Monetary and Non-Monetary Punishment in Public Goods Games with Teams.*

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Abstract

We experimentally investigate the behavior of teams in a public goods game with monetary and non-monetary punishment. Teams of two take part in a finitely repeated public goods game with and without punishment. We find that contributions without punishment are similar across teams and individuals. However, teams contribute significantly less than individuals under the threat of non-monetary punishment. Furthermore teams also contribute substantially lower under non-monetary punishment than monetary punishment. We also find evidence suggesting similar punishment decisions between teams and individuals, however teams are less (more) vindictive in assigning punishment under monetary (non-monetary) punishment than individuals. Finally, we find that teams are less reactive to monetary punishment than individuals.

Keywords: Public goods; Group decision-making; Punishment; Experiment; Communication

JEL Classification: C72; C73; C92; H41

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1 Introduction

The provision of public goods has been a widespread phenomenon. At the micro level, one can think about a household offering up its services for a neighborhood watch. A tier up, one can think about the local government offering to develop the infrastructure of the local county. At the macro level, one can consider national defense to be a prime example. At the global level, the most fundamental examples are policies pertaining to combating climate change. Due to their nature, however, public goods are often subjected to the free-rider problem. As a result, economic theory often predicts under-provision of public goods. To combat this, public goods are often associated with sanctioning mechanisms in place which punish free-riders for their lack of contributions.

A large body of experimental literature has documented behavior in public goods games with and without sanctioning environments. Experimental findings suggest that sanctions are indeed successful in mitigating the free-rider problem and increasing individual contributions to public goods (see Fehr and Gächter, 2000; Masclet et al., 2003; Herrmann et al., 2008, for example) irrespective of whether the sanctions are monetary or verbal in nature. However, this literature assumes that decision makers are individual people. In contrast, most decisions pertaining to public goods are undertaken by teams consisting of multiple people. For example, the decision to contribute to a neighborhood watch is undertaken by the whole household. National defense and climate change policies are set by their respective departments in the nations government. Similarly, sanctioning environments are also jointly decided upon by teams.

This begs the question: how do teams compare to individuals in public goods games? Recent experimental evidence suggests that teams act more rationally than individuals in a wide variety of settings (Charness and Sutter, 2012; Kugler et al., 2012). However, the literature comparing teams to individuals in public goods games is very scant. Cox and Stoddard (2018) are the first to analyze team behavior in a public goods game. They find similar contribution behavior between teams and individuals, however their experiment does not consider any sanctioning environment. Auerswald et al. (2018) take it a step further and compare teams to individuals in a public goods game with and without costly punishment. They find that costly punishment does increase contribution levels even when decision makers are teams, however they find that teams do punish less than individuals.

This paper seeks to experimentally investigate team behavior in public goods games. In our experiment, a group of decision makers first take part in a finitely repeated public goods game without a sanctioning mechanism and then take part in a finitely repeated public goods game with a sanctioning mechanism. Decision makers are either individuals or a team of two individuals who jointly make a decision. Our experiment allows for intra-team communication to aid coordination over decisions.

We consider two forms of sanctioning mechanisms. The first one is a costly punishment option (henceforth monetary punishment) under which decision makers can assign points to reduce other decision makers payoff at some cost. This is the sanctioning mechanism used in Auerswald et al. and mimics situations in which fines are imposed on free-riders. Our second sanctioning mechanism is a verbal punishment option (henceforth non-monetary punishment) in which decision makers are allowed to express their disapproval of other decision makers' contributions by assigning points. Disapproval is costless to assign and has no impact on earnings. We include non-monetary punishment as a sanctioning mechanism as 1) evidence suggests it has a similar effect in increasing contributions for individuals (Masclet et al., 2003) and 2) many sanctions involve the use of warnings and verbal admonishment.[1]

We find that contribution levels are similar between teams and individuals without punishment. We find that the threat of monetary punishment increases contribution levels when the decision makers are both teams and individuals. We also find that teams contribute more than individuals under monetary punishment. Furthermore, non-monetary punishment also increases contributions for individuals. However, non-monetary punishment appears to have no impact on contributions when decision makers are teams. Teams under non-monetary punishment contribute substantially lower than both individuals under non-monetary punishment *and* teams under monetary punishment.

The remainder of the paper proceeds as follows. Section 2 discusses the related literature in detail. Section 3 presents the experimental design. Section 4 outlines our testable hypotheses. Section 5 documents our results and Section 6 concludes with a discussion and future prospects.

[1]A prime example of an agency using both forms of sanctioning mechanisms is the Environmental Protection Agency who undertakes both Civil Administrative Actions (notices of violations – non-monetary) and Civil Judicial Actions (formal lawsuits – monetary) against non-compliant entities. https://www.epa.gov/enforcement/basic-information-enforcement

2 Related Literature

Our paper expands on the large experimental literature surrounding public goods game. Ledyard (1995) provides a concise survey of early experimental work. Summarizing those findings, studies show that individuals do not free-ride as game theory predicts. Individuals tend to cooperate more than game theory predicts, which tends to decline as the game progresses so, rates of free-riding increase over time. Fischbacher and Gachter (2010) attributes this effect to the fact that people are "imperfect conditional cooperators" in the sense that people's contribution decisions rely partly on their beliefs about other people's contributions as well as on their "predicted contributions."[2]

Our study investigates the impact that sanctioning institutions, such as monetary and non-monetary punishment, have on sustaining cooperative behavior in a public goods game (for a survey, see Chaudhuri 2011). Fehr and Gächter (2000) is the first experiment to study the effect of costly monetary punishment on cooperation. In their experimental design, individuals are allowed to assign punishment points to other individuals on the basis of their contribution decisions. Punishment is costly for both the assigner and the assignee. Each point assigned reduces an individuals payoff by 10%. The paper finds that monetary punishment is able to sustain a high degree of cooperation. This finding has been replicated in multiple follow up papers (see for example Masclet et al. 2003; Herrmann et al. 2008; Nikiforakis 2008; Nikiforakis and Normann 2008). Masclet et al. (2003) also documents the effects of non-monetary punishment. In this setting, punishment is costless to assign and does not have any impact on payoffs of individuals who are assigned punishment points. Masclet et al. (2003) finds under Partners matching, non-monetary and monetary punishment result in similar increases in contributions initially, however contributions decline under non-monetary punishment in the latter half. Our experiment expands on this body of literature by examining the effects of non-monetary and monetary punishment when decision makers are teams rather than individuals.

Recently, focus has shifted towards analyzing group decision making in public goods games. Cox and Stoddard (2018) is among the first experiment to analyze a public goods games in which teams of two jointly make contribution decisions. In comparing teams to individuals, they find

[2]Predicted contributions here refer to the contribution schedule elicited from each individual conditional on the average contribution of other group members.

that teams initially contribute more than individuals, however contribution tends to decline faster for teams. Overall, Cox and Stoddard (2018) documents similar contribution levels for teams and individuals. The experimental design allows for intra-team communication. Analysis of the chat logs indicate support for backwards induction reasoning within teams. Our experiment extends the setting of Cox and Stoddard by incorporating a sanctioning environment in the form of monetary or non-monetary punishment.

Kamei (2018) analyzes a two individual decision maker public goods game with teams and finds that cooperation is easier to sustain under Partners matching than Strangers matching. Christens et al. (2019) documents the effect of identification in public goods games with groups. They find that without identification, groups contribute higher than individuals, however the effect of identification (in increasing contributions) is smaller and temporary for groups.

The most closely related paper to our study is Auerswald et al. (2018) that documents the effect of monetary punishment in a public goods game with teams. The experimental design focuses on 3 person teams in which team members go through a series of rounds of proposals to reach an agreement over contribution and punishment levels. The treatments focus on majority and unanimity rules. The experiment finds that teams under unanimity rules contribute more than individuals, however they also punish significantly less. Furthermore, teams exhibit little to no anti-social punishment compared to individuals. Our paper extends the analysis of Auerswald et al. (2018) by allowing for intra-team communication as well as non-monetary punishment in the spirit of Masclet et al. (2003).

This paper also adds to the growing body of literature surrounding group decision making. Experimental evidence suggests that groups act more in accordance to game theoretic predictions than individuals (for a survey of early works in the literature, see Charness and Sutter 2012 and Kugler et al. 2012). For example, group decision making has been studied extensively in a variety of games: Signalling games (Cooper and Kagel, 2005); Centipede games (Bornstein et al., 2004); Beauty contests (Kocher and Sutter, 2005; Sutter, 2005); hidden action trust games (Kugler et al., 2007; Nielsen et al., 2019); and Dictator Games (Doerrenberg and Feldhaus, 2019). However, there is experimental evidence that suggests that groups may not be more rational than individuals. Müller and Tan (2013) experimentally investigates the effect of group decision making in a Stackelberg

Duopoly and finds that groups tend to stray further from Subgame Perfect Equilibrium.

More closely related to our setting are the studies documenting the effect of group decision making in repeated Prisoner's Dilemma games. Prisoner's Dilemma games and Public Goods game are very similar in nature in the sense that equilibrium predictions yield a Pareto Dominated outcome. In both cases, equilibrium predictions indicate that all decision makers will choose to defect (in Public Goods Games, defection is equivalent to free-riding) however the Pareto Optimal outcome involves cooperation. Kagel and McGee (2016) look at decision making in teams in a finitely repeated prisoner's dilemma setting. They find that teams exhibit significantly lower levels of cooperation than individuals in early supergames, however cooperation increases in later games to the point where overall teams are more cooperative than individuals. Endgame effects, however are stronger for teams than individuals in that teams are significantly less cooperative in the final stages of the game. Kagel (2018) extends the above to allow for cheap talk between opponents. While cheap talk does increase cooperation in both teams and individual settings, cooperation rates amongst teams are still significantly lower than individuals, especially in later stages of the game.

