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Communication and punishment in voluntary contribution experiments

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Abstract

We compare three forms of communication and punishment as incentives to increase contributions to public goods in laboratory experiments. We find, as in earlier experiments, that face-to-face communication has very strong effects, but surprisingly that verbal communication through a chat room preserving anonymity and excluding facial expression, etc. was almost as efficient. Numerical communication, via computer terminals, had no net effect on contributions or efficiency. Punishment, as in earlier experiments, increased contributions but because of its cost had little net effect on efficiency.

JEL classification: C91; H41; D23

Keywords: Public goods; Collective action; Communication; Punishment; Cheap talk

1. Introduction

In teams, firms and other groups, individuals are encouraged to undertake activities for the common good. Often managers use various forms of communication and/or punishment to reduce the well-known tendency to free ride on others' contributions, and subsequent loss

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of efficiency. Experimentalists and theorists have studied the free-rider problem in public goods and common pool resource games, finding that various forms of communication and sanctions can ameliorate this problem.

Isaac and Walker (1988) found free form face-to-face communication especially effective in increasing contributions and efficiency, and Brosig et al. (2003) suggested the effectiveness of face-to-face communication may be due to cues from facial expression, tone of voice, body language, and removal of anonymity. In this paper, we have explored this explanation by testing a free form version of text communication while preserving anonymity and eliminating vocal and visual cues. As a further step toward narrowing communication, we also tested a structured form of numerical communication, also by computer terminal, eliminating verbal communication, while preserving anonymity. This form of communication allowed nonbinding announcements of possible contribution levels that individuals could make and immediately revise in response to others' communication, in other words "cheap talk."

Our first question was whether chat room or numerical cheap talk would facilitate a Nash equilibrium with no contributions (as in the standard theory), or a Bayes–Nash equilibrium with signaling and substantial contributions. We found, surprising to us, that verbal communication through a chat room was only a little less efficient than face-to-face communication. We also found, that the numerical communication had no net effect on contributions or efficiency.

As another incentive mechanism, Ostrom et al. (1992) introduced sanctions in a common pool resource experiment, and Fehr and Gächter (2000a) introduced a similar punishment mechanism in a public goods experiment. In both experiments, punishment increased contributions but efficiency much less so. One reason for the limited effect of punishment on efficiency is well known—punishment is costly for both the punisher and the punished.[1] In the experiment of this paper, we explored another, less well known, reason. In Fehr and Gächter's experiment most of the punishment was targeted at low contributors and became an incentive to increase contributions, but some was targeted at high contributors. In our experiment, we found that a substantial amount of punishment was targeted at subjects with higher than average contributions. A regression analysis confirmed that this punishing of high contributors, what we call "perverse punishment," decreased the contributions of the targeted high contributors.

In designing the experiment, we conjectured that opportunities to communicate and punish might interact in ways such that each would enhance the effectiveness of the other. Communication might improve the efficiency of punishment by allowing subjects to convey threats to punish low contributors. A punishment option might make cheap talk less cheap, and communication might make punishment less necessary.

However, we found that verbal communication by itself increased cooperation so much that the combined treatment of communication and punishment had only slightly higher levels of contribution than either chat room or face-to-face communication alone, and the difference was not statistically significant for chat room only. Two of the three forms of communication without punishment had higher earnings (and hence efficiency) than when

[1] As an innovation in the punishment literature, Casari and Plott (2003) use sanctions in the form of fines, where the fine is transferred from the punished to the punisher, with resulting high efficiencies.

combined with punishment, but in no case did adding punishment to a communication treatment cause a difference in earnings significant at the 10% level.

Our findings are related to the literature as follows. The combined treatment of punishment and communication opportunities adds two degrees of freedom to the standard voluntary contributions mechanism (VCM) with neither opportunity. Ostrom et al. (1992) found adding "a sword" to "a covenant," (adding a sanctioning option to pre-play face-to-face communication) the most effective way of approaching full efficiency in their common pool resource experiments, of the treatments they studied. Their experiment differs from ours and others in the VCM literature in having an interior optimum and no pre-announced ending period (it has a randomly selected last period).

Isaac and Walker (1988) and Sally's (1995) review of that paper and 36 other experiments found that non-binding face-to-face communication frequently led to contributions of entire endowments. Brosig et al. (2003) found that both face-to-face communication and audio-visual conferences among subjects seated in separated locations increased contributions more than did audio communication only. Frohlich and Oppenheimer (1998) found that e-mail communications increased efficiency by less than face-to-face meetings. Wilson and Sell (1997) allowed each subject to numerically announce his or her "intention" of a contribution before making a binding contribution decision, and found little effect of the announcement over a baseline without it. In Section 4 we discuss differences between our communications treatments and those of Brosig et al., Frohlich and Oppenheimer, and Wilson and Sell.

Fehr and Gächter (2000a) found that introducing a costly opportunity to punish tended to increase average contribution levels from one period to the next, even when subjects were re-matched in each period with other groups of subjects, and even in the last period. They attributed the effectiveness of the punishment option to its permitting subjects with a preference towards cooperation to punish free riders without reducing their own contri butions. Similar experiments, including Carpenter (2000), Sefton et al. (2002), Masclet et al. (2003), and Page et al. (2005), found that while contributions don't always *increase* in later periods, the baseline trend of decay was substantially mitigated.

