VOTING, PUNISHMENT, AND PUBLIC GOODS

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Researchers have found that voting can help increase voluntary contributions to a public good—provided enforcement through a third party. Not all collective agreements, however, guarantee third-party enforcement. We design an experiment to explore whether a voting rule with and without endogenous punishment increases contributions to a public good. Our results suggest that voting by itself does not increase cooperation, but if voters can punish violators, contributions increase significantly. While costly punishment increases contributions at the price of lower efficiency, overall efficiency for a voting-with-punishment rule still exceeds the level observed for a voting-without-punishment rule. (*JEL* C92, D72, H41)

I. INTRODUCTION

This paper examines whether a nonbinding vote promotes cooperation in a linear public-good experiment. The vote is nonbinding because no third-party authority exists to enforce the voting outcome. We also examine how cooperation increases when voters punish those who do not adhere to the voting outcome.

The motivation behind examining voting institutions in public-good settings is that in many real-world situations people work as a collective to set policy rules to manage common property and to assign individual contributions to public goods, for example, summits of international organizations, environmental quality councils, or school board meetings. Rather than choosing between cooperation versus noncooperation or selecting an individual level of contribution, people in large groups frequently use a voting procedure to coordinate their efforts. Most experimental research on public or common goods, however, has focused on individual decisions rather than voting rules.[1] Walker et al. (2000) (WGHO) are an exception. They were the first to consider the efficiency implications of a combined common-property-with-voting allocation scheme in the laboratory. Group members voted on a proposal over how much everybody should contribute to the common good. All votes were binding, and a third-party authority guaranteed all voters abided by the majority proposal.[2] Their evidence

*We would like to thank Simon Gächter, Wolfgang Luhan, Peter Matthews, Matthias Sutter, two anonymous referees, the journal editor, and seminar participants at the meetings of the Public Choice Society, Canadian Economics Association, Austrian Economics Association, Colorado University Environmental and Resource Economics workshop, St. Lawrence University, California State University Sacramento, Loyola Marymount University, and University of California Davis for useful comments. We also thank St. Lawrence University for a research grant to fund this project and Vivek Bachhawat for programming the software. Most of this research was conducted while the first author was a faculty member at St. Lawrence University. He is also grateful to the Austrian Science Foundation (FWF, Project P16617) for financing his stay at the University of Innsbruck, while this paper was completed.

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1. For overviews, see, for example, the books by Ostrom (1990) and Ostrom, Walker, and Gardner (1994) and the survey articles by Ostrom (1998, 2000), Ledyard (1995), and Fehr and Gächter (2000a).

2. Footnote 4 in WGHO: "Note that the setting we investigate assumes the existence of an authority with the power to implement an adopted rule." This assumption is not important for the focus of their investigation, which is rather what kind of rule will be adopted than whether a rule will be adopted and obeyed or not.

ABBREVIATION

WGHO: Walker, Gardner, Herr, and Ostrom

Economic Inquiry
(ISSN 0095-2583)
Vol. 45, No. 3, July 2007, 557–570

doi:10.1111/j.1465-7295.2007.00028.x
Online Early publication February 13, 2007

suggests that people cooperate more with perfectly enforced voting rules relative to a no-vote scheme.[3]

We believe it is important to examine the effect of relaxing the assumption of perfect enforcement since not all common-property or public goods have such an external authority to guarantee enforcement of a proposal agreed on by majority rule. For instance, international environmental treaties between sovereign nations suffer from frail enforcement mechanisms (see Barrett 2003). The Kyoto protocol over climate change is the prime example. Within the protocol, no third-party mechanism exists to enforce the attainment of the carbon reduction targets and timetables for the sovereign signatory nations (e.g., members of the European Union, Japan). Smaller scale common-property goods like fisheries and irrigation communities do have supra authorities de jure, but de facto these external authorities can either be disinterested or lack the resources to monitor, enforce, and sanction any policy rule (Dolsak and Ostrom 2003). Evidence from the field suggests that these regimes are better built and enforced endogenously within the collective (see the overview in Ostrom, Walker, and Gardner 1994, chapter 12). Ostrom (1990, p. 94) notes that "[i]n these robust institutions, monitoring and sanctions are undertaken not by an external authority but rather by the participants themselves." An institution with many participants, however, can generate the need for a formal institutional mechanism such as voting, as opposed to a pure face-to-face communication system (WGHO). This voting might be nonbinding per se, but informal social sanctions defined by the collective can help enforce the voting outcomes (e.g., a small financial penalty coupled with reputation loss). Ostrom (1990, see Table 5.2, p. 180) reviewed 15 self-organized collectives around the globe, and her results suggest that these sanctions seem to be a necessary condition for robust institutional performance.

Experimental research on the effects of nonbinding voting and voting with little consequence has generated ambiguous results.[4] Some evidence suggests that majority voting "brings everybody on the same page" or generates a social norm. Feld and Tyran (2002) observed in their tax experiments that a fine on tax evasion endogenously agreed on by majority vote resulted in higher tax compliance than an exogenously determined fine (or no fine at all). Tyran (2004) found that voters tend to agree to a costly proposal if they expect that others will approve as well. Voting on policies that do not change the Nash equilibrium in public goods games also influences overall contribution levels (Sutter and Weck-Hannemann 2004; Tyran and Feld 2006). In contrast, Messer, Kaiser, and Schulze (2005) found that voting by itself had little effect on contributions in their public-good experiments.