A point of note is that Public Goods games are inherently more complex than Prisoner Dilemma games. The latter only involves decision makers making a binary decision (Cooperate or Defect) whereas the former involves decision makers choosing over a menu of options in regards to contribution decisions. As pointed out in Cox and Stoddard, this can result in the prevalence of complex social norms in Public Goods games. Furthermore, public goods games allow us to judge the degree of willingness to cooperate by analyzing contribution levels (Auerswald et al.). Lastly, we also focus on how sanctioning institutions (here monetary or non-monetary punishment) can impact cooperation.

3 Experimental Design

We consider a linear public goods game game similar to Masclet et al. (2003) and Auerswald et al. (2018). We focus on 4 treatments: 1) Teams with Partners matching and Monetary Punishment (TPMP), 2) Teams with Partners matching and Non-monetary Punishment (TPNMP), 3) Individuals with Partners matching and Monetary Punishment (IPMP) and 4) Individuals with Partners

matching and Non-monetary Punishment (IPNMP).

For each treatment, a group of 4 decision makers (DMs) take part in a finitely repeated public goods game. In individual treatments, a DM is an individual subject. In teams treatments, a DM is a team of 2 individuals who jointly make decisions. Teams are randomly assigned at the beginning of the treatment and remain fixed throughout the experiment. Furthermore, all DMs are randomly sorted into groups of 4 at the beginning of the session and these groups remain fixed throughout the experiment.[3] Each treatment follows an $A - B$ design. DMs first play 10 rounds of the public goods game without punishment (A) and then play 10 rounds with (monetary or non-monetary) punishment (B).[4]

In the "without punishment" part A, in each period, a DM in a group is endowed with a fixed number of tokens ω. Every DM i decides to (simultaneously) contribute an amount c_i ($0 \leq c_i \leq \omega$) to a "project". We set $\omega = 60$ for all treatments. Each token contributed to the group project raises the payoffs of **all** DMs in the group by 0.75 tokens. The payoff for a DM i at the end of each period in the "without punishment" part is:

$$\pi_i^{NP} = \omega_i - c_i + 0.75\left(\sum_{j=1}^{4} c_j\right)$$

Note that for teams, both team members get this payoff. We set this so that the incentives are identical in all treatments.

In the teams treatment, teams are allowed a total of 2 minutes at the beginning of each period to communicate with each other electronically in order to reach a decision on how much to contribute. In the individuals treatment, decision makers are allowed 1 minute to reach a decision. If they cannot reach a decision in this time, the computer selects a random contribution amount on their behalf.[5] At the end of each round, DMs were notified about their decision as well as the decisions of all other DMs in their group (including whether or not the decisions were randomly determined)

[3]Masclet et al. (2003) show that non-monetary punishment is most effective with individuals under partners matching. We therefore consider only Partners matching as it allows for a sharper comparison between teams and individual behavior under non-monetary punishment.

[4]Subjects were notified at the beginning that there will be two parts to the experiment and that instructions for part 2 (with punishment) will be given out after the end of part 1. Instructions for the team treatments are given in the appendix.

[5]Failure to reach a decision in time was very rare for Teams (out of 940 contribution decisions, only 32 decisions were randomly determined, 16 of which occurred in the first period of the entire session).

and their payoffs.

For the "with punishment" part (B), each round is a 2-stage game. The first stage proceeds exactly as above in the "without punishment" part with first stage payoffs $\pi_i^1 = \omega_i - c_i + 0.75\left(\sum_{j=1}^4 c_j\right)$. In the second stage, DMs are notified about the contribution levels of the other DMs in the group and are allowed to (simultaneously) punish them as they see fit.[6] A DM i can punish DM j by assigning them punishment points p_i^j. Each DM can assign a maximum of 15 points to every other DM in their group. For the teams treatments, each DM has 90 seconds to communicate and reach a decision. For individual treatments, each DM has 45 seconds. If a DM fails to reach a decision in time, the computer randomly decides on their behalf.[7]

In the non-monetary punishment treatment there is no cost to the punisher to assign punishment. The punishment does not cost the DM who is punished any of their earnings. This is the setting of the non-monetary punishment setting employed by Masclet et al. (2003). In particular, final period payoffs are the same as Stage 1 payoffs:

$$\pi_i^P = \pi_i^1$$

In the monetary punishment treatment each punishment point assigned to DM j reduces their first stage payoffs π_i^1 by 3 tokens. Furthermore, in the monetary punishment treatment, punishment is costly to the punisher as well. Each punishment point assigned to another DM costs 1 token. This punishment cost setup is identical to the one employed in Auerswald et al. (2018) and Herrmann et al. (2008). Nikiforakis and Normann (2008) show that in order for punishment to be effective at increasing the contribution levels, the reduction to cost ratio must be high enough. In particular, they find that a reduction to cost ratio higher than 2 manages to sustain cooperation. Following Auerswald et al., the payoffs for the period are given by:

$$\pi_i^P = \max\left\{0, \pi_i^1 - 3\sum_{j\neq i} p_j^i\right\} - \sum_{j\neq i} p_i^j$$

[6]The identifiers for the other group members are reshuffled randomly every period to prevent reputation building and ensure that DMs don't punish due to past actions. This reshuffling is common knowledge.

[7]Failure to reach a decision in time was observed in 28 out of 470 instances. Further analysis of the data indicates most of these were due to coordination failure and 21 of these instances occurred in the first 2 periods (15 of which happened in the first period).

Such payoffs ensure that the DMs only bear the cost of assigning punishment points in the case that the reduction from receiving points exceeds the stage 1 payoffs.

Sessions were conducted during the months of January and February 2020 at the Ohio State University Experimental Economics Laboratory. Subjects were recruited using the online recruitment system ORSEE (Greiner, 2015). Subjects were seated at computer terminals with privacy dividers in between. Instructions were read out loud at the beginning of the experiment. Subjects were then asked a series of control questions to test their understanding of the experiment and the experiment only proceeded once everyone answered the questions correctly (any mistakes or sources of confusion were clarified personally by the experimenters). Subjects were paid for the total number of tokens accumulated throughout the session at the rate of 100 tokens to $1. Earnings averaged around $30 including a $3 show-up fee. The experiment was programmed in zTree (Fischbacher, 2007).[8] Sessions lasted for 45 minutes for individuals and 75 minutes for teams.

4 Hypotheses

Our hypotheses stem from the fact that teams are expected to act more rationally than individuals. For a given stage game without punishment, there is a unique, dominance solvable Nash Equilibrium in which every decision maker contributes 0 tokens to the project. However, the socially optimum outcome occurs when everyone contributes the maximum possible amount (i.e. their endowment). Given the fact that teams are expected to behave more rationally, we expect lower contributions under team treatments as compared to individuals.

Hypothesis 1. *Teams contribute less than individuals.*

We also compare how decision makers behave under the threat of monetary and non-monetary punishment. We first consider the effect of monetary punishment on contribution levels. Past experimental evidence suggests that monetary punishment is effective in enhancing cooperation in public goods games (see Fehr and Gächter, 2000; Masclet et al., 2003; Herrmann et al., 2008). Furthermore, Auerswald et al. (2018) show that monetary punishment increases contribution levels

[8]The code used was adapted from the code used by Cox and Stoddard (2018) and Auerswald et al. (2018). The matching protocol and chat construction was adapted from Cox and Stoddard. The construction of the contracts table and the program to check for matching punishment decisions between team members was adapted from Auerswald et al.

even when the Decision Makers are teams, rather than individuals. We expect similar trends as the aforementioned studies in that the threat of monetary punishment increases contribution levels for both teams and individuals.

Hypothesis 2. *The threat of monetary punishment increases contribution levels for both Teams and Individuals.*

In regards to non-monetary punishment, Masclet et al. (2003) document that non-monetary sanctions have a similar effect in raising overall contribution levels when the decision makers are individuals. They argue that informal punishment may yield dis-utility to an individual, prompting them to raise contributions. We expect this result to hold true in our setting as well.

Hypothesis 3. *Individuals increase contribution levels under the threat of non-monetary punishment.*

In regards to team behavior, we expect the coordination process and joint decision making to effectively weed out the aforementioned effect. In particular, if teams are more rational, they should be able to identify that punishment has no effect on their earnings. We therefore expect no change in behavior for teams under the threat of non-monetary punishment.

Hypothesis 4. *Teams are unaffected by the threat of non-monetary punishment.*

We now turn towards punishment behavior. Under monetary punishment, it is costly for a Decision Maker to assign points. Using sub-game perfection, in the second stage it is rational for Decision Makers to assign 0 points. Given this, in the first stage, the equilibrium prediction suggests that no DM will contribute anything. Once again, we expect Teams to follow game theoretic predictions resulting in the following:

Hypothesis 5. *Under monetary punishment, teams punish less than individuals.*

We cannot offer predictions pertaining to punishment behavior under non-monetary punishment. Seeing how punishment has no impact on earnings, in any sub-game perfect equilibrium, each DM will contribute 0 tokens. However, any profile of punishment points is possible in any sub-game perfect equilibrium.

We finally turn towards the effect of received punishment on future contributions. Under monetary punishment, given that teams are expected to be more rational than individuals, we

expect contribution decisions under teams to be less effected by received points. We expect similar findings to hold under non-monetary punishment as well. In particular, we expect teams to not react to received punishment under non-monetary punishment.

Hypothesis 6. *Conditional on received points, teams increase their contributions less than individuals.*

5 Results

We present the results from data collected over 10 sessions. We ran 3 sessions each for the TPMP and TPNMP treatments and two sessions each for the IPMP and IPNMP treatments. Table 1 below summarizes the treatments conducted as well as the number of independent groups, decision makers and subjects per treatment.

Table 1: Summary of Treatments

Treatment	Groups	Decision Makers	Subjects
IPMP	6	24	24
IPNMP	6	24	24
TPMP[a]	6	23	46
TPNMP	6	24	48

[a] Due to a low number of show ups in one of the sessions, one of the experimenters had to be randomly matched with a subject to form a team. We drop all data for this "team" in our analysis.