Fehr and Gächter (2000a, b) suggested that experimental subjects may include a certain fraction of "reciprocator" types in addition to the more standard payoff-maximizing types. The reciprocator types repay kindness with kindness and unkindness with punishment. A related notion is that of "assurance game preferences," in which, following Sen (1967), actual utilities in prisoners' dilemma games differ from the material payoffs, leading to increased cooperation.

The effectiveness of communication in our own and in other experiments suggests that not all subjects have pay-off maximization as their only goal, and that many attach positive probabilities to their fellow subjects having non-payoff-maximizing preferences and/or entertaining the possibility of such preferences in others. High contributions and punishments in the final period of play suggest the presence of actual reciprocators (Andreoni and Miller, 1993, Falk et al., 2001; Page et al., 2005). These experimental results appear to be consistent with a Bayesian interpretation of VCMs.

The paper proceeds as follows. Section 2 specifies our experimental design. Section 3 presents experimental results and analysis. Section 4 provides discussion and concludes the paper. Further details are in our working paper (Bochet et al., 2005).

Table 1
Design of the eight experimental treatments

	Without reduction option	With reduction option
Baseline	**B** 3 sessions 4 groups of 4 each session	**R** 3 sessions 4 groups of 4 each session
Face to face	**FF** 2 sessions 4 groups of 4 each session	**FFwR** 2 sessions 4 groups of 4 each session
Chat room	**CR** 3 sessions 4 groups of 4 each session	**CRwR** 3 sessions 4 groups of 4 each session
Numerical cheap talk	**NCT** 3 sessions 4 groups of 4, 2 sessions 3 groups of 4, 1 session	**NCTwR** 3 sessions 4 groups of 4, 2 sessions 3 groups of 4, 1 session

2. Experimental design

We conducted 22 experimental sessions of eight treatments, as shown in Table 1. In each session, 16 inexperienced subjects, drawn from the general undergraduate population at Brown University, played a 10 period repeated VCM game in groups of four.[2] Except in the face-to-face (**FF**) treatment, subjects interacted only via computer terminals, and they could not tell which other subjects were in their group.[3]

*2.1. Baseline treatment (**B**)*

Each of the treatments builds on the baseline treatment, which we describe first. At the beginning of each decision period of the baseline (**B**) treatment, each subject in a group of four was provided (electronically) with 10 experimental dollars and was asked to allocate it, in integer amounts, between a personal and a group account. Money placed in the personal account accrued to the individual subject. In addition, each subject received 0.4 times the total amount in his or her group's account. Thus, the earnings of a subject, i, in a given

[2] Exceptions are one **NCT** session and one **NCTwR** session, in which low show-up rates made it necessary to reduce the subject pool to 12 students, so that only three groups of four could be formed.

[3] Subjects sat at desks in a computer lab seating about 22 and were unable to communicate during the experiment and thus unaware of whom they were grouped with. They were recruited from the university's entire undergraduate population, with the experiments being identified as being conducted by researchers in the Economics Department. A brief post-experiment debriefing questionnaire shows that 16.1% of the subjects were economics concentrators, a little more than the approximately 10% of all undergraduates at Brown who were in that concentration at the time. 50.4% of subjects had taken one or more economics courses, with the average number of economics courses taken being 1.3. Subjects were broadly drawn from all classes, from freshman to senior. 52.6% were females.

period of treatments without punishments, are

$$(10 - C_i) + (0.4)\sum_{j=1}^{4} C_j \tag{1}$$

where C_i is what i assigns to the group account, and the summation is taken over all members of i's group. After each group member made his or her contribution decision, each learned of the decisions of the others and of his or her own earnings. In this and the other treatments, each individual's binding decisions were made anonymously within his or her group because these decisions were displayed to other group members under labels "you," "B," "C" and "D" and the letter codes changed randomly from one period to the next. At the end of the experiment, the sum of the 10 periods of earnings were converted into real dollars at the rate of US$ 0.13 per experimental dollar, and each subject was paid a US$ 5 participation fee. Experiments lasted from one to one-and-three-quarter hours, and real earnings including the participation fee averaged around US$ 25.

2.2. Reduction treatment (**R**)

The reduction treatment (**R**) is the same as baseline except for an added stage in each period (in the instructions and much of what follows we use "reduction" as the more neutral term for "punishment"). After the assignment or contribution, subjects learned the assignments to the group account of each other subject in their group (by their letter code). A subject could then reduce the earnings of another subject at a 25 cent charge per one dollar of earnings reduction. Each subject then learned her earnings for the period, which were equal to her earnings from the assignment stage minus her charges for punishments minus the amount by which her earnings were reduced by other subjects. Thus, earnings of subject i are, in a given period:

$$(10 - C_i) + (0.4)\sum_{j=1}^{4} C_j - (0.25)\sum_{j=1}^{4} R_{ij} - \sum_{j=1}^{4} R_{ji} \tag{2}$$

where R_{ij} is the number of dollars by which i reduces j's earnings. If this yielded a negative number, earnings for the period were set to zero. The screen shot in Fig. 1 shows the format for entering decisions. In this example, a subject typed in $5 for his contribution in box a, then learned the others' contributions, and then reduced B's earnings by $2 in box b′, and reduced C's and D's by $3 and $4, respectively.