We are interested in more than nonbinding voting—we also consider whether adding explicit opportunities to punish those who do not abide by the majority vote can reduce the inefficiencies that arise from imperfect enforcement. We introduce a punishment mechanism into a public-good-with-voting experiment. By combining a punishment mechanism with the voting rule, we bring into play Ostrom's (2000) observation that three types of subjects inhabit public-good and common-property experiments—"conditional cooperators" and "willing punishers," in addition to the standard "rational egoists." Conditional cooperators initiate cooperation only when they expect others to reciprocate.[5] Willing punishers will bear some private cost to sanction others. In our voting-with-punishment environment, cooperation could increase since *conditional cooperators* should go along with a nonbinding majority vote because they expect *rational egoists* to contribute now to avoid being punished by the *willing punishers*. In a related (no-vote) public-good game, Fehr and Gächter (2000b) observed that cooperation

3. Margreiter, Sutter, and Dittrich (2005) found that homogeneous groups as in WGHO are more likely to reach an efficient outcome than heterogeneous groups in an equivalent situation.

4. In a sense, nonbinding voting resembles cheap talk, which has also generated ambiguous effects: while some researchers have observed no or very limited effect of cheap talk in several experimental studies (e.g., Cason and Gangadharan 2002; Kroll, Mason, and Shogren 1998), others found that cheap talk can increase cooperation even when the equilibriums of the game are suboptimal (e.g., Croson, Boles, and Murnighan 2003; Duffy and Feltovich 2002; Ostrom 2000).

5. In a one-shot public game experiment, Fischbacher, Gächter, and Fehr (2001) found that around 50% of their subjects were conditional cooperators.

rates increased substantially when the willing punishers had the opportunity to punish. They found that just the threat to punish can be enough to coerce others to cooperate (especially in later rounds), without even exercising the threat.[6,7]

Punishment had also some effect in Bochet, Page, and Putterman (2006), but they observed that the two influential forms of communication—face-to-face and chat room communication—had a bigger impact on cooperation than giving the subjects punishment opportunities without communication. Cooperation was still significantly greater in a treatment with punishment opportunities (and without any communication) compared to the baseline treatment without punishment or communication.[8]

In a setup similar to Fehr and Gächter, Masclet et al. (2003) compared monetary and nonmonetary punishment, that is, cheap talk. They found that both regimes increase cooperation rates relative to a regular individual contribution game, but cooperation in the nonmonetary punishment treatment declines faster. Cheap talk was not enough to maintain contribution levels as the players learned there was "no bite behind the bark." In addition, if both monetary and nonmonetary sanctions were available, contributions and welfare increased compared to when only one sanction is available (Noussair and Tucker 2005).[9]

Herein, we combine the key elements of the WGHO and Fehr and Gächter experimental designs to examine whether cooperation occurs without third-party enforcement. We compare this treatment against the lower and upper benchmarks in a treatment without voting and one with binding votes. Using a classic linear public-good game,[10] we observe that cooperation does occur under voting, but the opportunity to punish is important. Without this punishment condition, voting degenerates quickly into cheap talk, and the rates of cooperation are not substantially higher compared to a standard public-good game with individual contributions and without voting. Providing the opportunity to punish voters who ignore the majority proposal increases cooperation and efficiency rates substantially. Our results suggest that punishment works even under the constraints of an exogenous institution, the voting mechanism.

II. THEORY AND EXPERIMENTAL DESIGN

A. Theoretical Framework

Following Fehr and Gächter (2000b), we examine a linear public goods environment. In the basic framework without punishment opportunities, each individual i divides her endowment E into contributions to a public good, x_i ($0 \leq x_i \leq E$), and a private good, $E - x_i$. The n members of a group make their contribution decisions independently and simultaneously, and the monetary payoff π_i^o for each member i is

$$\pi_i^o = E - x_i + aX, \qquad (1)$$

in which $0 < a < 1 < na$, where a is the marginal per capita return from a contribution to the public good, and $X = \sum_{k=1}^{n} x_k$. The constraint on a ensures that the individually optimal contribution to the public good is zero, although the socially optimal outcome is

6. This observation contrasts the observation of Ostrom, Walker, and Gardner (1992) that sanctions alone were not enough to increase cooperation, but sanctions combined with face-to-face communication were sufficient.

7. Note, however, that Nikiforakis (2004) found that "counterpunishment," the opportunity of punishing the punishers, has a strong negative effect on contribution and efficiency levels in a public-good setup similar to the one in Fehr and Gächter (2000b).

8. Different punishment rules used in Decker, Stiehler, and Strobel (2003) also yielded higher contribution levels but not all of them resulted in higher efficiency.

9. A growing literature has emerged on using rewards in addition to punishment (Andreoni, Harbaugh, and Vesterlund 2003; Dickinson 2001; Offerman 2002; Sefton, Shupp, and Walker 2006). The main findings in this literature indicate that punishment mechanisms are used more frequently and are more successful than rewards in several different settings, but a synergistic effect arises from having both mechanisms available. In addition, Walker and Halloran (2004) reported no difference in contribution and efficiency levels across treatments with and without reward and sanction mechanisms in one-shot public-good games.

10. There are two differences between our experiment and that of WGHO: we are using a public-good game that is strategically similar to a common pool resource game with closed access (as in WGHO) and in our experimental setup there is merely one element in the core—no coalition smaller than the entire group can agree on a proposal that would make them better off compared to the noncooperative case and could win a vote. In WGHO, a minimum winning coalition other than the entire group can form, and WGHO examined whether this coalition would settle for an outcome that maximizes the payoffs for the members of the majority but puts the members of the minority at a disadvantage.

achieved when all group members contribute their entire endowments to the public good.

