ) The experiment income of Player 3 is 35 RMB yuan.

( ) The experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is selected by Player 3 him- or herself.

( ) The experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is randomly selected by the system.

Q4

Player 4 decides to send Player 3 (who chooses to punish in experiment A) X RMB yuan, send Player 3 (who chooses to help in experiment A) Y RMB yuan, and send Player 3 (who chooses to do nothing in experiment A) Z RMB yuan. If Player 4 paired with Player 3 who chose to punish in experiment A, then how much money will Player 3 get (after tripling)?

( ) Player 3 gets 3X RMB yuan.

( ) Player 3 gets 3Y RMB yuan.

( ) Player 3 gets X RMB yuan.

Q5

In experiment B, if Player 4 sends Player 3 40 RMB yuan and Player 3 decides to return Player 4 50%, what are the incomes of Player 3 and 4 in experiment B?

( ) Player 4 gets 20 RMB yuan, and Player 3 gets 60 RMB yuan.

( ) Player 4 gets 30 RMB yuan, and Player 3 gets 50 RMB yuan.

( ) Player 4 gets 60 RMB yuan, and Player 3 gets 60 RMB yuan.

Q6

In experiment B, which decision will make Player 4 get the highest income?

( ) It depends upon how much Player 3 decides to return to Player 4.

( ) Player 4 decides to send 40 RMB yuan to Player 3.

( ) Player 4 decides to send 0 RMB yuan for Player 3.

Correct answers: Q1) 2, 3, 1; Q2) 20; Q3) the experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is randomly selected by the system; Q4) Player 3 gets 3X RMB yuan; Q5) Player 4 gets 60 RMB yuan, and Player 3 gets 60 RMB yuan; Q6) it depends upon how much Player 3 decides to return to Player 4.

Player 3 Game A choice

You have received 25 RMB yuan. What would you like to do if Player 1 does not share?

NOTE: Player 4 will be told your choice in game A before deciding how much money to send to you.

(1) I would like to pay 5 RMB yuan to punish Player 1, and Player 1's income will be reduced by 5 RMB yuan.
(2) I would like to pay 5 RMB yuan to help Player 2, and Player 2's income will be increased by 5 RMB yuan.
(3) I would like to do nothing.

Player 4

How much money would you like to send to Player 3, who in game A…
– Chose to punish Player 1?
– Chose to help Player 2?
– Chose to do nothing? (Unit: RMB yuan).
NOTE: You can base your decision on Player 3's choice in game A.

()0 ()5 ()10 ()15 ()20 ()25 ()30 ()35 ()40

Player 3 Game B choice

Player 4 will decide how much to send to you. It is now your job to decide how much to return to Player 4.

Specifically, you will decide the percentage of money you would like to return.

For example, if you decide to return 10% of the money you receive…

– You will return 0 RMB yuan if Player 4 sends 0 RMB yuan (and you will receive 0 RMB yuan).

– You will return 3 RMB yuan if the sender sends 10 (and you will receive 27 RMB yuan).

What percentage would you like to return?

()0% ()10% ()20% ()30% ()40% ()50% ()60% ()70% ()80% ()90% ()100%

Experiment 2

In experiment 2, the dictator, recipient, third party, and fourth party are labeled as "Player 1", "Player 2", "Player 3", and "Player 4". The third party and the fourth party each receive instructions about the experiment, which is slightly different.

For the fourth party (Player 4):

This is a game in which you might earn a bonus. You are Player 4. You will only play in game B and will NOT be a part of game A. However, we would like you to read about and understand both games.

For the third party (Player 3):

This is a game in which you might earn a bonus. You are Player 3. You will play two games, game A and game B. We would like you to read about and understand both games before you play game A.

For both the third party (Player 3) and the fourth party (Player 4):

Game A

Game A has three players: Player 1, Player 2, and Player 3.

In this game:

A sum of 20 RMB yuan has been provisionally allocated to Player 1 and Player 2.

Player 1 can decide how much of the money each person is to receive.

Player 1 has two choices:

– DO share: give 10 RMB yuan to Player 2 (and keep 10 RMB yuan).

