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Leading by Words: A Voluntary Contribution Experiment With One-Way Communication

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Abstract

We use experimental methods to study the power of leading by words. The context is a voluntary contribution mechanism with one-way communication. One group member can send a free-form text message to his fellow players. Contrary to the commonly-accepted wisdom that the cooperation-enhancing effect of communication requires the mutual exchange of promises, we find that the introduction of one-way communication increases contributions substantially and decreases their variation. When communication is one-shot, its effect on contribution levels persists over time. Moreover, one-way communication is effective even in the absence of strategic concerns.

JEL Classification: C72; C92; H41

Keywords: Public goods experiment; Computer-mediated communication; Cheap talk; Cooperation

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1 Introduction

One of the most consistent experimental findings in the social dilemma literature is that costless, non-binding and non-verifiable communication (i.e., cheap talk) has a positive effect on cooperation.[1] But what is it about communication that boosts cooperation? Three aspects of communication have been suggested in the literature as inductive to cooperation (see, e.g., Dawes, McTavish and Shaklee 1977): identification, discussion, and commitment. Several experimental studies demonstrate that neither mere identification nor discussion is *sine qua non* for the communication effect to take place (see, e.g., Bouas and Komorita 1996; Bohnet and Frey 1999; Brosig, Weimann and Ockenfels 2003). Instead, the commitment to cooperate, in the form of a *mutual* exchange of promises and pledges, is considered crucial for the cooperation-enhancing effect of communication (see Kopelman, Weber and Messick 2002 and Bicchieri and Lev-On 2007 for surveys of relevant work in the psychology and economics literature, respectively).[2]

Most of the evidence on the role of commitment comes from two kinds of studies. First, experiments that draw a comparison between face-to-face and other forms of communication (e-mails, chat-rooms, audio-conferences, numerical cheap talk; see, for instance, Frohlich and Oppenheimer 1971; 1998; Brosig et al. 2003; Bochet, Page and Putterman 2006). Such experiments find that the strength of the communication effect depends on the communication medium, with a stronger effect of face-to-face discussion compared to any other alternative. The crucial factor here is that face-to-face discussion facilitates the exchange of mutual promises.[3] Notice, however, that all these communication opportunities do allow subjects to exchange non-binding promises, thereby encumbering the assessment of the effectiveness of commitment in enhancing cooperation. Second, experiments that draw a comparison between face-to-face and passive communication[4] (e.g., Brosig et al. 2003). This approach prevents commitment at the cost of rendering

[1] Sally (1995) offers a meta-analysis of 35 years of social dilemma experiments and shows that enabling people to communicate increases cooperation rates significantly. Balliet (2010), in a more recent meta-analysis, reports similar results.

[2] A notable exception is Bochet and Putterman (2009).

[3] According to Bicchieri and Lev-On (2007, pg. 145), "using computer-mediated communication instead of face-to-face communication can hamper the generation of normative settings in which promises are perceived as reliable".

[4] Passive communication means that subjects may attend but not intervene in the communication of outsiders (that is, people that do not belong to their group).

the source of the messages external to the group.

An unambiguous way of studying whether commitment is necessary for cooperation, in the sense that the effect of communication vanishes in its absence, calls for a setting where mutual pledges to cooperate are ruled out by design while the in-group communication channels remain intact. In this paper we provide a series of experimental studies based on such a setting.

We consider a linear public goods game with one-way communication. All group members make their contribution decisions privately and simultaneously. But prior to this, one of them, a group member that is randomly assigned the role of "communicator", can send a free-form text message to his fellow players.[5] This method of unidirectional messaging precludes the mutual exchange of promises. Hence, if commitment were necessary for the rise in cooperation rates, we would not observe any difference in contribution levels in comparison to a no-communication baseline treatment. If, on the other hand, all that is needed in order to overcome the problem of free riding is a "primed" cooperative behavioral rule, and all group members' preferences are consistent with that rule (see, e.g., Kerr, Garst, Lewandowski and Harris 1997; Bicchieri 2006), then the presence of the communicator should promote contribution towards the public good.