When a punishment mechanism is added to the voting scheme, a group member can be punished by one or more peers if she deviates from an agreed-upon contribution scheme. Using the specific punishment mechanism of Fehr and Gächter (2000b), we define $c_{i,j}$ as the punishment that member i imposes on nonabiding member j, with $0 \leq c_{i,j} \leq 10$ and $c_{i,j}$ an integer, and we define $f(c_{i,j})$ as the fee function that indicates how much member i pays to be able to punish nonabiding member j, whereby $f(c_{i,j})$ is positive and strictly increasing in $c_{i,j}$. With $f_i = \sum_{j=1, i \neq j}^{n} f(c_{i,j})$, a member abiding by the scheme receives the payoff:

$$(2) \qquad \pi_i = \pi_i^o - f_i.$$

A nonabiding group member—a cheater—can be punished by other group members reducing her payoff. We cap punishment $p_i = (1 - c_i/10)$ at 100% of the income, whereby $c_i = \sum_{j=1, i \neq j}^{n} c_{j,i}$ indicates the total amount others have contributed to punish member i. The payoff of i can then be written as:

$$(3) \qquad \begin{aligned} &\pi_i = p_i \pi_i^o - f_i \quad \text{if } c_i \leq 10 \\ &\text{or} \\ &\pi_i = -f_i \quad \text{if } c_i > 10. \end{aligned}$$

An aggregate punishment of c_i decreases i's earnings by $c_i \times 10\%$ provided that c_i does not exceed 10. If c_i exceeds 10, group member i loses all of his or her earnings (but not more if he or she does not punish somebody else).

Because of the fee function f_i, a punisher i can end up with a negative payoff in a given period, which occurs when a proposal wins a majority vote, at least one other member j decides to ignore the majority proposal, and member i chooses to punish j high enough. Since the focus of this paper is on the voting institution and the norms it might generate, and not on punishment per se, we chose a design that allows punishment only in periods in which there was a majority vote and for those members who do not adhere to this majority vote. We exclude the motives of "blind revenge" (Ostrom, Walker, and Gardner 1992) or raising one's own *relative* payoff by "punishing" others independent from their contributions (Saijo and Nakamura 1995).

TABLE 1
Punishment Level and Associated Costs

Punishment $c_{i,j}$ for group member j	0	1	2	3	4	5	6	7	8	9	10
Costs $f(c_{i,j})$ for group member i	0	1	2	4	6	9	12	16	20	25	30

B. Experimental Design

One hundred and forty students from St. Lawrence University participated in a computerized public goods experiment with four treatments in 14 sessions.[11] The parameters chosen for each period are $E = 10$ tokens, marginal return $a = 0.4$, and number of group members $n = 5$.

Table 1 shows the fee function $f_i = f(c_{i,j})$ for the punishment mechanism, which is the same as in Fehr and Gächter (2000b) and Masclet et al. (2003). Each punishment point decreases the earnings of the subject for that period by 10%. For example, if one subject punishes another subject with five points, the punished subject lost 50% of her earnings in that period (plus whatever she lost due to punishment from other group members), while the punisher lost nine tokens in this period.

Other features of the experimental design include the following: only if a subject decides to punish a cheater, can he or she lose tokens in that period; a subject can always avoid being punished by adhering to the majority proposal; a subject can always avoid getting a negative payoff in a period by not punishing any cheaters; and if no proposal gets a majority vote, no one can be punished in that period. Also, a group stays the same throughout the experiment (the "partner" design).

The experiment has four treatments: *individual contribution baseline*, *binding vote*, *nonbinding vote*, and *nonbinding vote with punishment*. Each treatment consists of two 10-period stages. In the first stage, subjects play an operational game—a standard public goods

11. A session of the experiment lasted on average 95 min, including reading the instructions. The exchange rate is 10 tokens = \$0.60, and subjects earned on average \$19.50. Vivek Bachhawat wrote all programs for this experiment. Fehr and Gächter (2000b) and other public goods experiments have been conducted on "*z*-tree," developed by Fischbacher (1999).

contribution game—that is identical across treatments. The second stage varies across the four treatments to examine the impact of voting with punishment on behavior in the public-good game. As in Fehr and Gächter (2000b), subjects are unaware at the beginning of each treatment that there will be an additional ten periods after Period 10 ended.

Individual-Contribution-Baseline Treatment. Group members continue to play the operational game in the second stage of the treatment. There are no changes in institutional rules across stages, only a brief pause between stages to mimic the other treatments (the subjects do not know during Periods 1–10 that they would play an identical game in Periods 11–20). The structure of this treatment can be summarized like this (O represents the operational game):

	Periods 1–10	Periods 11–20
Individual Contributions	O, O, . . ., O	O, O, . . ., O

Binding-Vote Treatment. In each period in Stage 2, every group member can electronically make a proposal on how much members should contribute to the public good. Once proposals are made, they are listed anonymously on the computer screen, whereby identical proposals by different members are listed only once. Group members then vote for one of the proposals. If a proposal receives three or more votes, it is automatically imposed on the group members. If no proposal is made or no proposal receives an absolute majority, then (and only then) the operational game is played. The structure of this treatment can be summarized like this (V represents the voting stage, and letters in parentheses indicate that the stage might not be played in that period):

	Periods 1–10	Periods 11–20
Binding vote	O, O, . . ., O	V (O), V (O), . . ., V (O)

Nonbinding–Vote Treatment. Subjects confront the same framework as in the binding-vote treatment except that the vote is nonbinding—a proposal that receives a majority vote is not imposed on group members, rather members only observe the voting results prior to playing the operational game. The structure of this treatment can be summarized like this:

	Periods 1–10	Periods 11–20
Nonbinding vote	O, O, . . ., O	V O, V O, . . ., V O

Nonbinding-Vote-with-Punishment Treatment. As in the nonbinding–vote treatment, Stage 2 has group members making proposals, voting, and playing the operational game. But while the vote is still not binding, this treatment introduces a punishment opportunity—group members can now punish others in the group who do not adhere to a majority voting outcome. If no proposal gets a majority vote, no one can be punished in that period. The structure of this treatment can be summarized like this (P represents the punishment stage):

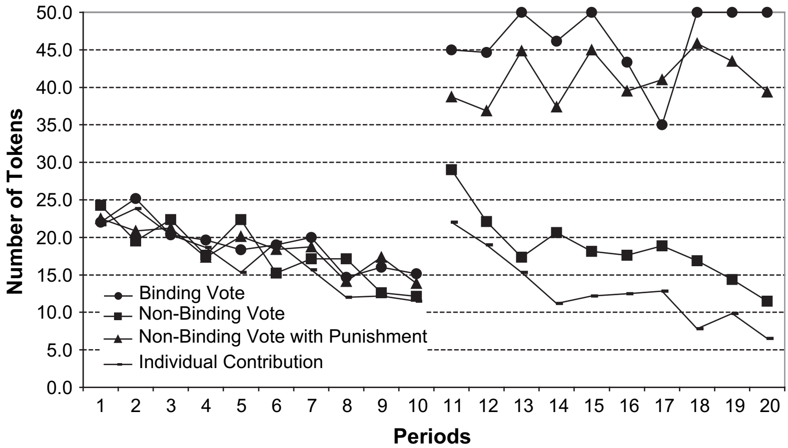
	Periods 1–10	Periods 11–20
Nonbinding vote with punishment	O, O, . . ., O	V O (P), V O (P), . . ., V O (P)

Six groups participated in the individual-contribution-baseline treatment, six groups in the binding-vote treatment, eight groups in the nonbinding–vote treatment, and eight groups in the nonbinding-vote-with-punishment treatment. Each group consisted of five subjects.

With four treatments, six pairwise comparisons of cooperation and efficiency are possible. The individual-contribution-baseline and binding-vote treatments are the baseline treatments. Since previous work has shown limited and declining cooperation in the basic public-good game (e.g., Ostrom 2000) and significantly greater cooperation in the presence of a binding voting mechanism (WGHO), we expect that these two treatments set the lower and upper contribution benchmarks against which we compare the impact of the voting/punishment rules.

A theoretical difference also exists between the second stage of the binding-vote treatment and the other three treatments: the binding-vote treatment is the only treatment with multiple subgame-perfect equilibriums, one of which consists of efficient contributions in each period. In the subgame-perfect equilibriums of the other three treatments, nobody

FIGURE 1
Aggregate Group Contributions



contributes in any period since the dominant strategy in the last period is not to contribute and, in the nonbinding-vote-with-punishment treatment, not to punish.

III. RESULTS: CONTRIBUTIONS

Figure 1 provides an initial overview of the aggregate group contributions by stage and treatment. We first review Stage 1 (Periods 1–10), in which subjects participated in the operational game across all four treatments. Observed behavior in Stage 1 of each treatment replicates the general findings reported in the literature (Ostrom 2000): contribution levels are greater than the theoretically predicted zero, and although levels decline over time they remain above zero. Group members initially contributed about 46% of their endowments (23 tokens) to the public good and decreased contributions to about 27% (13 tokens) in Period 10. Mann-Whitney tests found that contribution levels in the baseline stage are statistically equivalent across the four treatments.

In Stage 2 (Periods 11–20), subjects were introduced to one of four treatment variables: individual contribution baseline, binding vote, nonbinding vote, and nonbinding vote with punishment. Figure 1 provides a general illustration of the relative impact of each treatment variable on contribution levels. A preliminary review reveals substantial variation in contribution levels across treatments. As Figure 1 illustrates, the restart of the individual contribution baseline setting temporarily increases contribution levels similar to those observed at the beginning of Stage 1 (45%), but contributions return to levels observed at the end of Stage 1 within four periods and continue to decline to 13% at the end of Stage 2.[12] In the binding-vote treatment, groups initially contributed about 90% of their endowments to the public good, and the level of contributions remained high throughout Stage 2, reaching 100% in the final three periods. The nonbinding–vote treatment yielded contribution levels that correspond closely to those observed in the individual-contributions treatment—after an initial increase, contribution levels fell to 35% within three periods and to 23% by the end of Stage 2. Contributions in the nonbinding-vote-with-punishment treatment initially reached about 80% of group endowments and remained at or above this level throughout Stage 2.

Figure 1 illustrates two primary issues: the relative impact the treatment variables have on contribution levels and whether any effect is transitory or not. We address these issues

12. The observation that restarting a public-good experiment, even with the same groups, briefly increases cooperation is not a new result. See Figure 1 in Isaac and Walker (1988). More recently, Cookson (2000) observed that contribution levels returned on average to about 50% after each of three restarts in a repeated linear public-good game similar to ours.

with a between- and within-treatment analysis estimating panel models that control for subject- and round-specific effects. The between-treatment analysis estimates the treatment effects on contribution levels with the following model:

$$C_{it} = \beta_0 + \sum_{j=1}^{3} \beta_j \text{Treatment}_{j+1} + \psi_t + \omega_i + \varepsilon_{it}, \quad i = 1,2,\ldots,N;\ t = 1,2,\ldots,T \tag{4}$$

where the dependent variable, C_{it}, denotes the ith subject's contribution to the public good in period t; Treatment_j is a set of three dummy variables (baseline omitted) representing which treatment the ith subject participated in; ψ_t captures time-specific effects on contributions; ω_i captures individual subject effects; β_0 is the constant term; and ε_{it} represents the contemporaneous error term.[13] The model is estimated using only data from Stage 2 since no treatment variation exists in Stage 1. Table 2 presents the estimated coefficients from Equation (4).