– Do NOT share: give 0 RMB yuan to Player 2 (and keep 20 RMB yuan).

Afterwards, Player 3 is given 25 RMB yuan.

If Player 1 chose not to share with Player 2, Player 3 has three choices:

(1) If Player 1 chose not to share, pay 5 RMB yuan to punish Player 1, and Player 1's income is reduced by 5 RMB yuan.

(2) If Player 1 chose not to share, pay 5 RMB yuan to help Player 2, and Player 2's income is increased by 5 RMB yuan.

(3) If Player 1 chose not to share, do nothing.

Game B

Game B has two players: Player 3 and Player 4.

In game B:

A sum of 40 RMB yuan has been provisionally allocated to Player 3 and Player 4.

Player 4 will be informed of Player 3's choice in game A.

Player 4 then chooses how much money to offer to Player 3.

Player 3 then chooses to accept or reject this offer. If Player 3 accepts, Player 3 gets the offered amount and Player 4 keeps the rest.

However, if Player 3 rejects the offer, both Player 3 and Player 4 get nothing.

Income structure

Player 3.

The system will randomly choose between the experiment A income and the experiment B income as Player 3's experiment income.

Player 4.

The income in experiment B.

Please answer the following questions to ensure that you understand this instruction. You MUST answer ALL questions correctly to participate in the games.

Q1

In experiment A, when Player 1 chooses to give Player 1 zero RMB yuan and keeps 20 RMB yuan, Player 3 has three choices.

If Player 3 decides to spend 5 RMB yuan to punish Player 1, the experiment A incomes of Player 1, 2, and 3 are ( ).

If Player 3 decides to spend 5 RMB yuan to help Player 2, the experiment A incomes of Players 1, 2, and 3 are ( ).

If Player 3 decides to do nothing, the experiment A incomes of Players 1, 2, and 3 are ( ).

The following incomes do not include the appearance fee.

(1) Player 1 has 20 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 25 RMB yuan.

(2) Player 1 has 15 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 20 RMB yuan.

(3) Player 1 has 20 RMB yuan, Player 2 has 5 RMB yuan, and Player 3 has 20 RMB yuan.

Q2

If Player 3 is first endowed with 25 RMB yuan in experiment A and has 20 RMB yuan after making the experiment A decision and the experiment B income of Player 3 is 20 RMB yuan, then the final experiment income of Player 3 is _____RMB yuan? (excluding the appearance fee).

Q3

If a Player 3's experiment A income is 20 RMB yuan and experiment B income is 15 RMB yuan, which of the following statements is true about the experiment income of this Player 3? (excluding the appearance fee).

() The experiment income of Player 3 is 35 RMB yuan.

() The experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is selected by Player 3 him- or herself.

() The experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is randomly selected by the system.

Q4

Which of the following statements is correct?

( ) Player 4 is first informed about Player 3's choice in experiment A before he/she makes the offer.

( ) Player 4 is NOT first informed about Player 3's choice in experiment A before he/she makes the offer.

Q5

In experiment B, which decision will make Player 4 obtain the highest income?

( ) It depends upon whether Player 3 decides to accept Player 4's offer.

( ) Player 4 decides to offer 40 RMB yuan to Player 3.

( ) Player 4 decides to offer 0 RMB yuan to Player 3.

Correct answers: Q1) 2, 3, 1; Q2) 20; Q3) the experiment income of Player 3 is 15 RMB yuan or 20 RMB yuan, and the final income is randomly selected by the system; Q4) Player 4 is first informed about Player 3's choice in experiment A before he/she makes the offer; Q5) it depends upon whether Player 3 decides to accept Player 4's offer.

Player 3 Game A choice

You have received 25 RMB yuan. What would you like to do if Player 1 does not share?

NOTE: Player 4 will be told your choice in game A before deciding how much money to send to you.

(1) I would like to pay 5 RMB yuan to punish Player 1, and Player 1's income will be reduced by 5 RMB yuan.

(2) I would like to pay 5 RMB yuan to help Player 2, and Player 2's income will be increased by 5 RMB yuan.

(3) I would like to do nothing.