2.3. Face-to-face communication treatment (**FF**)

The face-to-face treatment (**FF**) is the same as **B** except that after the instruction period and before any decisions are made, the members of each group of four have a chance to talk for 5 min, the only restrictions being that threats and promises of side-payments are ruled out. Anonymity regarding group membership is lost, but after returning to their seats individuals do not know which subjects within a group made what decision because the letter codes change after each period. In addition to two **FF** sessions of our experiment without

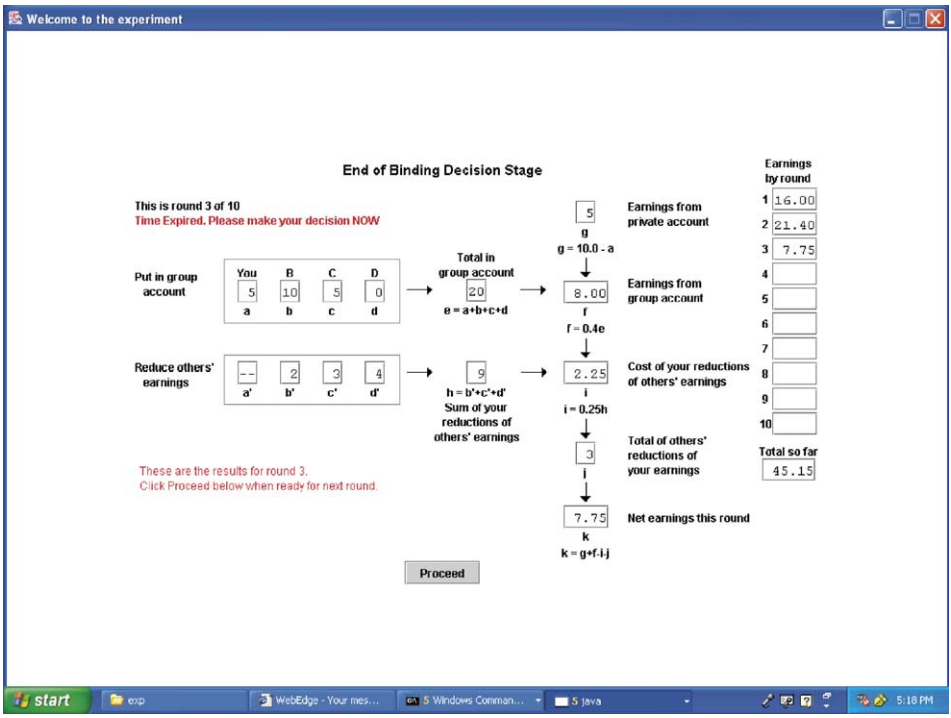

Fig. 1. Example of decision screen.

punishment, we ran two face-to-face sessions with reduction (**FFwR),** see Table 1. Like the **FF** treatment, the **FFwR** is the same as its no-communication counterpart **R** except that group members could talk for 5 min before beginning the decision portion of their session.

*2.4. Chat room treatment (**CR**)*

The chat room (**CR**) treatment is the same as **B** except that group members were brought together in an on-line chat room before the 1st, 4th, and 7th of the ten decision periods. In the chat room, they could discuss anything, except for restrictions against threats and offers of side-payments, revealing one's identity, and obscene language. Chat room messages were monitored, and the monitor blocked the restricted messages, informing its writer by a standard message (blocked messages were not frequent but not rare either). A successfully sent message was seen by all members of the subject's own group, but not those in other groups, each of which had its own chat room. In chat room communication, the open-ended character of face-to-face communication is possible, but anonymity is preserved, and it is more difficult to signal emotional states due to the unavailability of vocal intonation, facial expression, and body language. We carried out three sessions of **CR** in our VCM (without punishment), and three sessions of **CRwR** (with reduction), see Table 1.

2.5. Numerical cheap talk treatment (*NCT*)

The numerical cheap talk treatment (**NCT**) is the same as **B**, except that at the beginning of each period subjects had an opportunity to type in possible contribution levels. The screen for doing this was the same as the one used for the later binding decisions, except that the screen for this cheap talk stage was titled "Communication Stage." Each subject could then instantly overtype their possible contributions in response to others' messages until a fixed amount of time ran out, and no more NCT messages were accepted. Then a new screen heading appeared announcing the Binding Decision Stage, the numerical entries disappeared, and actual contribution decisions were entered.

In the treatment with numerical cheap talk and reductions (**NCTwR**), the subjects had the opportunity to type in possible punishments as well as possible contributions, and to revise their messages in response to others' messages of possible contributions and punishments. The screen for this stage was the same as Fig. 1, except for the differing title of "Communication Stage." After this stage was completed, the binding decision stage of contribution and reduction followed, as in **R** treatment. We conducted three sessions of numerical cheap talk without reduction (**NCT**), and three sessions with reduction (**NCTwR**).