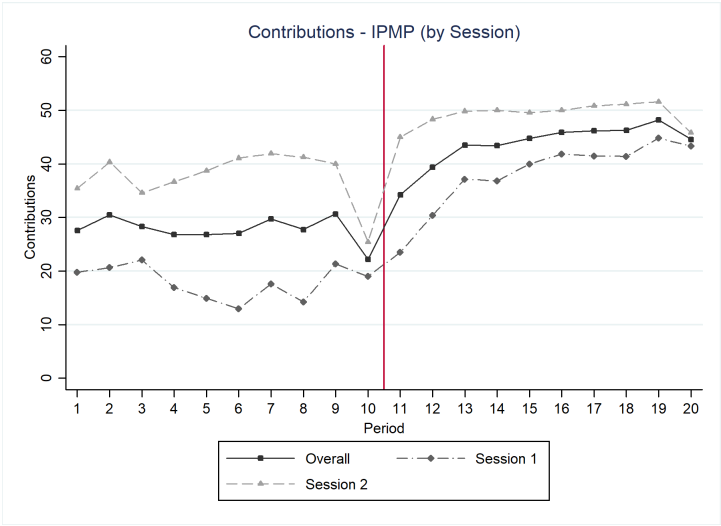
Figure 1 plots the average individual contribution trends for each treatment. We analyze each of these trends individually. In each trend, Periods 1-10 correspond to the "without punishment" treatment and Periods 11-20 (after the vertical line) correspond to the "with punishment treatment".

Figure 1(a) plots the contribution trends under IPMP. We observe considerable heterogeneity at the session level however overall trends are very similar. Without punishment, contribution rates are fairly stable overtime. With punishment, however, contribution levels see a steady rise over time. On average, contributions are higher with punishment compared to without punishment.

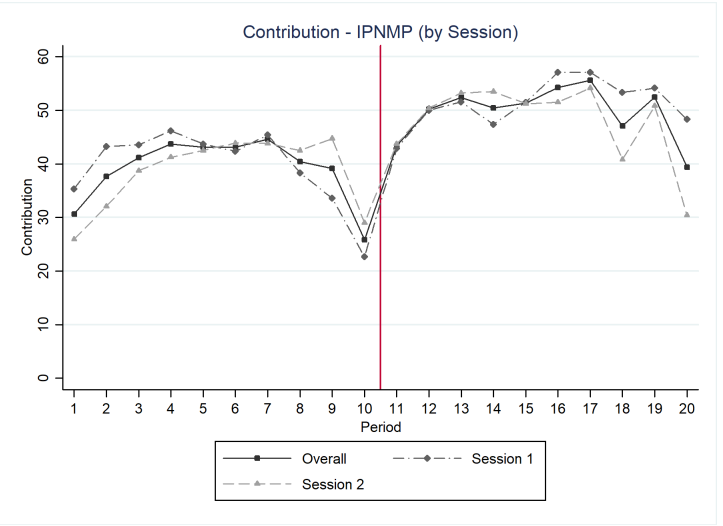
Figure 1(b) plots the trends under IPNMP. We observe fairly close trends at the session level. Contributions, without punishment, rise initially, stabilize in the middle and then drop steeply in the final periods. With punishment, we observe similar trends in that contributions rise initially,

Figure 1: Contribution Levels - By Session

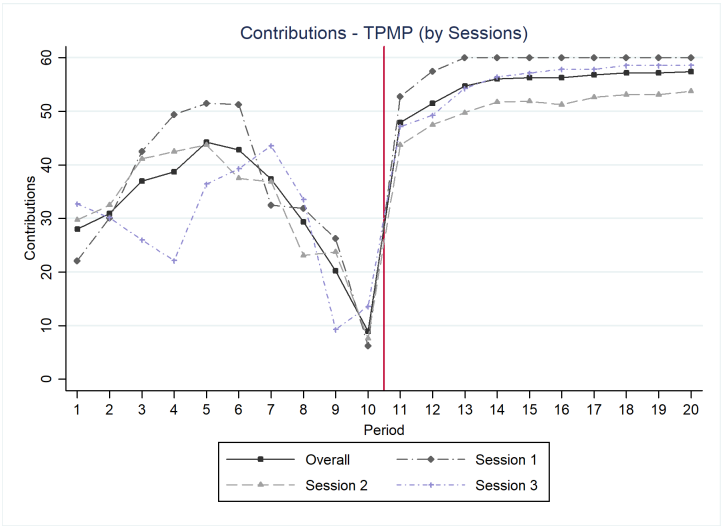
(a) IPMP



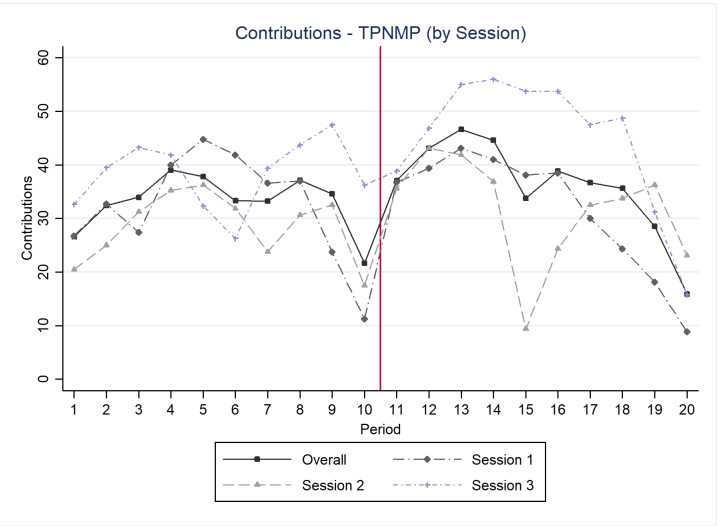
(b) IPNMP



(c) TPMP



(d) TPNMP



see a sustained rise and then drop sharply in the final periods. Contributions are on average higher with punishment however.

Figure 1(c) plots the trends under TPMP. Without punishment, contributions see a sustained rise in the early periods. However, cooperation quickly gives way and we see a persistent decline in contributions following the fifth period. With punishment however, we see a substantial jump in contributions in the first period and then a persistent increase in contributions over time.

Figure 1(d) plots the trends under TPNMP. Without punishment, we observe similar trends as those in Figure 1(b). Contributions rise initially, remain fairly stable in the middle and then drop sharply in the final period. With punishment, we observe an initial rise in contributions, however beyond period 14, contributions see a persistent decline. By the final period, contribution levels are even lower compared to without punishment.

5.1 Contribution Decisions

5.1.1 Treatment Effect of Punishment

To get an idea of the treatment effect of Punishment, we look at Table 2 below which summarizes average contribution levels per treatment.[9] Across the board we can see that the threat of punish-

Table 2: Average Contribution Levels

	Without Punishment	With Punishment	p-value
IPMP	27.75	43.65	0.0000
IPNMP	38.95	49.67	0.0031
TPMP	31.76	55.13	0.0000
TPNMP	32.98	36.09	0.1004

ment raises overall contributions in all treatments. Monetary punishment raises contributions in individual treatments from 27.75 tokens to 43.65 tokens. A nonparametric Wilcoxon signed rank matched-pairs test using individual decision makers as units of observation yields $p < 0.0001$.[10] Non-monetary punishment sees a similar effect in individuals, where contributions rise from 38.95

[9] We include observations in which contributions were randomly generated by the computer as a result of teams failing to coordinate. Dropping these observations has no effect on the findings below. Average contribution levels increase slightly to 32.07 for TPMP without punishment and 33.36 for TPNMP without punishment.

[10] In all tests that follow, we use an individual decision maker as a unit of observation.

tokens to 49.67 tokens ($p = 0.0031$ - Wilcoxon signed rank matched pairs test). Under team treatments, contributions rise significantly under monetary punishment (31.76 to 55.13, $p < 0.001$ - Wilcoxon signed rank matched pairs test). Teams exhibit a modest increase in contributions under non-monetary punishment, however this effect is not statistically significant (32.98 to 36.09, $p = 0.1004$). The results are summarized below:

Result 1. *Average contributions increase for both teams and individuals under monetary punishment. Average contributions increase for individuals under non-monetary punishment. Teams however don't appear to be affected by non-monetary punishment.*

5.1.2 Comparing Teams to Individuals

We first focus on contribution differences between teams and individuals without punishment. Pooling data across all treatments without punishment, we find that teams on average contribute 32.38 tokens. Individuals contribute on average 33.35 tokens. Mann-Whitney U tests using individual decision makers as units of observation show that this effect is not significant ($p = 0.58$). Figure 2 shows the trends of contribution levels across time, using pooled data for all treatments in the no punishment part. Contributions are very similar across teams and individuals. Initially, teams contribute slightly lower than individuals, however contribution levels steadily rise for teams for the first half of the treatment. We then observe a steady decline in contributions for teams. Team contributions drop sharply in the final periods and are on average lower than individuals, indicating stronger endgame effects for teams.

Table 3 reports results from a random effects panel regression using pooled data from all treatments without punishment. Our unit of observation is a single decision maker (an individual in the individual treatments and a team in the team treatments). We cluster standard errors at the group level. Due to a substantial degree of coordination failure at the beginning of the treatment, we control for randomly determined observations by including a dummy variable that captures whether or not the decision was randomly determined.[11] To control for time, we include period dummies.

[11] In total, there are 30 observations in which teams failed to coordinate, resulting in a random contribution for the Decision Maker. 16 of these occur in the first period. Dropping the dummy variable yields qualitatively similar results.