Player 4

Player 3 chose to punish Player 1/help Player 2 /do nothing in game A.

How much money would you like to offer to this Player 3? (Unit: RMB yuan).

NOTE: You can base your decision on Player 3's choice in game A.

()0 ()5 ()10 ()15 ()20 ()25 ()30 ()35 ()40

Player 3 Game B choice

Player 4 decides to offer you ( ) of 40. Do you accept the amount offered?

( ) Accept ( ) Reject.

Experiment 3 known group

In experiment 3, the dictator, recipient, third party, fourth-party principal and fourth-party proposer are labeled as "Player 1", "Player 2", "Player 3", "Player 4", and "Player 5".

For the fourth-party principal (Player 4):

This is a game in which you might earn a bonus. You are Player 4. You will only play in game B and will NOT be a part of game A. However, we would like you to read about and understand both games.

Game A

Game A has three players: Player 1, Player 2, and Player 3.

In this game:

A sum of 20 RMB yuan has been provisionally allocated to Player 1 and Player 2.

Player 1 can decide how much of the money each person is to receive.

Player 1 has two choices:

– DO share: give 10 RMB yuan to Player 2 (and keep 10 RMB yuan).

– Do NOT share: give 0 RMB yuan to Player 2 (and keep 20 RMB yuan).

Afterwards, Player 3 is given 25 RMB yuan.

If Player 1 chose not to share with Player 2, Player 3 has three choices:

(1) If Player 1 chose not to share, pay 5 RMB yuan to punish Player 1, and Player 1's income is reduced by 5 RMB yuan.

(2) If Player 1 chose not to share, pay 5 RMB yuan to help Player 2, and Player 2's income is increased by 5 RMB yuan.

(3) If Player 1 chose not to share, do nothing.

Game B

Game B has 3 players: Player 3, Player 4 and Player 5.

In game B:

According to the choices of Player 3 in experiment A, Player 4 could choose one kind of Player 3 on his/her behalf to participate in game B.

Then, a sum of 60 RMB yuan is provisionally allocated to Player 4, the selected Player 3 and Player 5.

Player 5 first will be informed about Player 3's choice in game A and then choose how much money to offer to Player 3 and 4.

Player 3 then chooses to accept or reject this offer.

If Player 3 accepts, Players 3 and 4 get the offered amount (Players 3 and 4 will split the amount equally), and Player 5 keeps the rest.

However, if Player 3 rejects, Players 3, 4 and 5 get nothing.

NOTE: Player 5 is first informed about the delegate's first-stage choice before he/she makes the offer.

Income structure

Player 3.

The system will randomly choose between the experiment A income and the experiment B income as Player 3's experiment income.

Player 4.

The income in experiment B.

Player 5.

The income in experiment B.

Please answer the following questions to ensure that you understand this instruction. You MUST answer ALL questions correctly to participate in the games.

Q1

In experiment A, when Player 1 chooses to give Player 1 zero RMB yuan and keeps 20 RMB yuan, Player 3 has three choices.

If Player 3 decides to spend 5 RMB yuan to punish Player 1, the experiment A incomes of Player 1, 2, and 3 are ().

If Player 3 decides to spend 5 RMB yuan to help Player 2, the experiment A incomes of Players 1, 2, and 3 are ().

If Player 3 decides to do nothing, the experiment A incomes of Players 1, 2, and 3 are ().

The following incomes do not include the appearance fee.

(1) Player 1 has 20 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 25 RMB yuan.

(2) Player 1 has 15 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 20 RMB yuan.

(3) Player 1 has 20 RMB yuan, Player 2 has 5 RMB yuan, and Player 3 has 20 RMB yuan.

Q2

If Player 3 is first endowed with 25 RMB yuan in experiment A and has 20 RMB yuan after making the experiment A decision and the experiment B income of Player 3 is 20 RMB yuan, then the final experiment income of Player 3 is _____RMB yuan? (excluding the appearance fee).

Q3

Which of the following statements is correct?

( ) Player 5 is first informed about Player 3's choice in experiment A before he/she makes the offer.

( ) Player 5 is NOT first informed about Player 3's choice in experiment A before he/she makes the offer.