A version of the full instructions for the experiment with the punishment option and numerical cheap talk is shown in Appendix B (Supplementary data). The paragraph of instructions specific to the **FF** and **FFwR** treatments is shown in Appendix C (Supplementary data), while instructions specific to the **CR** and **CRwR** treatments are shown in Appendix D (Supplementary data).

3. Results and analysis

Figs. 1 and 2 summarize the experiment's results by graphing the trends in contributions and earnings by period in our eight treatments. Results 1–3 below confirm and strengthen earlier results in the literature. Results 4–6 constitute the main new results of the paper.

3.1. Result 1

*Our baseline treatment (treatment **B**) replicated standard findings (Davis and Holt, 1993; Ledyard, 1995) that contributions begin at 50% or more of endowment, and decline with repetition*. Contributions began at an average of 62.9% of endowments, and declined to 19.6% of endowments in the last period (see Fig. 2 and Table 2). A regression of average contributions on period (excluding period 10 to exclude the large end-game effect apparent in all treatments) shows a statistically significant negative coefficient on period, consistent with an overall declining trend.

3.2. Result 2

*Our VCM experiments with a punishment option but no communication (treatment **R**) are consistent with others in finding: (a) higher initial contributions; (b) no decline in contributions until the end of the experiment; and (c) the absence of an overall earnings*

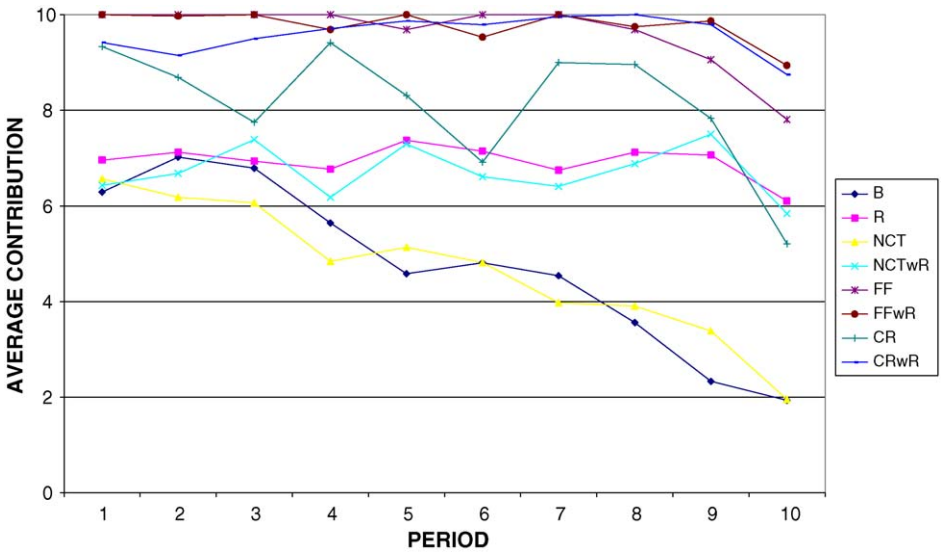

Fig. 2. Average contribution by period, sorted by treatment.

gain. Contributions began at an average of 69.6% of endowments, and the average was slightly higher, at 70.9% of endowments, in periods 5–9, with a drop to 61.0% in period 10 (compared to 19.6% in period 10 of treatment **B**). A regression of average contributions on period for periods 1–9 shows no significant trend, so that while a fairly small end-game effect appeared in period 10, the punishment option eliminated the overall downward trend of baseline contributions found in baseline VCM experiments, as in Fehr and Gächter (2000a).

In a Mann–Whitney test we found that average contributions over the 10 periods taken as a whole were significantly higher (p-value <0.01) in the treatment with punishments than in the baseline treatment. We use Mann–Whitney tests with the unit of observation group

Table 2
Average contribution to group account by period and treatment

	B	**R**	**FF**	**FFwR**	**CR**	**CRwR**	**NCT**	**NCTwR**
Period								
1	6.29	6.96	10.00	10.00	9.33	9.42	6.57	6.43
2	7.02	7.12	10.00	9.97	8.69	9.15	6.18	6.68
3	6.79	6.94	10.00	10.00	7.75	9.50	6.07	7.39
4	5.65	6.77	10.00	9.69	9.42	9.71	4.84	6.18
5	4.58	7.37	9.69	10.00	8.31	9.87	5.14	7.29
6	4.81	7.15	10.00	9.53	6.92	9.79	4.82	6.61
7	4.54	6.75	10.00	10.00	9.00	9.96	3.98	6.41
8	3.56	7.12	9.69	9.75	8.96	10.00	3.91	6.89
9	2.33	7.06	9.06	9.87	7.83	9.79	3.39	7.50
10	1.94	6.10	7.81	8.94	5.21	8.75	1.95	5.84
Average	**4.75**	**6.93**	**9.62**	**9.77**	**8.14**	**9.59**	**4.68**	**6.72**

level averages across periods to avoid problems of statistical dependence. See our working paper (2005) for further details.