We extend the between-treatment analysis with a similar within-treatment analysis to more fully explore whether any treatment effect is transitory or not. We estimate Equation (4) for each treatment separately using data from Stages 1 and 2, which provides within-treatment estimates of treatment effects. For the within-treatment estimates, the three treatment dummy variables fall out of the model, and the vector of period dummies is central to addressing two primary questions. First, estimates provide additional evidence of treatment effects by estimating relative contribution levels between the baseline (Stage 1) and the treatment (Stage 2) settings.[14] Second, estimates reveal whether contribution levels vary over time within the baseline and treatment settings. We expect, from previous research, that estimates will reveal a decline in contribution levels in Stage 1 and that estimates from Stage 2 will indicate whether any treatment effect is transitory or not.[15] Table 3 reports the within-treatment panel estimates.

TABLE 2
Between-Treatment Individual Contribution Analysis

	Coefficient	***p* Value**
Constant	3.37	0.000
Binding vote	6.70	0.000
Nonbinding vote	1.14	0.027
Nonbinding vote with punishment	5.66	0.000
χ^2	1,400	
N	276.02 ($p < 0.0001$)	

Notes: Dependent variable is individual contribution, panel estimates with individual and round effects. Model is estimated using data from Stage 2 (Rounds 11–20) in which treatments vary.

The binding-vote treatment introduced a voting mechanism that automatically implements the outcome established by a majority vote. The between-treatment estimates reported in Table 2 indicate that the binding vote rules had a highly significant impact on contributions ($p < 0.001$), with subjects contributing 6.7 more tokens (from an endowment of 10) in the binding-vote treatment than the individual contribution baseline. Estimates from the within-treatment model confirm this result by finding that individual contributions in the binding vote setting (Stage 2) are significantly greater than those in the Stage 1 baseline setting ($p < 0.001$) but also reveal the highly significant difference persisted over all ten periods of Stage 2—implying that the treatment effect is significant and permanent. Results indicate that groups generally identified the socially optimal outcome, and the binding vote mechanism led to the realization of that outcome. This finding is consistent with the results from WGHO.

Binding vote result: Binding voting significantly and permanently increased contributions to the public good.

13. Due to subjects participating in a single treatment, subject-specific heterogeneity is modeled as random effects.

14. This within-treatment estimate of treatment effects complements the between-treatment estimate by enabling period-specific effects to differ across treatments.

15. We omit Period 10 from the vector of period dummies so estimates show how the introduction of the treatment variable in Period 11 impacts contributions, while also showing whether any initial treatment effect persists (i.e., returns to Period 10 levels).

TABLE 3
Within-Treatment Individual Contribution Analysis

	Individual Contributions		Binding Vote		Nonbinding Vote		Nonbinding Vote With Punishment	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Constant	2.300***	4.604	3.033**	6.323	2.425***	5.713	2.775***	5.668
Period 1	2.033***	3.799	1.367***	2.208	2.425***	4.040	1.725***	2.864
Period 2	2.467***	4.609	2.000*	3.231	1.475**	2.457	1.400**	2.325
Period 3	1.767***	2.678	1.033	1.669	2.050***	3.415	1.475***	2.449
Period 4	1.433***	2.678	0.900	1.454	1.100*	1.832	0.700	1.162
Period 5	0.767	1.433	0.633	1.023	2.050***	3.415	1.250**	2.076
Period 6	1.567***	2.927	0.767	1.239	0.625	1.041	0.900	1.494
Period 7	0.833	0.852	0.967	1.562	1.250**	2.082	0.975	1.619
Period 8	0.100	0.187	0.100	−0.162	1.050*	1.749	0.050	0.083
Period 9	0.200	0.375	0.167	0.269	0.100	0.167	0.700	1.162
Period 10	—	—	—	—	—	—	—	—
Period 11	2.100***	3.924	5.967***	9.639	3.375***	5.622	4.975***	8.261
Period 12	1.500***	2.803	5.900***	9.531	2.000***	3.332	4.600***	7.638
Period 13	0.767	1.433	6.967***	11.254	1.050*	1.749	6.200***	10.295
Period 14	−0.067	−0.125	6.200***	10.016	1.700***	2.832	4.700***	7.804
Period 15	0.133	0.249	6.967***	11.254	1.200**	1.999	6.225***	10.336
Period 16	0.200	0.374	5.633***	9.100	1.100*	1.832	5.125***	8.510
Period 17	0.267	0.498	3.967***	6.408	1.350**	2.249	5.425***	9.008
Period 18	−0.733	−1.370	6.967***	11.254	0.850	1.416	6.400***	10.627
Period 19	−0.333	−0.623	6.967***	11.254	0.450	0.750	5.925***	9.838
Period 20	−1.000*	−1.869	6.967***	11.254	−0.125	−0.208	5.100***	8.468
χ^2	128.57 ($p < 0.0001$)		845.89 ($p < 0.0001$)		78.23 ($p < 0.0001$)		609.52 ($p < 0.0001$)	
N	600		600		800		800	

Notes: Dependent variable is individual contributions, panel estimates with random individual effects. Stage 1 consists of Periods 1–10 and represents the within-treatment baseline, while Stage 2 consists of Periods 11–20 and introduces the treatment variable. Period 10 is omitted and therefore represents the baseline period, which indicates the change in contributions within and across stages. *, **, and *** denote significance at the 10, 5, and 1 percent levels.