Q4

In experiment B, if Players 3 and 4 are offered a total of 40 RMB yuan and Player 3 accepts the offer, what are the experiment B incomes of Players 3, 4, and 5?

( ) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 20 RMB yuan.

( ) Player 3: 30 RMB yuan, Player 4: 10 RMB yuan, Player 5: 20 RMB yuan.

( ) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 40 RMB yuan.

Correct answers: Q1) 2, 3, 1; Q2) 20; Q3) Player 5 is first informed about Player 3's choice in experiment A before he/she makes the offer; Q4) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 20 RMB yuan.

Player 3 Game A choice

You have received 25 RMB yuan. What would you like to do if Player 1 does not share?

(1) I would like to pay 5 RMB yuan to punish Player 1, and Player 1's income will be reduced by 5 RMB yuan.

(2) I would like to pay 5 RMB yuan to help Player 2, and Player 2's income will be increased by 5 RMB yuan.

(3) I would like to do nothing.

Player 4

NOTE! Player 5 will observe your choice and make subsequent decisions based on your choices.

Which of the following types of Player 3 do you wish to choose to complete experiment B for you?

( ) Choose the player who spent 5 in experiment A to punish Player 1.

( ) Choose the player who spent 5 in experiment A to compensate Player 2.

( ) Choose the player who does nothing in experiment A.

Player 5

Player 4 has chosen the player who punished Player 1/helped Player 2 /did nothing in game A.

How much money would you like to offer to this Player 3 and Player 4? (Unit: RMB yuan).

()0 ()5 ()10 ()15 ()20 ()25 ()30 ()35 ()40

Player 3 Game B choice

Player 4 decides to offer you and Player 4 ( ) of 40 RMB yuan. Do you accept the amount offered? (You and Player 4 will split the amount equally).

( ) Accept ( ) Reject.

Experiment 3 unknown group

In experiment 3, the dictator, recipient, third party, fourth-party principal and fourth-party proposer are labeled as "Player 1", "Player 2", "Player 3", "Player 4", and "Player 5".

For the fourth-party principal (Player 4):

This is a game in which you might earn a bonus. You are Player 4. You will only play in game B and will NOT be a part of game A. However, we would like you to read about and understand both games.

Game A

Game A has three players: Player 1, Player 2, and Player 3.

In this game:

A sum of 20 RMB yuan has been provisionally allocated to Player 1 and Player 2.

Player 1 can decide how much of the money each person is to receive.

Player 1 has two choices:

– DO share: give 10 RMB yuan to Player 2 (and keep 10 RMB yuan).

– Do NOT share: give 0 RMB yuan to Player 2 (and keep 20 RMB yuan).

Afterwards, Player 3 is given 25 RMB yuan.

If Player 1 chose not to share with Player 2, Player 3 has three choices:

(1) If Player 1 chose not to share, pay 5 RMB yuan to punish Player 1, and Player 1's income is reduced by 5 RMB yuan.

(2) If Player 1 chose not to share, pay 5 RMB yuan to help Player 2, and Player 2's income is increased by 5 RMB yuan.

(3) If Player 1 chose not to share, do nothing.

Game B

Game B has 3 players: Player 3, Player 4 and Player 5.

In game B:

According to the choices of Player 3 in experiment A, Player 4 could choose one kind of Player 3 on his/her behalf to participate in game B.

Then, a sum of 60 RMB yuan is provisionally allocated to Player 4, the selected Player 3 and Player 5.

Player 5 then chooses how much money to offer to Players 3 and 4.

Player 3 then chooses to accept or reject this offer.

If Player 3 accepts, Players 3 and 4 get the offered amount (Players 3 and 4 will split the amount equally), and Player 5 keeps the rest.

However, if Player 3 rejects, Players 3, 4 and 5 get nothing.

NOTE: Player 5 is NOT first informed about the delegate's first-stage choice before he/she makes the offer.

Income structure

Player 3

The system will randomly choose between the experiment A income and the experiment B income as Player 3's experiment income.

Player 4

The income in experiment B.

Player 5

The income in experiment B.