As in Fehr and Gächter (2000a), there was a willingness to impose costly punishments on other subjects' earnings, with 83% of subjects imposing at least one punishment during their ten period session. Also as in that experiment, punishments were aimed mainly at low contributors. An analysis of changes in contributions shows that subjects tended to increase their contribution following a punishment, if their contribution had been below the group mean. This pattern of punishment and response helps explain the higher contributions in the **R** treatment compared with **B**. As in Fehr and Gächter, contributions were higher even in the first period of the **R** treatment than in the first period of the **B** treatment, suggesting that subjects anticipated that low contributors may be punished, even before they had seen evidence of it in the experiment. Finally, punishment was substantial in the last period. Total dollars of punishments were significantly higher in period 10 than their average in periods 5–9, according to a Mann–Whitney test. This shows that some punishments were non-strategic (not carried out to increase the future contributions of others).

3.3. Discussion

The introduction of punishment effectively changed incentives to contribute to the group account, since high contributors tended to earn more than low contributors in the **R** treatment, while the reverse held for the **B** treatment. However, the costliness of punishing and being punished led to no net gain in average earnings from introducing the punishment option in our experiment (see Table 3). Not only were earnings reduced by the costs of punishing free riders, but also 22% of punishment events were targeted at a group's highest contributor for the period in question. In a regression analysis we found that high contributors who were punished tended to reduce their contribution by \$0.50 in period $t+1$ for every \$1 by which their earnings were reduced by punishment in period t.

We begin discussion of our communication results with treatment **FF**.

Table 3
Average earning by period and treatment

	B	**R**	**FF**	**FFwR**	**CR**	**CRwR**	**NCT**	**NCTwR**
Period								
1	13.77	12.98	16.00	16.00	15.60	14.53	13.94	11.67
2	14.21	12.58	16.00	15.98	15.21	14.50	13.71	12.59
3	14.07	12.05	16.00	15.96	14.65	15.05	13.81	13.35
4	13.39	12.39	16.00	15.50	15.65	15.15	12.90	12.57
5	12.75	12.55	15.81	16.00	14.99	15.19	13.08	13.27
6	12.89	12.93	16.00	15.33	14.15	15.11	12.89	12.35
7	12.72	11.99	16.00	16.00	15.40	15.66	12.39	11.88
8	12.14	12.92	15.81	15.69	15.37	15.33	12.57	12.45
9	11.40	12.91	15.44	15.92	14.70	15.59	12.03	13.31
10	11.16	11.89	14.69	15.01	13.12	13.22	11.17	11.40
Average	**12.85**	**12.52**	**15.77**	**15.74**	**14.88**	**14.93**	**12.84**	**12.48**

3.4. Result 3

*A 5-minute pre-play face-to-face communication period dramatically raised contributions to the group account in all periods relative to their corresponding levels in the **B** and **R** treatments*. As shown by Fig. 2 and Table 2, members of the eight groups in the **FF** treatment contributed their entire endowments in periods 1–4, 6, and 7; contributed more than 90% of their endowments in periods 5, 8, and 9; and nearly 80% of their endowments in period 10. Average contributions in the **FF** treatment exceed those in both the **B** and the **R** treatments in every period and, comparing the **FF** and **B** treatments, in every group. Mann–Whitney tests confirm that groups in the **FF** treatment contributed and earned significantly more than groups in treatment **B**, and likewise, than groups in treatment **R**.

3.5. Discussion

The impact of communication on subjects' decisions is inconsistent with predictions for an environment of common knowledge of payoff-maximizing behavior, but consistent with a world in which subjects assign some probability that their counterparts believe them to have preferences for reciprocity and/or truth-telling. That 25 out of 32 subjects continued to contribute their full endowments to the group account, even in period 10, strongly suggests that many subjects actually have such preferences. A small number of subjects contributed their full endowments in every period but the last, and nothing in the last. These subjects may have feigned reciprocity for strategic reasons in the earlier periods, bailing out in the last period when there was no further opportunity to influence others' behavior; or these subjects might have expected others to contribute little in the last period and not wanted others free riding on their last period contribution.

3.6. Result 4

*Open-ended but anonymous verbal communication in an on-line chat room was more effective in eliciting contributions to the group account than were the **B** and **R** treatments but less than face-to-face communication*. The average contribution in the **CR** treatment was 15% less than that in the **FF** treatment (see Fig. 2 or Table 2), and 30% higher than **R**. (A two-tailed Mann–Whitney test finds contribution levels in **CR** significantly lower than in **FF** at the 10% level but not the 5% level). Like the **FF** treatment, contributions in the **CR** treatment were significantly higher than those in both the **B** and the **R** treatments, according to Mann–Whitney tests.