Voting outcomes, however, may not be enforceable. Nonbinding voting might act as a coordination mechanism that directs group members to voluntarily follow the majority's preferences. But then again, such voting may be cheap talk that has no impact on actual behavior. The nonbinding–vote treatment explores this by introducing a voting mechanism identical to the binding–vote treatment except that the majority determined outcome is not automatically implemented; rather it is simply announced.

Results from Table 2 suggest that nonbinding voting has a relatively small, although statistically significant ($p = 0.027$), effect on contributions. Estimates indicate that subjects contributed about one more token in the nonbinding–vote treatment than in the individual contribution baseline. However, the within-treatment estimates in Table 3 elaborate on this result by showing that while contributions do significantly increase with the introduction of the nonbinding voting rules, contributions eventually return to levels statistically equivalent to those observed in the final round of the Stage 1 baseline. While the nonbinding–vote treatment allowed groups to identify the socially optimal outcome and may have provided temporary support for greater contributions, it failed to provide sufficient incentives for any lasting impact on contribution levels.

> **Nonbinding vote result**: A nonbinding voting mechanism increased contributions to the public good marginally and temporarily, and the contributions were significantly lower than with the binding-vote mechanism.

The weak performance of nonbinding voting seems to be due to a lack of commitment,

TABLE 4
Cheating and Punishment in Nonbinding Vote and Nonbinding Vote With Punishment

	Nonbinding Vote		Nonbinding Vote With Punishment	
	Stage 2	Final Period	Stage 2	Final Period
Average aggregate contribution level of majority proposal	45.8	42.5	48.6	50.0
Average actual contribution level (when there was a majority proposal)	21.2	12.7	44.4	41.7
Average actual contribution level (all periods)	18.6	11.5	41.2	39.5
Average number of cheaters	3.34	4.33	0.54	0.86
Average number of punishers	–	–	2.84	3.00
Average punishment per cheater	–	–	4.32	4.00
Average punishment costs per punisher	–	–	2.34	1.60

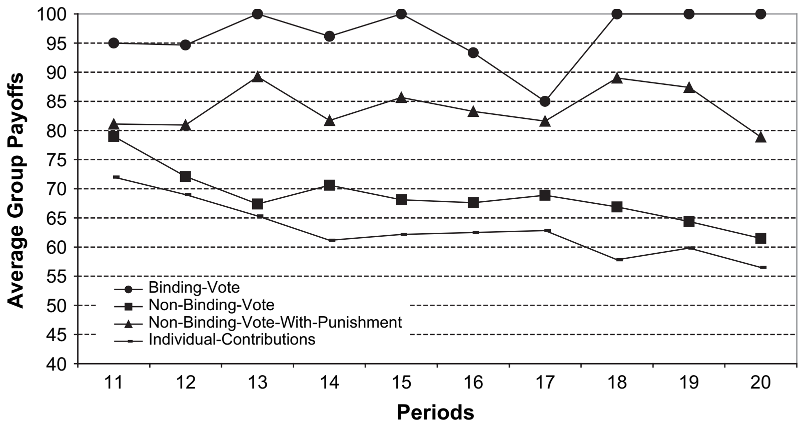
and not a lack of sophistication. In the initial period, members of six groups proposed and voted for the socially optimal contribution plan, and the other two groups did so within four periods. Of the 80 opportunities, 54 cases resulted in a proposal receiving a majority vote, in which 44 of the 54 were the socially optimal plan. This is further illustrated by comparing actual contributions to proposed contributions receiving a majority vote. Proposals receiving majority votes entailed an average group contribution of 45.8—close to the optimal 50—while the actual average contribution was 18.6 (Table 4). Right from the start in Period 11, a majority of group members cheated on the proposed contribution plan. While the voting allowed groups to express and learn what was best for them, it failed to deter individual members from deviating from the optimal plan. This finding contrasts the sizable effect reported with verbal communication, another form of cheap talk (e.g., see General Finding 5 in Ostrom 2000 or the findings in Bochet, Page, and Putterman 2006), and is also inconsistent with the results in voting-on-tax experiments, but it is in line with the small effect voting had on public-good contributions in Messer, Kaiser, and Schulze (2005).

While it may be impossible to compel groups to adhere to a voting outcome, it may be doable for group members to punish other members. The final treatment therefore introduces punishment into the nonbinding voting mechanism to examine whether punishment can provide the incentives necessary to enable nonbinding voting to match binding vote rules. Results from Table 2 confirm our initial impressions from Figure 1 that punishment may have a highly significant positive effect on contributions in a nonbinding voting setting. First, estimates suggest that contributions to the public good were significantly greater in the nonbinding-vote-with-punishment treatment relative to the baseline ($p < 0.001$). Specifically, subjects contributed 5.66 more tokens in the nonbinding-vote-with-punishment treatment than the individual contribution baseline. But estimates also indicate that contributions in the nonbinding-vote-with-punishment treatment were significantly greater than those in the nonbinding vote (without punishment) treatment ($p < 0.001$). Results from the within-treatment models reported in Table 3 confirm punishment's significant effect on contributions when voting is not binding. Estimates show that contributions were significantly greater in the nonbinding vote with punishment setting (Stage 2) than in the final round of the baseline setting (Stage 1). More importantly, estimates also show that the highly significant positive effect on contributions persists until the final periods of Stage 2. Results indicate that the threat of punishment may provide a sufficient incentive to match the benefits of a binding vote mechanism, which implies that punishment may suffice when an enforceable vote is infeasible.