Figure 2: Contribution Trends without Punishment

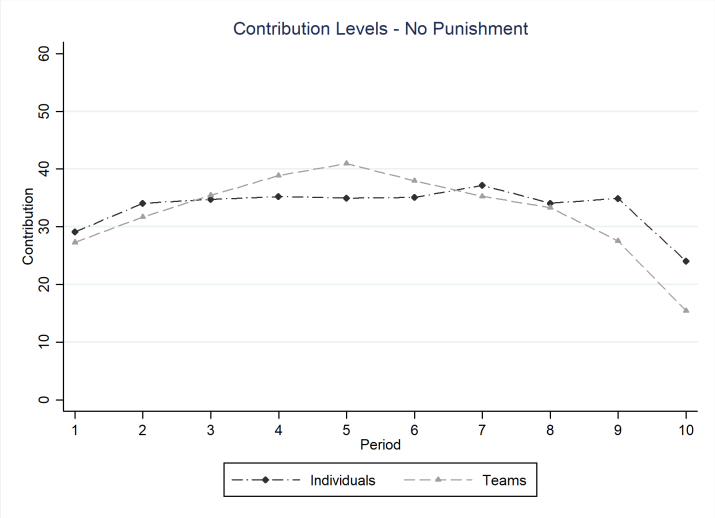


Table 3: Contribution levels - Without Punishment

	(1) Without Punishment
	contribution
Team	-0.580
	(6.012)
Constant	29.51***
	(4.399)
Periods	1-10
Period Dummies	Yes
N	950

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. Unreported regressors include Period dummies, and a dummy for random contribution. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We find that there is no significant difference in average contribution levels between teams and individuals. On average, without punishment, teams contribute 0.58 tokens less than individuals, however this effect is not statistically significant. The aforementioned are summarized in the following result:

Result 2. *Without punishment, contribution decisions are not significantly different between teams and individuals.*

We now turn to treatment specific effects. In particular, we compare how teams and individuals differ in their contribution decisions under punishment.

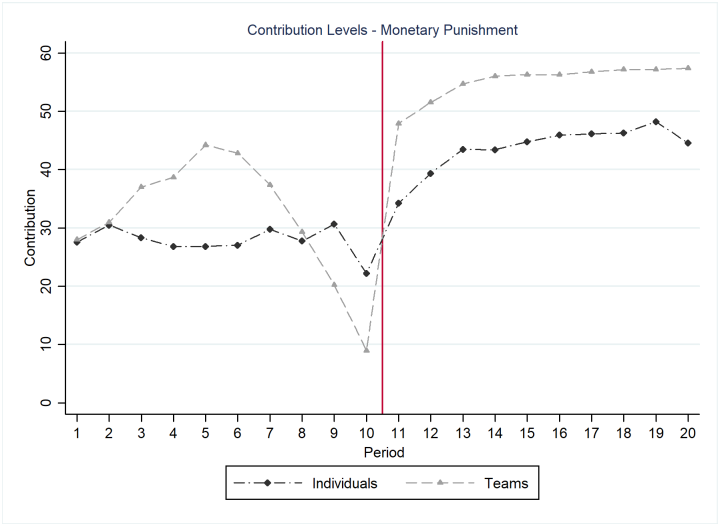
Figure 3 compares the contribution trends between teams and individuals under both Monetary and Non-Monetary Punishment. The vertical line indicates the restart point at beyond which subjects take part in the with punishment treatment. Trends under monetary punishment are given in Figure 3(a). We can see that without punishment, contributions under teams rise initially, whereas contribution under individuals remain fairly constant. During the middle, teams contribute significantly higher than individuals, however contributions drop sharply under teams. In the final periods without punishment, teams contribute substantially less than individuals. However, overall contribution levels for teams and individuals without punishment are not statistically different from each other (Mann-Whitney U test $p = 0.4372$). From Period 11 onwards (with punishment), we observe steadily increasing contributions overtime for both teams and individuals. However teams consistently contribute more than individuals and this difference is significant (Mann-Whitney U test $p = 0.015$).

Figure 3(b) compares the trends under non-monetary punishment. Without punishment, we see similar trends across teams and individuals. Contributions rise initially then drop significantly in the final periods. Furthermore, we see that teams, on average, contribute lower than individuals and this is consistent throughout the treatment. However, this difference is not significant (Mann-Whitney U test $p = 0.106$). Starting from Period 11 (with punishment), contributions again rise initially in both treatments. However, we see that the levels of contributions start to decline under teams starting from the 4th period. Final contributions in teams are lower than the final contributions in the without punishment part. Furthermore, individuals contribute consistently higher than teams (Mann-Whitney U Test $p = 0.0007$) and contributions only decline in the final

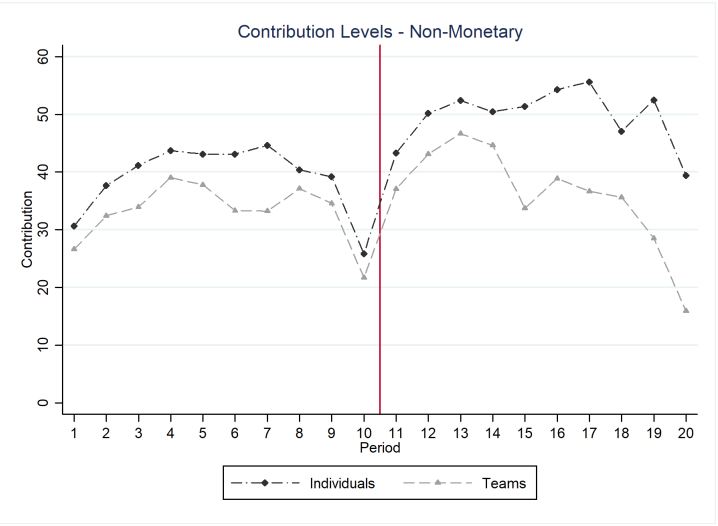
periods.

Figure 3: Comparison of Contributions

(a) Monetary



(b) Non-Monetary



To get a more detailed idea about the average difference between teams and individuals, we conduct a panel regression analysis. Table 4 presents random effects regression results documenting the average team effect on contributions in both monetary and non-monetary punishment.

The results mirror our findings above. Without Punishment, there is no discernible difference in contribution levels between teams and individuals. Contributions rise on average under monetary punishment however by 18.50 tokens and teams raise their contributions even more by an additional 7.1 tokens. On average, teams contribute around 11.5 tokens more than individuals under monetary punishment and this effect is close to being significant ($p = 0.1012$). Under non-monetary punishment however, contributions increase on average by 2.2 tokens (although this effect is not significant). However, Teams actually lower their contributions by 7.87 tokens compared to individuals under non-monetary punishment. On average, teams contribute around 13.5 tokens less than individuals under monetary punishment and this effect is significant ($p = 0.032$). We summarize these findings below:

Result 3. *Under monetary punishment, teams contribute more than individuals. Under non-monetary punishment, teams contribute less than individuals.*

Table 4: Contribution levels - Teams vs Individuals

	(1) MP	(2) NMP
	contribution	contribution
Team	4.433	-5.695
	(8.759)	(7.979)
Punishment	18.50***	2.236
	(4.250)	(6.299)
Team x Punishment	7.079	-7.868
	(4.786)	(6.134)
Constant	26.72***	32.19***
	(6.931)	(5.578)
Periods	1-20	1-20
Period Dummies	Yes	Yes
N	940	960

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. Unreported regressors include Period dummies, and a dummy for random contribution. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

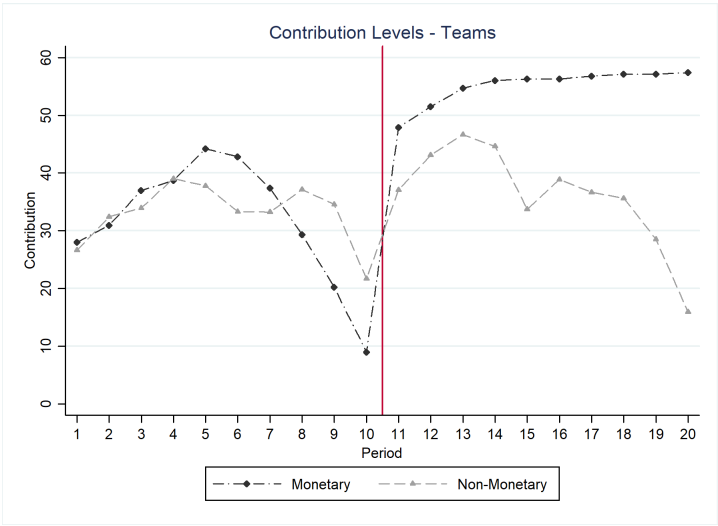
5.1.3 Comparing Monetary and Non-Monetary Punishment

We now analyze the contribution differences under monetary and non-monetary punishment. Figure 4 compares contribution trends between Monetary and Non-monetary punishment for both teams and individuals. Comparing teams in Figure 4(a), we find similar trends without punishment. Initially, contributions increase under both treatments, and start to decline in later periods. The decline happens faster under TPMP. Overall, average contributions are not statistically different (Mann-Whitney U test $p = 0.915$). Starting from Period 11 (with Punishment), we again observe an initial rise in contribution levels under both treatments. However, contributions show a steadily increasing trend under monetary punishment under which teams converge to nearly full cooperation. In contrast, under non-monetary punishment, teams show a significant decline after Period 13, to the point where, in the end, contributions are even lower than without punishment. Average contributions are significantly higher under monetary punishment (Mann-Whitney U test $p < 0.001$).

Figure 4(b) plots contribution trends for individuals. We find that without punishment (Period 1-10), contributions are consistently higher under IPNMP. (Mann-Whitney U test $p = 0.08$). Contributions increase initially under IPNMP and decline in the latter half. In contrast, under IPMP, contributions remain fairly stable overtime. With punishment (Periods 11-20), contributions on average are higher under both treatments. We see contributions steadily rise under both treatments. However, contributions do decline in the final periods under non-monetary punishment. On average, contribution levels are higher under non-monetary punishment as compared to monetary punishment, however this difference is not statistically significant ($p = 0.5605$).