3.7. Discussion

Our results showed a chat room to be a surprisingly effective means of reaching an agreement and engendering trust and commitment, a result which seems to augur well for the conduct of business and other communications on-line. However, the fact that the subject pool consisted entirely of students in a university of moderate size (about 5800 undergraduates) and that each was aware of the presence of the other 15 subjects in the room may also be important to bear in mind (as discussed in Section 4). A review of the contents

of subjects' messages shows that about a quarter of substantive messages are concerned with discussion of what the best strategy would be (e.g.: "If we all keep putting in $10, we'll all earn $16."), with most of the remaining messages being statements of commitment to the common strategy (e.g.: "I'm with you, A."), and morale and team-building remarks (e.g.: "That was a breeze, let's stick with this!").

3.8. Result 5

*The addition of a punishment option to face-to-face meetings did not significantly alter the high level of cooperation seen in this treatment, while it increased contributions only moderately in the **CR** treatment.* Overall, there are no statistically significant differences in either contributions or earnings among the **FF**, **FFwR**, and **CRwR** treatments, and the **CR** treatment has only moderately lower contributions and earnings.[4]

"There were relatively high contributions in these treatments (see Fig. 2 or Table 2) and the treatments that added a punishment option had little punishment in most groups. Contributions and earnings among each of these four verbal communication treatments were significantly higher than those in the **B** treatment and in the **R** treatment, according to our Mann–Whitney tests."

3.9. Discussion

Perhaps surprisingly, the record of **CRwR** messages shows few subjects explicitly proposed using punishments as a method of enforcement. Members of some groups even seemed to see the punishment option as a trap set by the experimenters to help keep down their earnings. Nevertheless, low contributors did tend to be punished. As shown in Table 2 and Fig. 2, there was an end game effect in all four verbal communication treatments, but less so in the two that included a punishment option (**FFwR** and **CRwR**), suggesting that the possibility of punishment deterred some free riding in the end game.

3.10. Result 6

The addition of numerical cheap talk did not result in additional cooperation. As Figs. 2 and 3 show, the **NCT** treatment has a declining trend in contributions and earnings very similar to baseline. As shown in Table 2 the opportunity of communication by numerical cheap talk leads to slightly lower average contributions than baseline (Mann–Whitney tests find no significant difference (p-values >0.10) between the two treatments in either contributions or in earnings). In a corresponding way, Figs. 2 and 3 show that the **NCTwR** treatment has a stability of contributions and earnings through period 9 very similar to the **R** treatment alone. Again the differences in average contribution and earnings are slight, and Mann–Whitney tests find no significant difference between the two treatments in contributions or in earnings. As shown in Table 2, like the **R** treatment, overall contributions

[4] According to Mann–Whitney tests using group-level observations, contributions are lower in the **CR** than in the **FF**, **FFwR** and **CRwR** treatments, significant at the 10%, 5% and 5% levels, respectively. The same type of tests show earnings to be indistinguishable in the **CR** and **CRwR** treatments, and lower in the **CR** than in the **FF** and **FFwR** treatments, significant at the 10% and 5% levels, respectively.

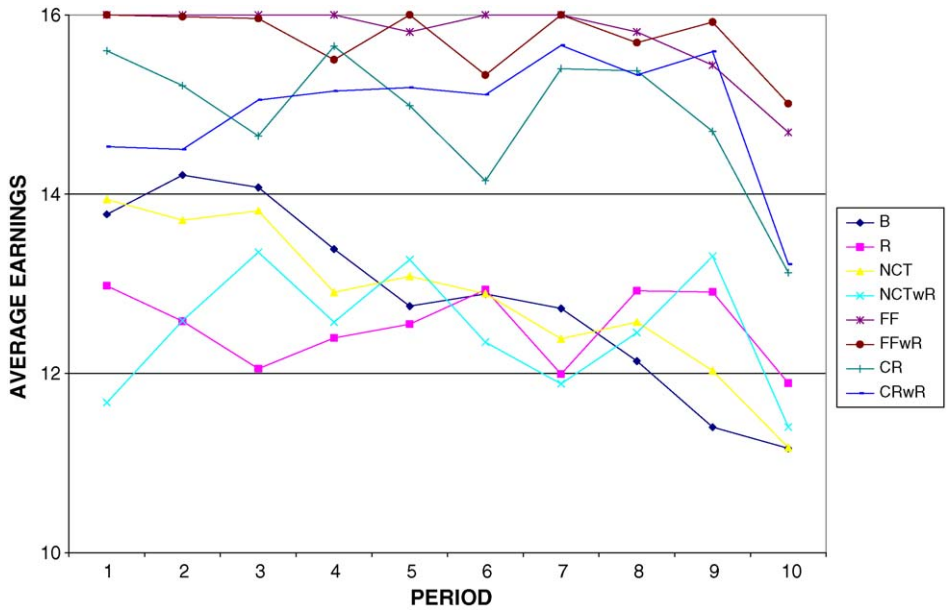

Fig. 3. Average earnings by period, sorted by treatment.

in the **NCTwR** treatment were higher than those in the **NCT** and **B** treatments (because contributions were more sustained over time). Table 3 shows that, like the **R** treatment, earnings were lower in the **NCTwR** treatment than in the **NCT** and **B** treatments, although the difference is not statistically significant. Earnings in the **NCTwR** treatment were also lower than in the **FF**, **FFwR**, **CR**, and **CRwR** treatments, and significantly so.