Punishment result: Nonbinding voting with the opportunity to punish cheaters significantly and permanently increased contribution levels to the public good, with a magnitude similar to the effect from the binding vote mechanism.

Similar to observations in Fehr and Gächter (2000b), voting with the fear of

FIGURE 2
Average Group Payoffs as Indication of Efficiency



punishment seems to outweigh the motives that drive cheating. With punishment, group members not only propose and vote for socially optimal contribution plans but they also follow through on the plan. As Table 4 reports, proposals with and without punishment did not differ much (48.6 vs. 45.8), but actual contributions differed dramatically (41.2 vs. 18.6). Correspondingly, the number of cheaters differed substantially (0.54 vs. 3.34).

The impact on voting with potential punishment arises even though punishing itself is not an individually optimal strategy since subjects should free ride on others' willingness to punish cheaters. We observe that voters do consistently contribute to the punishment public good. When cheating occurred, 2.8 of five subjects on average were willing to incur between 1.5 and 3.4 tokens in punishment fees. Even in the last period, when there were no apparent reputation advantages from punishment, three of five group members were still willing to bear punishment costs.

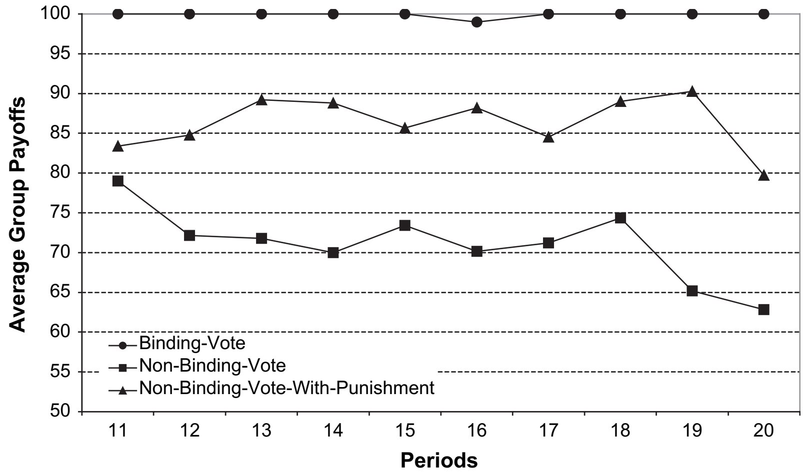
IV. RESULTS: EFFICIENCY

Achieving cooperation under voting with punishment is a success, but it comes at a cost because punishment reduces the net returns to both the punisher and the punished. The open question is whether the gains of adding the punishment mechanism to the voting scheme exceed the costs such that overall efficiency is improved. For example, Fehr and Gächter (2000b) found in their "stranger" experimental treatment with randomly changing group members that the increased contribution to the public good does not compensate for the costs of the punishment tool until the next-to-last period. In their "partner" treatment with fixed groups, which is more comparable to our experimental setup, efficiency loss occurred in the first three periods of the punishment condition. Decker, Stiehler, and Strobel (2003) also found that some punishment rules had positive and others had negative effects on efficiency.

For purpose of comparison between the treatments, we define efficiency as the percentage of potential payoff realized by the group. It corresponds to payoffs in the nonpunishment treatments and may differ with the introduction of costly punishment.

Figure 2 shows the average group payoffs including punishment costs in Stage 2 for each treatment; Figure 3 shows the same for periods in which a proposal was accepted by a majority of voters (since the individual-contributions treatment did not include a voting scheme, we omit the payoffs from the treatment in Figure 3). As expected, binding voting achieves the greatest efficiency. The question is whether voting without or with punishment leads to greater efficiency gains. Examination of the individual data reveals

FIGURE 3
Average Group Payoffs as Indication of Efficiency (for Periods With Majority Proposals Only)



that efficiency is significantly greater when nonbinding voting is supplemented with punishment ($p < 0.0001$).[16] The cost of punishment is more than recovered with gains provided by adding punishment to voting.

> **Punishment efficiency result:** Given our parameters, the gains realized from adding the threat of punishment exceed the costs of the punishment, and therefore nonbinding voting with punishment achieves significantly greater efficiency than without punishment and approaches similar efficiency levels observed with binding voting.

Voting with punishment generates substantial gains as players gain experience. While the efficiency gains in the first period of Stage 2 are about 80% regardless of the treatment, things quickly diverge. With punishment, the nonbinding voting maintains efficiency above 80%; without punishment efficiency drops to about 65%.

Our results suggest a stronger efficiency effect from punishment than observed in Fehr and Gächter (2000b). Figure 4 presents efficiency gain and loss of the treatment with punishment opportunities as the difference between average payoffs in the nonbinding-vote-with-punishment and nonbinding–vote treatments, normalized by the average payoffs in the nonbinding–vote treatment. For comparison, the corresponding graph for the partner treatment from Fehr and Gächter (1999) is replicated.[17] While a statistically rigorous comparison between the two efficiency curves is inappropriate due to differences between the experiments, Figure 4 paints a clear picture: the punishment mechanism has an even stronger effect on efficiency in public-good experiments when the contribution levels are determined by a (even nonbinding) majority vote than when determined individually, as in the experiment of Fehr and Gächter.[18] This could be due to a stronger social norm imposed through a vote—it is implicitly expected that everybody contributes to the public good as in a individual contribution game, but now this expectation has been