Figure 4: Comparison of Contributions

(a) Teams



(b) Individuals

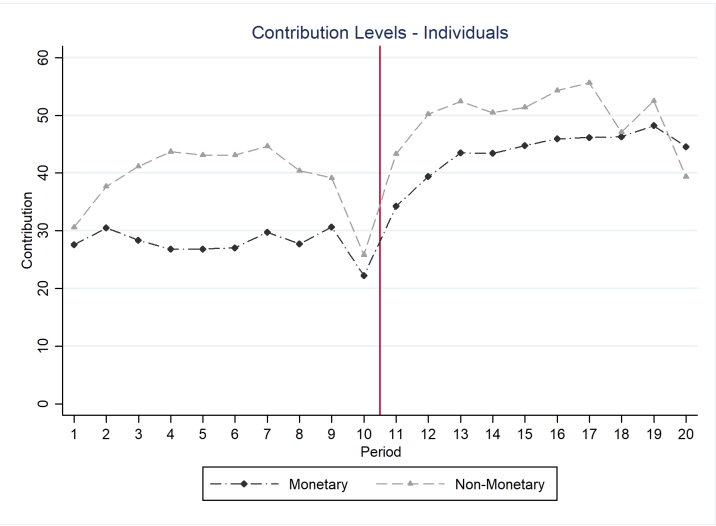


Table 5 presents random effects regression results documenting the effect of monetary and non-monetary punishment on contributions in both teams and individual treatments. Qualitatively, the results confirm the findings from above. Let us first consider teams. We find that without punishment (Periods 1-10), there is no discernible difference in contribution levels between TPMP and TPNMP. Punishment on average reduces contributions by 3 tokens however this effect is not significant. However, teams under monetary punishment raise their contribution levels by an *additional* 20 tokens and this effect is highly significant.

Comparing individuals, contribution levels without punishment (Periods 1-10) under IPMP are

Table 5: Contribution levels - Monetary vs Non-Monetary Punishment

	(1) Teams	(2) Individuals
	contribution	contribution
MP	-1.305	-11.20
	(4.425)	(10.73)
Punishment	-3.102	10.28**
	(5.344)	(5.129)
MP X Punishment	20.35***	5.183
	(3.614)	(6.788)
Constant	30.00***	34.70***
	(4.057)	(5.946)
Periods	1-20	1-20
Period Dummies	Yes	Yes
N	940	960

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. Unreported regressors include Period dummies, and a dummy for random contribution. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

on average lower than IPNMP by 11 tokens, however this difference is not significant. Punishment increases contributions by 10.3 tokens and this effect is significant. On average though, individuals contribute around 6 tokens higher under non-monetary punishment and this effect is statistically insignificant ($p = 0.39$). Our findings are summarized below.

Result 4. *Teams under non-monetary punishment contribute significantly lower than teams under monetary punishment. Without punishment, contribution levels are similar.*

5.2 Punishment Decisions

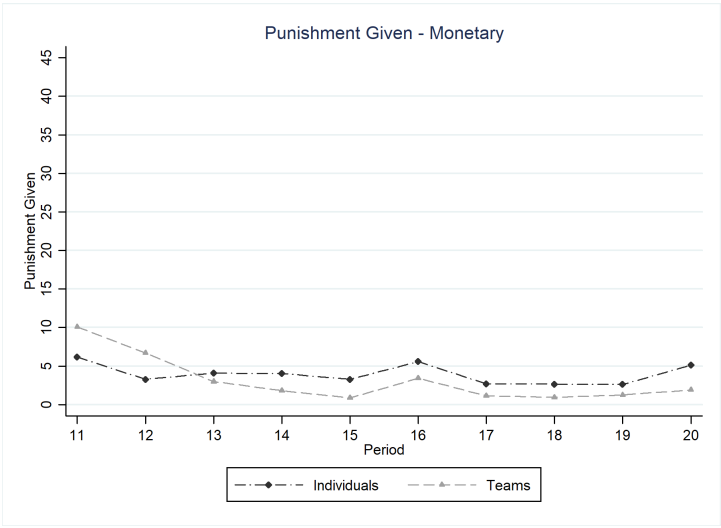
We focus on Hypothesis 5 by analyzing Punishment Decisions across different treatments. Figure 5 plots out the average number of punishment points assigned by a DM. Figure 5(a) compares the punishment decisions across teams and individuals under monetary punishment. We can observe that, barring the first two periods, teams consistently assign a lower number of points. The relatively higher amount of punishment assigned in the first two periods can be attributed to the fact that a

substantial number of teams failed to coordinate in the first two periods, resulting in the computer selecting a high punishment allocation as a result.[12] Furthermore, the consistently lower number of punishment points assigned under teams from Period 13 onward can be attributed to the fact that teams tend to contribute higher than individuals under monetary punishment. In particular, teams on average are very close to the fully cooperative outcome, which indicates why teams don't assign a high number of punishment points very often.

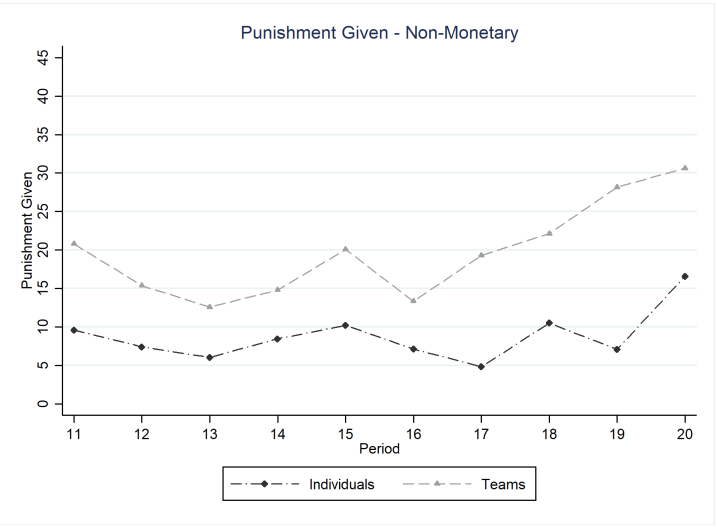
Comparing the trends across non-monetary punishment, we can see that teams on average assign substantially more punishment points than individuals. Furthermore, the number of points assigned on average is increasing in teams. This can be attributed to the fact that 1) teams consistently contribute lower amounts than individuals and 2) contribution tends to decline sharply in teams overtime.

Figure 5: Average Punishment Points Assigned

(a) Monetary



(b) Non-Monetary



We analyze the average team effect on punishment whilst controlling for a Decision Maker's own contribution as well as the other group member's contribution. Table 6 presents results using data of individual punishment assignments to each DM in each Period. Since data is heavily left

[12]Recall that DMs are allowed to assign up to 15 points to each other DM in their group.

censored in Monetary Punishment, we use a Tobit model to estimate the average team effect.[13]

Table 6: Comparing Punishment Decisions

	(1) MP	(2) NMP
	Punishment Given	Punishment Given
Others Contribution	-0.281***	-0.202***
	(0.0436)	(0.0194)
Contribution	0.0190	0.00850
	(0.0373)	(0.0211)
Team	-0.480	0.956
	(2.018)	(1.020)
Constant	4.396**	12.17***
	(2.123)	(1.256)
Periods	11-20	11-20
Period Dummies	Yes	Yes
N	1410	1440

Notes: Standard Errors clustered at Group level in Parentheses. Panel (1) reports results from a Tobit Model. Panel (2) reports results from an OLS regression. Unreported regressors include Period dummies, and a dummy for random punishment.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 yields the following results. As expected, other DMs' contribution has a significant and negative relationship with the number of points assigned. Upon looking at the team effect, we find that under monetary punishment, teams do assign on average 0.48 points lower than individuals, however this effect is not significant. Under non-monetary punishment, we find that teams assign around 1 point higher than individuals however again this effect is not significant. This implies that the the difference in trends can solely be attributed to the fact that teams under monetary punishment contribute more than individuals and, under non-monetary punishment, contribute much lower than individuals.

Result 5. *Controlling for own and other contributions, teams on average assign the same number of points as individuals. This holds true for monetary and non-monetary punishment.*

We also compare the vindictiveness between teams and individuals. We analyze how punishment behavior differs between teams and individuals, conditioning on a decision maker's contri-

[13] 1091 out of 1410 Punishment Decisions were 0.

bution deviation from the contribution of their fellow group members. Table 7 documents these findings.

Table 7: Comparing Vindictiveness

	(1) MP	(2) NMP
	Punishment Given	Punishment Given
Absolute Positive Dev	0.360***	0.221***
	(0.0452)	(0.0188)
Absolute Negative Dev	0.135***	0.00969
	(0.0458)	(0.0331)
Team	-3.018*	2.907***
	(1.675)	(0.936)
Constant	-7.837***	0.924
	(2.519)	(0.630)
Periods	11-20	11-20
Period Dummies	Yes	Yes
N	1410	1440

Notes: Standard Errors clustered at Group level in Parentheses. Panel (1) reports results from a Tobit Model. Panel (2) reports results from an OLS regression. Unreported regressors include Period dummies, and a dummy for random punishment. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We find absolute positive deviation to be significantly and positively correlated with punishment given. Under monetary (non-monetary) punishment, an increase in the positive deviation results in an additional 0.36 (0.221) points assigned to the other decision maker. We find a significant effect for absolute negative deviation as well under monetary punishment, indicating some existence of anti-social punishment.

Controlling for these two factors, we find that teams are actually less vindictive under monetary punishment, in the sense that they assign on average 3 points less than individuals, and this effect is slightly significant. On the other hand, under non-monetary punishment, teams are more vindictive than individuals as they, on average, assign 3 points more, and this effect is highly significant.

5.3 The Effect of Punishment on Contribution

We now turn towards analyzing Hypothesis 6. Table 8 documents the effects of lagged punishment received on changes in contribution under both Monetary and Non-Monetary punishment. We control for lagged contributions and the lagged average of other group member's contributions.