Please answer the following questions to ensure that you understand this instruction. You MUST answer ALL questions correctly to participate in the games.

Q1

In experiment A, when Player 1 chooses to give Player 1 zero RMB yuan and keeps 20 RMB yuan, Player 3 has three choices.

If Player 3 decides to spend 5 RMB yuan to punish Player 1, the experiment A incomes of Player 1, 2, and 3 are ( ).

If Player 3 decides to spend 5 RMB yuan to help Player 2, the experiment A incomes of Players 1, 2, and 3 are ( ).

If Player 3 decides to do nothing, the experiment A incomes of Players 1, 2, and 3 are ( ).

The following incomes do not include the appearance fee.

(1) Player 1 has 20 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 25 RMB yuan.

(2) Player 1 has 15 RMB yuan, Player 2 has 0 RMB yuan, and Player 3 has 20 RMB yuan.

(3) Player 1 has 20 RMB yuan, Player 2 has 5 RMB yuan, and Player 3 has 20 RMB yuan.

Q2

If Player 3 is first endowed with 25 RMB yuan in experiment A and has 20 RMB yuan after making the experiment A decision and the experiment B income of Player 3 is 20 RMB yuan, then the final experiment income of Player 3 is _____RMB yuan? (excluding the appearance fee).

Q3

Which of the following statements is correct?

( ) Player 5 is first informed about Player 3's choice in experiment A before he/she makes the offer.

( ) Player 5 is NOT first informed about Player 3's choice in experiment A before he/she makes the offer.

Q4

In experiment B, if Players 3 and 4 are offered a total of 40 RMB yuan and Player 3 accepts the offer, what are the experiment B incomes of Players 3, 4, and 5?

( ) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 20 RMB yuan.

( ) Player 3: 30 RMB yuan, Player 4: 10 RMB yuan, Player 5: 20 RMB yuan.

( ) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 40 RMB yuan.

Correct answers: Q1) 2, 3, 1; Q2) 20; Q3) Player 5 is NOT first informed about Player 3's choice in experiment A before he/she makes the offer; Q4) Player 3: 20 RMB yuan, Player 4: 20 RMB yuan, Player 5: 20 RMB yuan.

Player 3 Game A choice

You have received 25 RMB yuan. What would you like to do if Player 1 does not share?

(1) I would like to pay 5 RMB yuan to punish Player 1, and Player 1's income will be reduced by 5 RMB yuan.

(2) I would like to pay 5 RMB yuan to help Player 2, and Player 2's income will be increased by 5 RMB yuan.

(3) I would like to do nothing.

Player 4

NOTE! Player 5 is NOT first informed about the delegate's first-stage choice before he/she makes the offer.

Which of the following types of Player 3 do you wish to choose to complete experiment B for you?

( ) Choose the player who spent 5 in experiment A to punish Player 1.

( ) Choose the player who spent 5 in experiment A to compensate Player 2.

( ) Choose the player who does nothing in experiment A.

Player 5

Player 4 has chosen the player 3.

How much money would you like to offer to this Player 3 and Player 4? (Unit: RMB yuan).

()0 ()5 ()10 ()15 ()20 ()25 ()30 ()35 ()40

Player 3 Game B choice

Player 4 decides to offer you and Player 4 () of 40 RMB yuan. Do you accept the amount offered? (You and Player 4 will split the amount equally).

( ) Accept ( ) Reject.

B: Results

B1: Experiment 1

(1) Fourth-party trust questionnaire

After the TG, the fourth-party players were asked "How much do you trust the helper/punisher/player who did nothing (PDN)?" using a 10-point Likert scale ranging from "Completely distrust" to "Completely trust".

The Friedman test showed differences in fourth parties' trust in third parties. (χ^2 (2)=41.097, p<0.001, effect size=0.623) Fourth-party players thought the helpers (mean rating=7.03, S.D.=2.365) were more trustworthy than the punishers (mean rating=5.39, S.D.=2.597) [Benjamini–Hochberg FDR correction, adjusted p=0.019] and the PDN (mean rating=2.52, S.D.=2.386) [Benjamini–Hochberg FDR correction, adjusted p=0.002]. Furthermore, fourth-party players trusted punishers more than the PDN [Benjamini–Hochberg FDR correction, adjusted p=0.002]. Partial

questionnaire data were not recorded during Experiment 1. We collected data from 33 fourth-party players (of 43 players) in the trust questionnaire.