3.11. Discussion

The similarity of the average net outcomes of the **NCT** and **NCTwR** treatments to their counterpart treatments without communication, **B** and **R**, is consistent with the expectations of standard economic theory that communication is simply "cheap talk" when there is common knowledge that subjects are payoff maximizers. But a closer inspection of **NCT** messages and behaviors shows that most subjects attempted to achieve coordination on high-contribution equilibria, using the threat of punishment to enforce this in the **NCTwR** treatment. Consistent with this, some groups achieved higher levels of cooperation in the **NCT** and **NCTwR** treatments than in their counterpart **B** and **R** treatments. What accounts for the absence of an overall effect is the fact that in other groups, subjects attempted to use misleading **NCT** messages to generate opportunities to free ride. The latter **NCT** and **NCTwR** groups achieved even poorer outcomes than did low-end performers in the **B** and **R** treatments.[5]

[5] We explore the richness of **NCT** interactions in a companion paper (Bochet and Putterman, 2005).

4. Discussion and conclusion

The frequent instances of contributions and punishment are inconsistent with solution concepts of iterated dominance and subgame perfect Nash equilibria but they are consistent with Bayes–Nash equilibria as formalized in simpler repeated games by Kreps et al. (1982), McKelvey and Palfrey (1992), and Guttman (2000). These models have Bayesian equilibria with high initial cooperation with an end-game fall off similar to the behavior observed in this and other VCM experiments in the recent literature.

Last period contributions in face-to-face and chat room treatments without punishment suggest that some subjects have other preferences besides monetary payoff maximization, for example altruism, reciprocity, or disutility from reneging on an agreement. The observed last period punishments in treatments with the punishment option also suggest other preferences besides payoff maximization, for example, revenge for having been made a sucker, or "negative reciprocity" (Fehr and Gächter, 2000b).

Both contributions and earnings were considerably higher in the four treatments (**FF**, **FFwR**, **CR**, and **CRwR**) with open ended communication than in those with punishment but without such communication. Adding a punishment option to a verbal communication treatment (**FF** or **CR**) either did not raise contributions (**FF**) or did so only moderately (**CR**). In fact in **CRwR** and **FFwR** most subjects shied away from explicit threats in their communications, preferring to cultivate a harmonious atmosphere of cooperation by agreement and not threat.[6] The effectiveness of such verbal and technically non-binding agreements—even without face-to-face communication—is one of the most impressive results to emerge from our analysis.

Our experimental design differs somewhat from that of Wilson and Sell and we have somewhat different results in our treatments with numerical cheap talk. In their design the numerical announcements of "intended" contribution were made simultaneously and only once within each period. Thus there was no opportunity to respond to others' cheap talk and attempt coordination within a period. We allowed rapid response and revision at the beginning of each period, and there was frequent response and revision. When numerical cheap talk was combined with a punishment option there were many cheap talk threats of punishment and cheap talk responses with higher cheap talk contributions. We found attempts to coordinate, leading some groups to have substantially higher average contributions with cheap talk than did the most cooperative baseline groups, which had no possibility of communication. But we also found many instances where the binding decisions of contributions (and punishment) differed from the cheap talk, leading to lower average contributions than in the least cooperative baseline groups. It appeared that there was increased coordination in some groups and increased cynicism in others, offsetting each other; in any case, the net effect of numerical cheap talk was small and statistically insignificant.

Unlike numerical signaling, verbal communication allows subjects to issue explicit professions of commitment and to try to convince one another that they will not renege on

[6] The difference between cooperation achieved by 'friendly' agreement and that brought about under the pressure of threats is also illustrated by comparing the final period of the **FF** and **CR** treatments, discussed in this paper, with those of an "expulsion" experiment reported in Cinyabuguma et al. (2005). In the latter, contributions fell from an average of about 90% in the next-to-last period to about 20% in the last one.

their commitments. We found these efforts to be largely successful. Sally (1995) found communication to have a statistically and economically stronger effect on cooperation than any other treatment variable in a large set of VCM experiments. Our study has expanded the already large universe of treatments studied by Sally by adding numerical cheap talk and chat room communication. The failure of our **NCT** treatments and the success of our **CR** treatments provide qualitatively new support for Sally's conclusion that "the specific medium of language may be an essential factor in influencing behavior."

The observed high levels of cooperation in our **CR** treatments differ somewhat from other findings on communication without visual and/or vocal dimensions, but there are also differences in the experimental set ups. Brosig et al. (2003) compared a no communication baseline to one in which subjects could communicate by an audio channel but not see one another. It seems surprising that that treatment led to only slightly more cooperation than did their baseline. However, Brosig et al. went to great lengths to isolate their subjects from one another, whereas our subjects sat in the same room in every treatment, including **CR**.[7] Frohlich and Oppenheimer (1998) found substantially and significantly less cooperation with e-mail communication than with face-to-face communication. But e-mail communication requires opening messages one by one without a running record of the communications.[8]

In conclusion, communication of (non-binding) promises permitted high efficiency levels to be achieved in our two verbal communication treatments. Observed reciprocity seemed to foster an atmosphere of cooperation from which many did not want to unilaterally defect. Without a vehicle for proclaiming commitments, numerical cheap talk lacked this effect. In treatments with monetary punishment opportunities but without verbal communication, higher contributions were elicited by fear of punishment, but these contributions were not as high as those following verbal communication, and they were obtained at a high cost. In our experiments, perhaps, the non-pecuniary self-punishment of a guilty conscience proved more efficient than the materially costly punishments imposed by others.