We run two series of experiments. The first series consists of finitely repeated games in which the primary treatment variable is the number of communication opportunities. The baseline treatment involves no communication at all. In two other treatments, participants can communicate either prior to each and every period (continuous communication) or just prior to the first period (pre-play communication). With these experiments we can assess not only the effectiveness of one-way communication but also its dependence on the frequency of messaging. The second series of experiments consists of one-shot games where people have no strategic incentives to contribute (Kreps, Milgrom, Roberts and Wilson 1982). These experiments allow us to investigate whether strategic reputation building is essential for the workings of one-way communication.

Another way of looking at our setup is to consider the communicator as a

[5]We prefer free-form text messages to face-to-face communication so as to isolate the impact of the message's content from visual (i.e., body language, eye contact, facial expressions) and verbal cues (tone of voice, phrasing, fluency, manner of expressing moral rhetoric). We prefer free-form to pre-specified messages so as to allow subjects to express freely their thoughts and views of the game.

leader who leads by words.[6] One can easily guess the power such words may carry. For example, Susan B. Anthony strongly promoted women's suffrage in the United States by giving, over a 45-year period, 75 to 100 speeches per year. Moreover, Löfgren and Nordblom's (2010) survey shows that people in Sweden became less reluctant towards the CO_2 tax on gasoline after the release of Al Gore's global warming documentary "An inconvenient truth".

Previous experiments dealing with communication in social dilemma games testify that the presence of a leader that dominates the discussion elicits mutually beneficial cooperation. Orbell, van de Kragt and Dawes (1991), for instance, note that self-selected group leaders encourage a particular strategy and ask the others to conform to it; in leaderless groups, instead, agents find it difficult to reach an agreement and often terminate the discussion ahead of time. Rocco (1998) conducts a finitely repeated common pool resource experiment and compares a face-to-face treatment with an electronic mailing list treatment. Unlike face-to-face communication where the first group member to advocate a position gains leadership status and influences disproportionately his fellow members, electronic communication inhibits the establishment of effective cooperation agreements. Finally, Simon and Gorgura (2006) observe that the emergence of a leader within a group deters dissent and helps people keep talking.[7] In these studies all members can communicate with each other and leadership emerges endogenously. Consequently, whether the message(s) of an exogenously appointed leader influence the effectiveness of communication in social dilemma games remains, to the best of our knowledge, an open question.[8]

Whether and to what extent one-way communication, in the form of

[6]With a few exceptions (e.g., Houser, Levy, Padgitt, Peart and Xiao 2007; Gürerk, Irlenbusch and Rockenbach 2009), experimental economists investigating the effects of leadership in social dilemma games concentrated on leading by example (see, e.g., Moxnes and van der Heijden 2003; Güth, Levati, Sutter and van der Heijden 2007; Levati, Sutter and van der Heijden 2007; Potters, Sefton and Vesterlund 2007).

[7]For an account of the importance of leaders in coordinating the group see also Bicchieri (2006). In a similar vein, but from a theoretical perspective, Foss (1999) observes that somebody who leads via suggesting a strategy can coordinate the actions of many people by making that strategy commonly known.

[8]The study of leadership by words has been pursued in more detail in the context of coordination games (see, e.g., Brandts and Cooper 2007 and references therein). Pogrebna, Krantz, Schade and Keser (2009) consider a voluntary contribution game where first the leader can promise to contribute a certain amount and then all group members make binding contribution decisions. The authors compare leading by pre-game communication with leading by example and find that contributions do not depend on the leadership style.

leading by words, can affect cooperation levels in social dilemmas could be of interest to group organizers and institution designers. As noted for example by Messick and Brewer (1983), multilateral communication in real-world social dilemmas can be very costly, or even unfeasible.[9] Yet, if – as our results indicate – one-way communication fosters cooperative outcomes and one-shot communication is as effective as communication on a repeated basis, then the required organizational cost may be lower than presumed.