(2) Third-party and fourth-party partner choice questionnaire

After the experiment, the third-party players indicated the type of player with whom they would prefer to play the TG if they were fourth-party players.

"If you were Player 4, which of the following types of players do you wish to choose to as Player 3 complete Experiment B with you?

( ) Choose the player who spent 5 in Experiment A to punish Player 1.

( ) Choose the player who spent 5 in Experiment A to compensate Player 2.

( ) Choose the player who did nothing in Experiment A."

After the experiment, fourth-party players were asked about the player with whom they preferred to play the TG.

"Which of the following types of players do you wish to choose to complete Experiment B with you as Player 3?

( ) Choose the player who spent 5 in Experiment A to punish Player 1.

( ) Choose the player who spent 5 in Experiment A to compensate Player 2.

( ) Choose the player who did nothing in Experiment A."

E1: Chooser	Punishers (%)	Helpers (%)	PDN (%)
Third party	18.60	53.49	27.91
95% CI	6.49–30.72	37.96–69.02	13.94–41.87
Fourth party	11.63	65.12	23.26
95% CI	1.65–21.61	50.28–79.96	10.1–36.41

(a) The Chi-square test indicated the third-party players' differential preferences for partners in the TG when they were in the fourth party's position (n=43, χ^2 (2)= 8.419, p=0.015, effect size=0.313). The helpers were chosen more often (53.49%) than both the PDN (27.91%) and the punishers (18.60%).

(b) The Chi-square test showed fourth-party players' differential preferences for partners in TG (n=43, χ^2 (2)=20.419, p<0.001, effect size=0.487). Helpers (65.12%) were chosen more often than both PDN (23.26%) and punishers (11.63%).

(3) Third-party sending questionnaire

After the experiment, the third-party players indicated how much money they would send to different kinds of third-party players if they were fourth parties.

"If you were Player 4, how much money would you send to Player 3 who, in game A, …

– Chose to punish Player 1?

– Chose to help Player 2?

– Chose to do nothing? (Unit: RMB yuan)".

The third-party players entrusted the most money to the helpers (mean money trusted=22.56 RMB yuan, S.D.=12.217), followed by the punishers (mean money trusted=16.63 RMB yuan, S.D.=12.758), and the PDN (mean money trusted=9.88 RMB yuan, S.D.=9.417).

A Friedman test showed differences in the amount sent to three types of trustees. The amounts sent varied significantly (χ^2 (2)=47.091, $p<0.001$, effect size=0.548). Pairwise comparisons revealed that the third-party players sent 14.83 more percentage points to the helpers than to the punishers (Benjamini–Hochberg FDR correction, adjusted $p=0.002$). The third-party players sent 16.86 more percentage points to the punishers than to the PDN (Benjamini–Hochberg FDR correction, adjusted $p=0.003$).

(4) The return of third-party players in trust game

Player 4 will decide how much to send to you. It is now your job to decide how much to return to Player 4.

Specifically, you will decide the percentage of money you would like to return.

For example, if you decide to return 10% of the money you receive…

– You will return 0 RMB yuan if Player 4 sends 0 RMB yuan (and you will receive 0 RMB yuan).

– You will return 3 RMB yuan if the sender sends 10 (and you will receive 27 RMB yuan).

What percentage would you like to return?

( )0% ( )10% ( )20% ( )30% ( )40% ( )50% ( )60% ( )70% ( )80% ( )90% ( )100%

A Kruskal–Wallis H test revealed that there were no significant differences in the amounts returned between three types of third-party players (χ2 (2)=2.929, $p=0.23$).

	Punishers (%)	Helpers (%)	PDN (%)
Mean	28.33	18.18	15
95% CI	18.33–36.67	12.73–23.94	2.50–32.5

B2: Experiment 2

(1) Fourth-party offering questionnaire

After the experiment, the fourth-party players indicated how much money they would offer to different kinds of third-party players.