Table 8: Effect of Lagged Punishment - Teams vs Individuals.

	(1) MP	(2) NMP
	Contribution First Difference	Contribution First Difference
Lag Contribution	-0.314***	-0.573***
	(0.0648)	(0.0709)
Lag Other Cont	0.284***	0.360***
	(0.0565)	(0.0862)
Lag Team x PunR	0.0426	-0.161
	(0.0885)	(0.117)
Lag Indiv x PunR	0.357***	-0.0470
	(0.119)	(0.133)
Constant	4.413**	16.92***
	(1.847)	(5.667)
Period	12-20	12-20
Period Dummies	Yes	Yes
N	423	432

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. Unreported regressors include Period dummies, and a dummy for random contribution. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We find that under monetary punishment, individuals raise their current contribution by around 0.4 tokens for each punishment point received. Teams on the other hand exhibit virtually no change in their contribution levels. The difference in responses is statistically significant ($p = 0.0027$). On the other hand, we find virtually no effect of lagged punishment on changes in contribution under non-monetary punishment for both teams and individuals.

Result 6. *Under monetary punishment, individuals increase their contribution more than teams when reacting to lagged punishment. There is no difference in reactions to lagged punishment under non-monetary punishment.*

6 Discussion

We experimentally investigate the behavior of teams in a public goods game with and without a sanctioning environment. We consider sanctions of two kinds: 1) monetary punishment in which decision makers can assign points to reduce others' payoffs at some cost and 2) non-monetary punishment in which decision makers can assign points to indicate their measure of disapproval of others' decisions, which has no impact on earnings. We find that without punishment, contribution behavior is similar across both teams and individuals. We find that monetary punishment increases contributions for both teams and individuals and that non-monetary punishment increases contributions for individuals. In contrast, teams appear to be unaffected by non-monetary punishment. We find that teams contribute significantly lower under non-monetary punishment compared to teams under monetary punishment and individuals under non-monetary punishment.

These findings have some interesting implications. Many real life sanctioning mechanisms make use of both monetary and non-monetary punishment to effectively combat the prevalence of free-riding. For example, the EPA uses both measures against violators of pollution abatement policies. Furthermore, many of these decisions pertaining to public goods provisions and sanctions are undertaken jointly by teams comprising of more than one individual. Given that teams are unresponsive to non-monetary punishment, this does provide an indication for the appeal of using monetary punishment to effectively enhance cooperation.

Furthermore, analyzing team behavior can also give us some insight as to how joint decision making can effectively rule out or overcome certain innate desires that individuals have and take into account when making their decisions. For example, our experiment suggests that individuals do react to non-monetary punishment and increase cooperation. Masclet et al. (2003) observe the same behavior and argue that this effect may stem from the fact that individuals may feel dis-utility from receiving any form of disapproval in a group setting. In contrast, teams don't appear to be effected in the same way. It is highly possible that joint decision making can effectively introduce an "us versus you" dynamic in social dilemma settings which might make teams less sensitive to disapproval from other members, especially if disapproval has no effect whatsoever on their payoffs.

To further investigate the joint decision making process we intend on exploring communication

logs between team members. Recall that in our experiment, team members are allowed to communicate freely with each other in order to coordinate their decisions. These communication logs can reveal valuable information as to the rationale behind joint decision making. We wish to focus on motives pertaining to contribution decisions under the threat of punishment as well as motives for punishing others. We conjecture that punishment decisions are associated with pro-social beliefs i.e. teams punish others more following discussions about putting pressure on others to enhance cooperation (curb free-riding). We also expect to see, under monetary punishment, contribution decisions being motivated by the threat of punishment in the sense that teams contribute higher following discussions that exhibit fear of receiving punishment *or* discussions that exhibit negative emotions pertaining to past punishment. Lastly, we expect teams to disregard non-monetary punishment when coordinating on contributions, however we still expect to see a positive correlation between pro-social beliefs and punishment decisions.

One final point to note is that, contrary to past experiments on public goods games, we observe a substantially high degree of cooperation without sanctions. In contrast, past experimental evidence suggests a rapid decline in cooperation over time, both in teams and individual treatments. We attribute this to the fact that our experimental design utilizes a rather high MPCR of 0.75 whereas past experimental studies use an MPCR of 0.4. An MPCR of 0.75 makes cooperation more likely as it only requires 2 out of 4 decision makers to contribute in order to profit. In contrast, an MPCR of 0.4 requires 3 decision makers to contribute in order to profit, making cooperation all the more difficult. We intend to investigate how behavior changes using a nearly identical design to our experiment, save for the fact that we set an MPCR of 0.4. We conjecture that contribution levels will decline significantly over time in all treatments without punishment. We expect similar results to the above under monetary punishment, however we expect sharper differences between teams under non-monetary and monetary punishment.

Appendix A Additional Results

A.1 Average Contributions at the Group Level

Table A1: Group Contribution Averages - Individuals

	IPMP		IPNMP	
	No Punishment	With Punishment	No Punishment	With Punishment
Group 1	13.925	21.125	44.85	45.6
Group 2	12.325	39.125	17.225	49.925
Group 3	27.6	54	56.25	58.5
Group 4	48.95	57.75	15.75	37.075
Group 5	7.3	29.9	53	50.75
Group 6	56.375	60	46.6	56.15

Table A2: Group Contribution Averages - Teams

	TPMP		TPNMP	
	No Punishment	With Punishment	No Punishment	With Punishment
Group 1	36.925	59.925	42.825	47.35
Group 2	31.825	58.125	21.6	16.3
Group 3	26.925	41.85	26.225	20.375
Group 4	36.775	59.85	30.675	43
Group 5	15.9	49.67	39.975	47.7
Group 6	38.25	60	36.575	41.8

A.2 Analysis of Period Profits

In this section we perform some basic analysis of final period profits under all treatments. For monetary punishment, final period profits are calculated as stage 1 payoffs *net* of received punishment and assigned punishment costs. Under non-monetary punishment, final period payoffs are simply stage 1 payoffs since punishment has no impact on earnings.

In comparing the effect of monetary and non-monetary punishment on profits, we find that on average, profits increase across all treatments under the threat of punishment. Under IPMP, profits increase from 115.5 tokens without punishment to 131.5 tokens with punishment ($p < 0.0001$ - Wilcoxon signed-rank test). Under IPNMP, profits increase from 137.9 tokens without punishment

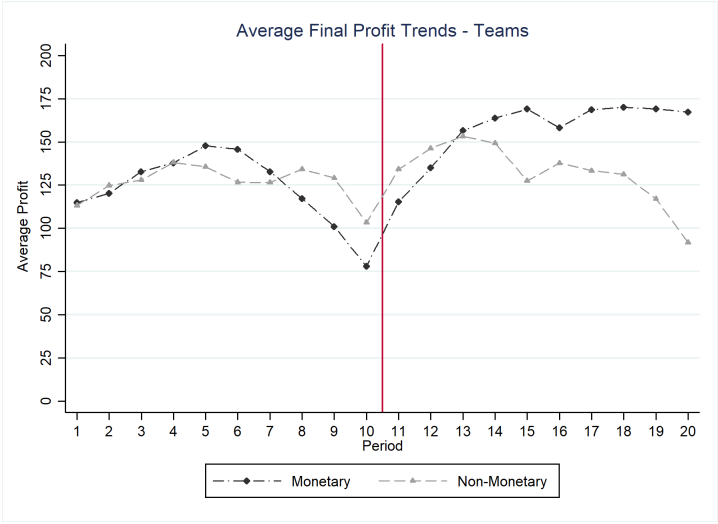
to 159.3 tokens with punishment ($p = 0.0005$). Under TPMP, profits increase from 122.86 tokens to 157.3 tokens ($p = 0.0001$). Finally, under TPNMP, profits increase marginally from 126 tokens to 132.2 tokens ($p = 0.0765$). The results are summarized below.

Result 7. *Profits increase under the threat of punishment in all treatments.*

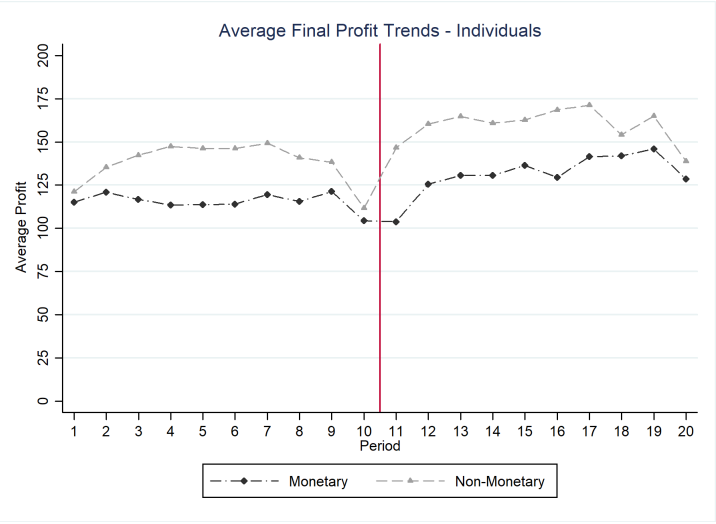
We now compare profits across treatments. Figures A1 and A2 plot final period payoff trends comparing monetary to non-monetary punishment (A1) and comparing teams to individuals (A2).