The paper is organized as follows. Section 2 lays out our experimental design and details our research questions. Sections 3 and 4 provide analytical results on the finitely repeated and one-shot treatments, respectively. Section 5 concludes.

2 The experiment

2.1 The basic public goods game

The basic game is the voluntary contribution mechanism (e.g., Isaac, Walker and Thomas 1984). Let $I = \{1, \ldots, 4\}$ stand for a group of four participants who interact for $t = 1, \ldots, T$ periods in a partner design (that is group composition does not change throughout the experiment). At the beginning of every period, each individual $i \in I$ is endowed with 25 ECU (Experimental Currency Units) which he can either consume privately or contribute to a public good. Denoting i's contribution level by $c_{i,t}$, where $0 \leq c_{i,t} \leq 25$, his monetary payoff per period is given by:

$$\pi_{i,t}(\mathbf{c}_t) = (25 - c_{i,t}) + 0.4 \sum_{j=1}^{4} c_{j,t} \quad \forall\, i, t, \tag{1}$$

where $\mathbf{c}_t = (c_{1,t}, \ldots, c_{4,t})$ and $0.4 \sum_{j=1}^{4} c_{j,t}$ represent the period t strategy profile and income from the project, respectively.

Since the marginal per capita return is less than unity, the dominant strategy for a monetary payoff maximizer is to contribute nothing. If all group members free rided, then each one of them would earn 25 ECU. On the other hand, the socially efficient outcome (i.e., the outcome that is max-

[9] Most social dilemmas are large group problems (e.g., global environmental problems) offering participants little or no opportunity at all to either communicate or negotiate a solution.

imizing the sum of $\pi_{i,t}(\mathbf{c}_t)$ over $i = 1, \ldots, 4$) is to contribute everything. If all group members made the socially efficient choice, then each one of them would earn 40 ECU. The dominance of free riding extends to the finitely repeated game: it can be shown, by means of backward induction, that free riding in each period is the unique subgame perfect equilibrium.

2.2 Treatments and research questions

Using a between-subjects design, we study five treatments that build on the basic game described above. The treatments differ with respect to the number of repetitions and, in the case of repeated games, the frequency of communication.

2.2.1 Finitely repeated games

In the first three treatments, participants interact for ten periods. The characteristics of these treatments are as follows:

Baseline (B_{10}): Group members cannot communicate with each other. In each period, they decide simultaneously and privately on the number of ECU that they want to contribute to the public good.

Continuous Communication (CC): At the beginning of the experiment, one member of each group is randomly appointed communicator (a role which he retains throughout the experiment). The communicator is given, prior to each period, the opportunity to send a message to his co-players.

Pre-play Communication (PC): The (randomly selected) communicator can send just one message prior to the first period (i.e., in advance of any decision making). Afterward, group interaction follows B_{10}.

These treatments are expressly designed to address the following questions:

Question 1: *Does one-way communication affect contributions towards the public good?*

Question 2: *Is the number of communication periods relevant, i.e., does the effect of one-way communication depend on whether written messages are sent repeatedly or just once?*

Question 3: *What kind of arguments are invoked by the communicator and how they do influence behavior?*

The correspondence between these research questions and the methods used to address them is displayed in the upper panel of Table 1.

[Table 1 about here.]

With regard to Question 1, a number of papers have addressed the theoretical conditions under which augmenting the game with cheap talk helps to achieve efficient outcomes (see Farrell and Rabin 1996 and Crawford 1998 for surveys). Yet, whenever individual and group interests conflict completely (as in our case), cheap talk is not expected to alter the prediction of full free riding insofar as people care only about their own monetary payoff. However, this prediction has been contradicted by decades of experimental research, with commitment being regarded as the most likely explanation of the effect of communication.