"How much money would you like to offer to Player 3 who, in game A,…
– Chose to punish Player 1?
– Chose to help Player 2?
– Chose to do nothing?" (Unit: RMB yuan).

The fourth-party players offered the most money to the punishers (mean money offered=17.50 RMB yuan, S.D.=5.470), followed by the helpers (mean money offered=16.56 RMB yuan, S.D.=5.980), and the PDN in the TPPG (mean money offered=14.5 RMB yuan, S.D.=6.362). Partial questionnaire data were not recorded during Experiment 2 (N=90).

A Friedman test showed differences in the amount sent to three types of responders. The amounts offered varied significantly (χ^2 (2)=24.410, p<0.001, n= 90, effect size=0.136). Pairwise comparisons revealed that the fourth-party players offered 2.36 more percentage points to the punishers than to the helpers (Benjamini–Hochberg FDR correction, adjusted p=0.192). The fourth-party players sent 5.14 more percentage points to the helpers than to the PDN (Benjamini–Hochberg FDR correction, adjusted p=0. 012).

(2) Third-party and fourth-party partner choice questionnaire

After the experiment, the third-party players indicated the player with whom they would prefer to play the UG if they were the fourth party.

"If you were Player 4, which of the following types of Player 3 do you wish to choose to complete Experiment B with you?

( ) Choose the player who spent 5 RMB yuan in Experiment A to punish Player 1.

( ) Choose the player who spent 5 RMB yuan in Experiment A to compensate Player 2.

( ) Choose the player who did nothing in experiment A."

After the experiment, the fourth-party players indicated the player with whom they preferred to play the UG.

"Which of the following types of Player 3 do you wish to choose to complete Experiment B with you?

( ) Choose the player who spent 5 RMB yuan in Experiment A to punish Player 1.

( ) Choose the player who spent 5 RMB yuan in Experiment A to compensate Player 2.

( ) Choose the player who did nothing in Experiment A."

E2: Chooser	Punishers (%)	Helpers (%)	PDN (%)
Third party	12.26	64.15	23.58
95% CI	5.92–18.61	54.87–73.43	15.37–31.8
Fourth party	9.43	60.38	30.19
95% CI	3.78–15.09	50.91–69.8	21.91–39.07

(a) The Chi-square test showed the third-party players' differential preferences for partners in the UG when they were in the fourth party's position (n=106, χ^2 (2)= 91.236, p<0.001, effect size=0.656). The helpers (64.15%) were chosen more often than both the PDN (23.58%) and the punishers (12.26%).

(b) The Chi-square test showed the fourth-party players' differential preferences for partners in the UG (n=106, χ^2 (2)=41.736, p<0.001, effect size=0.444). The helpers (60.38%) were chosen more often than both the PDN (30.19%) and the punishers (9.43%).

(3) Third-party choice in TPPG

"You have received 25 RMB yuan. What would you like to do if Player 1 does not share?

(1) Punishing: I would like to pay 5 RMB yuan to punish Player 1 and reduce Player 1's income by 5 RMB yuan.

(2) Helping: I would like to pay 5 RMB yuan to help Player 2 and increase Player 2's income by 5 RMB yuan.

(3) Doing nothing: I would like to do nothing."

The Chi-square test showed the third-party players' different choices in the TPPG of Experiment 2 (n=106, χ^2 (2)=13.717, p=0.001, effect size=0.254). Third-party players chose to do nothing (47.17%) more often than to help (34.91%) or punish (17.92%).

Furthermore, we analyzed the proportion of third-party players' TPPG choices across experiments. The two multinomial probability distributions were not equal among the groups (χ^2(2)=23.789, p<0.001, effect size=0.282). Third-party players chose to help in Experiment 1 (76.74%) more than in Experiment 2 (34.91%, p< 0.001). Conversely, the third-party players chose to do nothing in Experiment 1 (9.30%) less than in Experiment 2 (47.17%, p<0.001). There were no significant differences in the proportion of third-party players who chose to do nothing in the different experiments. (13.95% versus 17.92%), p=0.557.