Figure A1: Profit Levels - Monetary vs Non-Monetary

(a) Teams



(b) Individuals



Across all treatments, profit trends mirror contribution trends for Periods 1-10 (without punishment).[14] We therefore focus on profits with punishment (Periods 11-20). Comparing teams under monetary and non-monetary punishment (Figure A1 (a)), we find that initially, net profits are lower under monetary punishment. This is reflective of the fact that punishment is costly to assign and receive and there is substantial amount of coordination failure in early periods, resulting in random amounts of punishment assigned. We can see, however, that starting from period 13, net profits are higher under monetary punishment and continue to rise, whereas in non-monetary punishment, profits mirror contribution trends and decline. Mann-Whitney U tests over all periods show

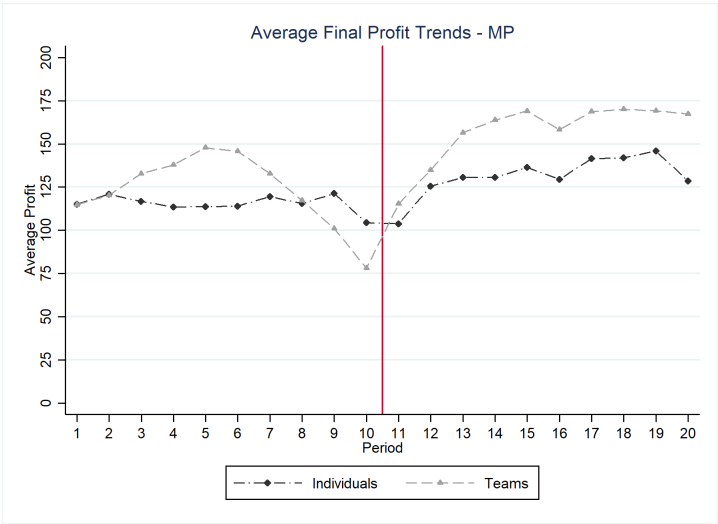
[14]This is unsurprising seeing how profits are simply linear functions of contributions.

that profits under monetary punishment are significantly higher than non-monetary punishment ($p = 0.001$).

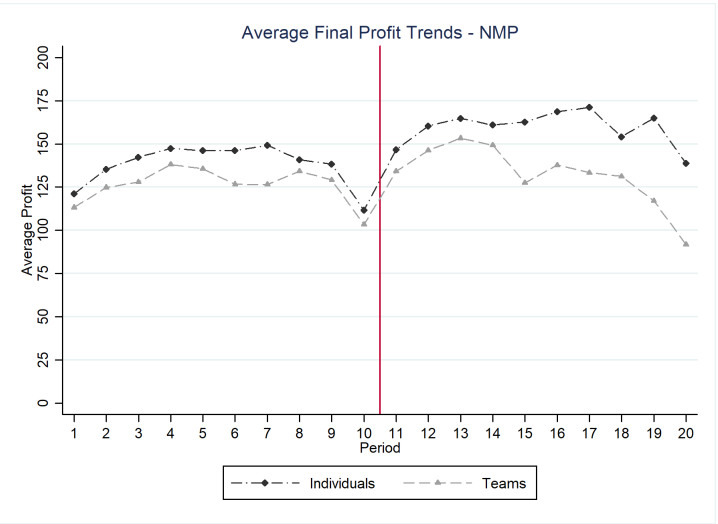
Comparing individuals (Figure A1 (b)), we find that profits are consistently higher under non-monetary punishment. This is understandable, given the fact that individual contributions are on average higher under non-monetary punishment and that punishment is costly under monetary punishment. Mann-Whitney U test reveals that this difference is significant ($p = 0.0477$).

Figure A2: Profit Levels - Teams vs Individuals

(a) Monetary



(b) Non-Monetary



We now turn towards comparing teams and individuals. Figure A2(a) plots profit trends under monetary punishment. We find that, with punishment, teams earn more throughout. This difference is significant ($p = 0.0280$ Mann-Whitney U test) and can be attributed to the fact that teams on average contribute more than individuals and, consequently, punish less. Figure A2(b) plots profit trends under non-monetary punishment. These trends mirror contribution trends, since punishment has no impact on profits. We therefore see teams earning lower than individuals throughout and this difference is significant ($p = 0.0002$ Mann-Whitney U test). These results are summarized below.

Result 8. *Teams earn more under monetary punishment than both individuals under monetary punishment and teams under non-monetary punishment. Furthermore, teams under non-monetary punishment earn less*

than individuals under non-monetary punishment.

Appendix B Robustness Checks

In this section, we present several robustness checks. In the main text, we accounted for randomization in early periods by incorporating a dummy variable that indicates whether or not a decision maker failed to reach a decision in time. We present results here for several regressions in which we drop this dummy variable. Qualitatively, the results are robust to inclusion or exclusion of this dummy variable. We also present some regressions in which we replace the period dummies with a period trend. Once again, we find that our results are robust to incorporating a Period trend.

B.1 Regressions dropping Random Contribution Dummy

This subsection presents results using the specifications in Tables 3, 4, 5 and 8 whilst dropping the random contribution dummy variable. Table B3 is the analog to Table 3, Table B4 is the analog to Table 4, Table B5 is the analog to Table 5 and Table B6 is the analog to Table 8. As mentioned earlier, there is very little difference in the results. All prior results are robust to dropping the random contribution dummy variable.

Table B3: Contribution levels - No Punishment

	(1) Without Punishment
	contribution
Team	-0.963
	(5.878)
Constant	28.69***
	(4.584)
Periods	1-10
Period Dummies	Yes
N	950

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B4: Contribution levels - Teams vs Individuals

	(1) MP	(2) NMP
	contribution	contribution
Team	4.015	-5.967
	(8.621)	(7.752)
Punishment	19.41***	2.827
	(4.584)	(6.179)
Team x Punishment	7.465	-7.613
	(4.681)	(6.097)
Constant	25.82***	31.61***
	(7.174)	(5.764)
Periods	1-20	1-20
Period Dummies	Yes	Yes
N	940	960

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B5: Contribution levels - Monetary vs Non-Monetary Punishment

	(1) Teams	(2) Individuals
	contribution	contribution
MP	-1.218	-11.20
	(4.387)	(10.73)
Punishment	-1.000	10.28**
	(5.356)	(5.129)
MP x Punishment	20.26***	5.183
	(3.608)	(6.788)
Constant	27.89***	34.70***
	(3.475)	(5.946)
Periods	1-20	1-20
Period Dummies	Yes	Yes
N	940	960

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B6: Effect of Lagged Punishment - Teams vs Individuals.

	(1) MP	(2) NMP
	Contribution First Difference	Contribution First Difference
Lag Contribution	-0.314***	-0.573***
	(0.0647)	(0.0709)
Lag Other Cont	0.284***	0.360***
	(0.0565)	(0.0862)
Lag Team x PunR	0.0427	-0.161
	(0.0883)	(0.117)
Lag Indiv x PunR	0.357***	-0.0470
	(0.118)	(0.133)
Constant	4.415**	16.92***
	(1.847)	(5.667)
Period	12-20	12-20
Period Dummies	Yes	Yes
N	423	432

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.2 Regressions with trends

This section reproduces the results in Tables 3, 6, 7 and 8 using a trend rather than Period Dummies. Table B7 is the analog to Table 3, Table B8 is the analog to Table 6, Table B9 is the analog to Table 7 and Table B10 is the analog to Table 8.

Table B7: Contribution levels - No Punishment

	(1) Without Punishment
	contribution
Team	-0.321
	(5.961)
Period	-0.716**
	(0.340)
Constant	37.28***
	(5.303)
Periods	1-10
N	950

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation. Unreported regressor is a random contribution dummy* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B8: Comparing Punishment Decisions

	(1) MP	(2) NMP
	Punishment Given	Punishment Given
Others Contribution	-0.279***	-0.202***
	(0.0429)	(0.0197)
Contribution	0.0198	0.00820
	(0.0369)	(0.0205)
Team	-0.531	0.947
	(2.039)	(1.007)
Period	0.243	0.0862
	(0.184)	(0.0642)
Constant	4.870**	12.08***
	(2.010)	(1.421)
Periods	11-20	11-20
N	1410	1440

Notes: Standard Errors clustered at Group level in Parentheses. Panel (1) reports results from a Tobit Model. Panel (2) reports results from an OLS regression. Unreported regressors include a dummy for random punishment. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B9: Comparing Vindictiveness

	(1) MP	(2) NMP
	Punishment Given	Punishment Given
Absolute Positive Dev	0.354***	0.226***
	(0.0449)	(0.0201)
Absolute Negative Dev	0.127***	0.0145
	(0.0469)	(0.0329)
Team	-3.033*	2.871**
	(1.725)	(0.927)
Period	0.197**	0.266*
	(0.0868)	(0.127)
Constant	-6.915***	-0.110
	(2.355)	(0.762)
Periods	11-20	11-20
N	1410	1440

Notes: Standard Errors clustered at Group level in Parentheses. Panel (1) reports results from a Tobit Model. Panel (2) reports results from an OLS regression. Unreported regressors include a dummy for random punishment. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B10: Effect of Lagged Punishment - Teams vs Individuals.

	(1) MP	(2) NMP
	Contribution First Difference	Contribution First Difference
Lag Contribution	-0.315***	-0.579***
	(0.0677)	(0.0684)
Lag Other Cont	0.279***	0.345***
	(0.0569)	(0.0924)
Lag Team x PunR	0.0603	-0.173
	(0.0960)	(0.128)
Lag Indiv x PunR	0.349***	-0.0352
	(0.123)	(0.141)
Period	-0.455***	-1.492***
	(0.147)	(0.300)
Constant	9.430**	34.64***
	(3.722)	(7.228)
Period	12-20	12-20
N	423	432

Notes: Standard Errors clustered at Group level in Parentheses. Results from Random Effects Regression with a DM as a unit of observation.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C Instructions for Team Treatments

These instructions are adapted and modified from the instructions used in Masclet et al. (2003), Cox and Stoddard (2018) and Auerswald et al. (2018). Instructions for individual treatments are available on request.

Instructions

Welcome and thank you for participating in this economic experiment. This experiment will take approximately 60-75 minutes. If you read the instructions carefully, you can earn a considerable amount of money depending on your decisions and the decisions of others which will be paid to you in cash at the end of the experiment.