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[7] This difference between isolation and sharing a room might have an impact on the effectiveness of **CR**. Sally (1995) finds that physical isolation of subjects from one another significantly reduces contributions in VCM experiments.

[8] Rocco (1998) compared e-mail with face-to-face communication in a set of social dilemma experiments akin in payoff structure to those of Ostrom et al. In a comment comparing e-mail to **FF** but perhaps unintendedly shedding light on the inferiority of e-mail to a chat room, she noted that "In contrast to face-to-face communication in which speakers govern the sequence of the discussion, in the mailing list sequence depends on the recipient of the messages who decides what to read first. The lack of need to take turns permits several threads to be discussed at the same time, causing the focus of the discussion to be lost."

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2003.06.006.

References

Andreoni, J., Miller, J.H., 1993. Rational cooperation in the finitely repeated prisoner's dilemma: experimental evidence. Economic Journal 103, 570–585.

Bochet, O., Page, T., Putterman, L., 2005. Communication and punishment in voluntary contribution experiments, working paper no. 2005-09. Department of Economics, Brown University.

Bochet, O., Putterman, L., 2005. Not just babble: a voluntary contribution experiment with iterative numerical messages, working paper no. 2005-05. Department of Economics, Brown University.

Brosig, J., Ockenfels, A., Weimann, J., 2003. The effect of communication media on cooperation. German Economic Review 4, 217–242.

Carpenter, J., 2000. Mutual monitoring in teams: the role of monitoring group size, second-order free-riding, or coordination. Paper presented at a meeting of the Economic Science Association, New York, June.

Casari, M., Plott, C.R., 2003. Decentralized management of common property resources: experiments with a centuries-old institution. Journal of Economic Behavior and Organization 51, 217–247.

Cinyabuguma, M., Page, T., Putterman, L., 2005. Cooperation under the threat of expulsion in a public goods experiment. Journal of Public Economics 89, 1421–1435.

Davis, D.D., Holt, C.A., 1993. Experimental Economics. Princeton University Press, Princeton.

Falk, A., Fehr, E., Fischbacher, U., 2001. Driving forces of informal sanctions. Institute for Empirical Economics working paper no. 59, University of Zurich.

Fehr, E., Gächter, S., 2000a. Cooperation and punishment. American Economic Review.

Fehr, E., Gächter, S., 2000b. Fairness and retaliation: the economics of reciprocity. Journal of Economic Perspectives 14, 159–181.

Frohlich, N., Oppenheimer, J., 1998. Some consequences of e-mail versus face-to-face communication in experiment. Journal of Economic Behavior and Organization 35, 389–403.

Guttman, J., 2000. On the evolutionary stability of tastes for reciprocity. European Journal of Political Economy 16, 31–50.

Isaac, R.M., Walker, J.M., 1988. Communication and free-riding behavior: the voluntary contributions mechanism. Economic Inquiry 26, 585–608.

Kreps, D., Milgrom, P., Roberts, J., Wilson, R., 1982. Rational cooperation in finitely repeated prisoners' dilemma. Journal of Economic Theory 27, 245–252.

Ledyard, J., 1995. Public goods: a survey of experimental research. In: Kagel, J., Roth, A. (Eds.), Handbook of Experimental Economics. Princeton University Press, Princeton, pp. 111–194.

Masclet, D., Noussair, C., Tucker, S., Villeval, M.-C., 2003. Monetary and non-monetary punishment in the VCM. American Economic Review 93, 366–380.

McKelvey, R.D., Palfrey, T.R., 1992. An experimental study of the centipede game. Econometrica 60, 803–836.

Ostrom, E., Walker, J., Gardner, R., 1992. Covenants with and without a sword: self governance is possible. American Political Science Review 86, 404–416.

Page, T., Putterman, L., Unel, B., 2005. Voluntary association in public goods experiments: reciprocity, mimicry, and efficiency. Economic Journal 115, 1032–1053.

Rocco, E., 1998. Trust breaks down in electronic contexts but can be repaired by some initial face-to-face contact. Proceedings of CHI (April), 496–502.

Sally, D., 1995. Conversation and cooperation in social dilemmas: a meta-analysis of experiments from 1958 to 1992. Rationality and Society 7, 58–92.

Sefton, M., Shupp, R., Walker, J., 2002. The effect of rewards and sanctions in provision of public goods, working paper. University of Nottingham and Indiana University.

Sen, A., 1967. Isolation, assurance and the social rate of discount. Quarterly Journal of Economics 81, 112–124.

Wilson, R., Sell, J., 1997. "Liar, Liar..": cheap talk and reputation in repeated public goods settings. Journal of Conflict Resolution 41, 695–717.