(4) Third party's real benefits in the UG

	Punishers	Helpers	PDN
Mean	16.579	14.459	10.70
S.D	6.081	5.903	8.186

A Kruskal–Wallis H test indicated that there were differences in three kinds of third-party players (χ^2 (2)=10.754, p=0.005, effect size=0.102). This post hoc analysis (pairwise comparisons) revealed that the actual average income of the

punishers was higher than that of the helpers (Benjamini–Hochberg FDR correction, adjusted $p=0.054$) and the PDN (Benjamini–Hochberg FDR correction, adjusted $p=0.004$). In addition, the actual average income of the helpers was higher than that of the PDN (Benjamini–Hochberg FDR correction, adjusted $p=0.054$).

B3: Experiment 3

(1) The specific design of experiment 3

For Experiment 3, we applied two designs to minimize the effect of deception. First, although player 3 and player 5 did not exist, we still let player 4 wait for player 3 and player 5 to make decisions in turn. More importantly, to prevent player 4 from being skeptical about whether other players existed, in case they communicated with each other regarding their payoffs after the experiment, we set the payoff for player 4 according to the payoff result of player 3 in Experiment 2. In Experiment 2, the punishers received proposals that were less exploitive and had higher payoffs than the helpers and noncooperative players in the ultimatum game. If player 4, on average, regarded TPP as an effective deterrence signal, then players in that role who chose punishers as delegates should have expected that they would receive a higher payoff than other players. In addition, participants were thanked and debriefed. All participants may withdraw data provided prior to debriefing without penalty or loss of benefits to which they were otherwise entitled.

Experimental income settings:

The experimental income distribution of the fourth party that chooses different types of third parties in Experiment 3 was set based on the income of the three types of third parties in Experiment 2 (UG).

Income (RMB yuan)	Punisher		Helper		PDN	
	Mean	(Std.err)	Mean	(Std.err)	Mean	(Std.err)
Experiment 2: third party (responder)	16.579	(1.433)	14.459	(0.984)	10.7	(1.169)
Experiment 3 (known): fourth party	16.724	(1.145)	14.118	(1.5)	10	(4.183)
Experiment 3 (unknown): fourth party	17	(2)	14.259	(1.154)	10	(2.224)

Just as the different TPPG choices of the third party caused their incomes in the UG to vary significantly, the different choices of the fourth party also caused their incomes to vary significantly; for example, choosing a punisher made them more likely to have higher gains.

In Experiment 2:

There was a significant difference between the gains of the punishers, helpers and PDN (Kruskal–Wallis test: $\chi^2=10.754$, $p=0.005$, effect size=0.102).

In Experiment 3 (known group):

There was a significant difference between the gains of the punisher choosers, helper choosers and PDN choosers (Kruskal–Wallis test: $\chi^2=7.186$, $p=0.028$, effect size=0.144).

In Experiment 3 (unknown group):

There was a significant difference between the gains of the punisher choosers, helper choosers and PDN choosers ($\chi^2=7.139$, $p=0.028$, effect size=0.143).

(2) The bystanders chose delegates under different information conditions (known group vs. unknown group)

Fourth-party choice	Known group	Unknown group
Punisher	29	10
proportion	56.90%	19.60%
95% CI	42.79–70.93%	8.33–30.89%
Helper	17	27
proportion	33.30%	52.90%
95% CI	19.94–46.72%	38.76–67.12%
Player who did nothing	5	14
proportion	9.80%	27.50%
95% CI	1.36–18.25%	14.77–40.13%

(3) Fourth-party choices in multiple logistic regression

Fourth-party choice Baseline category	Punisher Helper	Player who did nothing Helper	Helper Player who did nothing
Known condition	1.527***	− 0.567	0.567
	0.482	0.609	0.609
Intercept	− 0.993	− 0.657	0.657
	0.372	0.331	0.331

Robust standard errors in parentheses *$p<0.1$, **$p<0.05$, ***$p<0.01$.

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Data availability All data are available as supplementary information.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval All the procedures performed in this study were reviewed and approved by the Ethics Committee of Zhejiang University of Finance and Economics.

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