Before we begin, we ask that you turn off your cell phones for the duration of the experiment. We also ask that you do not communicate with anyone and only use the experimental software provided to you. Failure to comply with these rules will result in dismissal from the experiment and forfeiture of any earnings you may have otherwise received.

Overview of The Experiment

This experiment consists of **two** parts as well as a small questionnaire in the end. Instructions for Part 1 will be provided below and instructions for Part 2 will be given out after the end of part 1. During the experiment you will earn **'Tokens'**. You will be paid based on the total number of tokens you accumulate during both Part 1 and 2 of the experiment. At the end of the experiment the total number of tokens you earned will be converted to dollars at the following rate:

100 tokens = \$1

You will also receive a show up fee of \$3. Your payment will be paid to you in cash at the end of the experiment.

Team Formation

For the duration of this experiment, you will be making decisions in **teams of two**. At the beginning of the experiment, you will be randomly matched with someone else in the room. You and your partner must decide things together. **You will have the same partner for the whole experiment**. You and your partner will receive the same earnings for the experiment, depending on your teams' decisions and the decisions of other teams.

To facilitate your decision making, you and your partner will be allowed to communicate with each other using a chat box, like instant messaging. These messages will be recorded, however only you and your partner will be able to see them. **When communicating with your partner, we ask that you; 1) Be civil and not use any profanity; 2) do not reveal any personal identifying information.**

Instructions for Part 1

Part 1 of this experiment consists of 10 rounds. At the beginning of Round 1, your team will be **randomly and anonymously** assigned to a group with 3 other teams. Therefore, each group will have 4 teams. This group will remain fixed for all of Part 1.

At the beginning of each round your team will receive 60 tokens. These 60 tokens are referred to as your team's endowment. Your team's decision in each round is to choose how many tokens from your team account to contribute to a group project and how many to keep for your team. Your team must make this decision without knowing the decisions of the other teams in your group.

Each Token that your team keeps earns your team 1 Token. For every Token your team contributes to the group project, the group project increases by one Token. Your team's earnings from the group project are equal to 0.75*the total number of tokens contributed to your group's project. All other teams in your group will also earn 0.75*the total number of tokens contributed to the group project.

You will have **2 minutes** (120 seconds) to decide how much of your endowment to keep for your team and how much to contribute to the group project. You should use the chat box to communicate with your partner before deciding.

Once you decide on a contribution, press the **"Send Choice"** button. You will then see your and your partner's contribution suggestions. If your suggestions don't match, you will be asked to

revise your decision. If your decisions match, you will be allowed to continue. At this point, **both of you must click the Continue button to finalize your decision**. If you fail to reach a decision, the computer will choose a random contribution for your team. This is just to ensure that the experiment continues as scheduled and should not be used as an option.

After all teams in your group have made their decision your screen will show you the total number of Tokens contributed to the group project, the breakdown for what each team contributed, whether the team's decision was joint or random and your earnings for this round. Note that the IDs of other teams in your group are randomly shuffled every round. You will not know which ID corresponds to which team.

Your teams' earnings consist of two parts:

1. The Tokens your team decided to keep
2. The total contribution of all 4 teams to the group project * 0.75.

That is your team's earning for each round will be equal to:

(60 – your team's contribution) + 0.75*(total number of tokens contributed to the Group project)

Earnings of each team from the project are calculated the same way. Note, that each of you will earn whatever your team earns (i.e. you and your partner will both get your teams' earnings).

To test your understanding of the experiment, we would like you to answer the following questions. We will go over the answers. If you have any questions, raise your hand and an experimenter will come to answer them.

Questions for Part 1

1. Your partner will remain the same for the whole experiment (True/False) _____
2. The teams in your group will change every round (True/False) _____
3. You and your partner will both be paid your team's earnings (True/False) _____
4. How many tokens are in your team account at the start? _____
5. Each token your team contributes to the group project raises the earnings of _____ teams in your group by _____ tokens.

6. Each token contributed to the group project by other teams raises your teams' earnings by _____ tokens

7. Suppose your team contributes X tokens to the project and the other teams contribute 0. Each team gets _____ tokens from the project.

8. Suppose your team and all the other teams in your group contribute a total of Y tokens. Each team gets _____ tokens from the project.

Instructions for Part 2 - Monetary Punishment

Part 2 of the experiment also has 10 rounds. At the beginning of Round 1, your team will be assigned to the **same group as in Part 1**. Therefore, each group will have 4 teams. This group will remain fixed for all of Part 2. Each round consists of 2 stages. Your earnings for each round depend on the decisions in both stages.

Stage 1

Stage 1 is identical to what you have done in Part 1: Your team will receive 60 tokens and must decide how much to keep or contribute to the group project. Your potential earnings from stage 1 will be the same as in part 1.

(60 – your team's contribution) + 0.75*(total number of tokens contributed to the Group project)

Stage 2

At the beginning of Stage 2, your screen will show you the total number of Tokens contributed to the group project, the breakdown for what each team contributed, whether the team's decision was joint or random and your earnings for the first stage. Note that the IDs of other teams in your group are randomly shuffled every round. You will not know which ID corresponds to which team.

At this point your team can assign between 0 and 15 points to what each of the other teams contributed to the group project as a measure of your disapproval of what each team did. Each point your team assigns to a team **costs your team** 1 token and **costs the other team** 3 tokens. Each other team has the same opportunity to assign points as well. Your team must make this decision without knowing the decision of the other teams in your group.

Each team will have **90 seconds** to decide on whether to issue disapproval points and, if so, how many to each other team. Once again you should plan on doing this in consultation with your partner via the chat box. Once you reach a decision, click the **"Send Choice"** button. The screen will display whether you and your partner have made the same decision as well as the total cost of your assigned points. If you and your partner have not made the same decision, you will be asked to revise your decision. If you and your partner have made the same decision, you will be allowed to continue. **Both you and your partner must click "continue" to finalize your decision**. If either you or your partner fail to reach a decision in time, the computer will randomly decide for your team. This is just to ensure that the experiment continues as scheduled and should not be used as an option.

How much a team's earnings from the first stage are reduced depends on the total number of points received from all other teams. The reduction from receiving points **cannot exceed** your stage 1 earnings, however, your team must still bear the cost of assigning disapproval points.

After every team has made their decision in stage 2, you will be provided information on your teams' earnings in stage 1, the total points your team assigned, the total number of points received by your team and your teams' final earnings for the round. Your teams' final earnings are calculated as:

1) If your earnings from stage 1 are higher than the reduction by receiving points:

Your team's earnings = (Your team's earnings from stage 1) – [3 x (total received points)] - total assigned points

2) If your earnings from stage 1 are less than (or equal to) the reduction by receiving points:

Your team's earnings= 0 – total assigned points

As in part 1, each of you will earn whatever your team earns (i.e. you and your partner will both get your teams' earnings).

To test your understanding of the experiment, we would like you to answer the following questions. We will go over the answers. If you have any questions, raise your hand and an experimenter will come to answer them.

Questions for Part 2

1. Stage 1 is identical to Part 1 in the experiment (True/False) _____
2. Each point your team assigns to another team in your group costs your team _____ tokens.
3. Each point your team is assigned costs your team _____ tokens.
4. Suppose your team assigns X points to team A, Y to team B and Z to team C. The total cost of your assigned points is _____ tokens.
5. Suppose your team is assigned X points from the other teams in your group. This reduces your team's earnings by _____ tokens.

Instructions for Part 2 - Non-Monetary Punishment

Part 2 of the experiment also has 10 rounds. At the beginning of Round 1, your team will be assigned to the **same group as in Part 1**. Therefore, each group will have 4 teams. This group will remain fixed for all of Part 2. Each round consists of 2 stages.

Stage 1

Stage 1 is identical to what you have done in Part 1: Your team will receive 60 tokens and must decide how much to keep or contribute to the group project. Your potential earnings from stage 1 will be the same as in part 1.

(60 – your team's contribution) + 0.75*(total number of tokens contributed to the Group project)

Stage 2

At the beginning of Stage 2, your screen will show you the total number of Tokens contributed to the group project, the breakdown for what each team contributed, whether the team's decision was joint or random and your earnings for the first stage. Note that the IDs of other teams in your group are randomly shuffled every round. You will not know which ID corresponds to which team.

At this point your team can assign between 0 and 15 points to what each of the other teams contributed to the group project as a measure of your disapproval of what each team did. **The points your team assigns to other teams cost your team nothing. Similarly, the points received by**

your team has no impact on your team's earnings. They just represent your disapproval of other teams' choices in stage 1.

Each team will have **90 seconds** to decide whether or not to assign disapproval points and if so, the number of points to assign to each other team. Once again you should plan on doing this in consultation with your partner via the chat box. Once you reach a decision, click the **"Send Choice"** button. If you and your partner have not made the same decision you will be asked to revise your decision. If you and your partner make the same decision, you will be allowed to continue. **Both you and your partner must click "Continue" to finalize your decision**. If either you or your partner fail to reach a decision in time, the computer will randomly decide for your team. This is just to ensure that the experiment continues as scheduled and should not be used as an option.

After every team has made their decision in stage 2, your screen will show your team's earnings in stage 1, the total number of points your team assigned, and the total number of points your team received and your team's final earnings for the round.

Your team's earnings = Your team's earnings from stage 1.

As in part 1 each of you will earn whatever your team earns (i.e. you and your partner will both get your teams' earnings).

To test your understanding of the experiment, we would like you to answer the following questions. We will go over the answers. If you have any questions, raise your hand and an experimenter will come to answer them.

Questions for Part 2

1. Stage 1 is identical to Part 1 in the experiment (True/False) _____
2. You will have between _____ and _____ disapproval points to send to other teams in stage 2.
3. Each point you assign to another team results in _____ disapproval points for that team.
4. The points you assign cost your team nothing (True/False) _____
5. The points other teams assign your teams cost your team nothing (True/False) _____

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