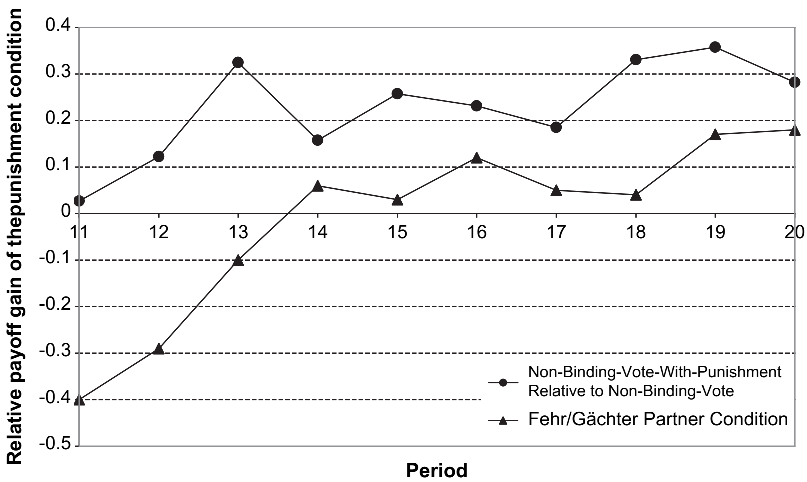
16. Wilcoxon tests comparing Treatment 3 (nonbinding) and Treatment 4 (nonbinding with punishment) revealed that efficiency was statistically equivalent in Stage 1 ($z = -0.113$; $p = 0.91$) while being significantly different in Stage 2 ($z = -11.316$; $p < 0.0001$).

17. Fehr and Gächter (1999) is the working paper on which Fehr and Gächter (2000b) is based. The graph, which is part of Figure 6 in the working paper, was not shown in the journal version of the paper; we thank Simon Gächter for sharing the average efficiency data from that figure with us. We also thank a referee for making us aware of this graph.

18. Small or nonexistent efficiency gains from punishment have been observed in other experiments similar to Fehr and Gächter (2000b) as well. See, for example, Figure 7 in Nikiforakis (2004) or Figure 2 in Noussair and Tucker (2005).

FIGURE 4

Average Payoff Gain of the Punishment Treatment Relative to the Nonpunishment Treatment



stated explicitly and is out in the open for everybody to see.

V. CONCLUSIONS

Groups commonly use a voting mechanism to provide public goods—group members offer alternative options, and then they vote on which option to implement, if any (e.g., global climate change, OPEC and the oil output level, and villagers and fishing quota). In many situations, however, no external enforcement mechanism exists to guarantee that each member adheres to the majority proposal. The group must find an internal enforcement mechanism to discipline or punish those who ignore the majority proposal. The problem is that punishment itself is a public good—each member wants to see the noncooperator(s) punished but their rational strategy is to free ride on another's punishment efforts. According to this theory, in the subgame-perfect equilibrium of the game nobody punishes deviators, and therefore it is rational to deviate from the majority vote. Adding an explicit punishment mechanism to a nonbinding voting mechanism should not help improve cooperation.

This paper provides evidence that voting alone as a tool of cooperation and communication is not enough; many subjects quickly realize that nonbinding votes are cheap talk, so they deviate from what the group majority decides. This result is consistent with Messer, Kaiser, and Schulze (2005) who also find that voting alone does not make a difference in a voluntary contribution mechanism game. But when group members—that is, voters—are able to punish cheaters, our results suggest that cooperation can be sustained on a higher level than without punishment opportunities. This result supports the findings of Fehr and Gächter (2000a, 2000b) that punishment opportunities discipline group members and help establish group norms that extend into the last period of a repeated game even though it is individually rational to forgo punishment and to free ride on other members' punishment efforts. Greater cooperation, however, does not necessarily translate into greater efficiency. More cooperation comes at a cost since adding the punishment tool to voting reduces the returns to both the cheater and the punisher. But while efficiency decreased in the treatment with punishment relative to the binding-vote treatment, we find that it was significantly greater relative to the nonbinding–vote treatment. The efficiency gain from punishment in the voting institution is large compared to results in Fehr and Gächter (1999, 2000b) and other experiments in which punishment opportunities are added to an individual contribution scheme without vote.

Important questions remain for future work: do these results hold for nonlinear public goods and for minimum winning coalitions smaller than the grand coalition and do they transfer to setups with heterogeneous groups? In many real-world situations, the relevant choice is not only between whether to join the entire group versus free riding but what coalition within the group to form and join. The negotiations following Kyoto again serve as an example.[19] But when agreements are nonbinding, an additional trade-off appears: members of the minority in a 3–2 vote might be required to contribute more to the public good according to the majority proposal, which makes them less inclined to follow the proposal even if punishment opportunities exist. This behavior could give rise to unanimous decisions even if the members of a minimum winning coalition are better off compared to the members of a grand coalition.

In addition, recent experimental papers found significant differences in behavior and efficiency between homogeneous and heterogeneous groups (Cherry, Kroll, and Shogren 2005; Kroll, Cherry, and Shogren forthcoming; Margreiter, Sutter, and Dittrich 2005). In their common-pool-resource experiment with binding votes, Margreiter, Sutter, and Dittrich observed that heterogeneous groups have a more difficult time to agree on and vote for a single proposal. This reduces the efficiency for such groups: even though whenever a proposal is adopted by a heterogeneous group, efficiency is much greater than if group members decide individually. An open empirical question is what will happen when punishment opportunities are added to a nonbinding voting scheme with heterogeneous groups.

19. The experiment of WGHO allows for smaller coalitions than the grand coalition. Ray and Vohra (2001) provided a theoretical examination of coalition formation in nonlinear public-good games. Both papers assume that all agreements are binding and do not allow for punishment.

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