We argue that there is more to the communication's impact on cooperation than the behavioral importance of promises to cooperate.[10] The communicator may enhance cooperation by underlining other facets of the game (like the efficiency gains that can be obtained under full contribution by all subjects) or by "priming" a cooperative rule with which all group members' preferences are consistent. For instance, in his theoretical analysis of leadership, Foss (1999, p. 22) maintains that a leader's words can change the payoff structure of a prisoner's dilemma by influencing preferences towards generalized "niceness". The game in this case becomes a coordination game where the communicator's cheap talk may be far more effective (see, e.g., Farrell and Rabin 1996).[11] On the basis of these arguments, we conjecture a positive answer to Question 1.

Question 2 is more difficult to tackle, as not only the existing research contrasting pre-play with continuous communication is founded on multidirectional communication, but its findings are also mixed. While certain studies find that pre-play communication has a lasting effect on cooperation (Radlow and Weidner 1996; Brosig et al. 2003; Balliet 2010), others find that

[10]Gneezy (2005), Charness and Dufwenberg (2006), and Vanberg (2008), among others, have shown that people have a preference for keeping their word.

[11]See also Bicchieri (2006) for an analysis of how the establishment of a cooperative social norm can transform a prisoner's dilemma into a coordination game.

cooperation rates decline in response to limiting the opportunities to communicate (Ostrom, Walker and Gardner 1992; Frohlich and Oppenheimer 1998). In our *PC* treatment, the communicator may, on the one hand, activate an internalized norm of cooperation that persists even in the absence of further messages. On the other hand, individuals may need "counter reinforcers," such as the communicator's approval or disapproval, in order to sustain a cooperative behavior. Thus, the answer to Question 2 is not *a priori* clear.

Finally, we have no preconceptions about Question 3. Previous studies analyzing the content of communication either involve multi-directional communication or consider games where promises to cooperate play a crucial role (see, e.g., Charness and Dufwenberg 2006; Simon and Gorgura 2006; Brandts and Cooper 2007; Sutter and Strassmair 2009).

2.2.2 One-shot games

Here, participants interact just once.

Baseline (B_1): The group members cannot communicate with each other. They make a one-shot contribution decision.

Communication (C): Before the one-shot interaction, one member of each group is randomly appointed communicator and can send a message to his co-players.

These two treatments intend to address the following question (see as well the lower panel of Table 1):

Question 4: *What is the effect of one-way communication when subjects are denied the opportunity to play strategically?*

In finitely repeated games, if the information about types is incomplete, strategic reasoning may by itself suffice to bring about more cooperation. For example, suppose that a selfish player believes that some other players in his group are conditional cooperators (that is they cooperate conditionally on the others' contributions) and that the communicator's message might coordinate them on a specific contribution. Then, it may be optimal for him to contribute that amount early in the game (so as to induce these conditional cooperators to contribute) but free ride later on (Kreps et al.

1982; Andreoni 1988; Sonnemans, Schram and Offerman 1999). However, with one-shot interaction there are no incentives for such a forward-looking behavior. Hence, by comparing individual contributions in B_1 and C, we can assess whether one-way communication is effective in the absence of strategic incentives.

2.3 Procedures

The experiment was programmed in z-Tree (Fischbacher 2007) and conducted in the experimental laboratory of the Max Planck Institute of Economics (Jena, Germany). The subjects were undergraduate students from the Friedrich-Schiller University of Jena. They were recruited using the ORSEE (Greiner 2004) software. Upon entering the laboratory, the subjects were randomly assigned to visually isolated computer terminals. The instructions (which are reproduced in the supplement) were distributed and then read aloud to establish common knowledge. All subjects' questions were answered individually at their seats. Before starting the experiment, subjects had to answer a control questionnaire which tested their comprehension of the rules.

One-shot treatments started with six training periods that involved neither interaction (the others' decisions were selected randomly by the computer) nor communication. The sole aim of these periods was to familiarize the participants with the game and its incentives (no payments were associated with them).

Whenever communication was allowed, the communicator could use a text box to type in his message. He had a maximum of four minutes to compose the message, but it was at his discretion to send it ahead of the deadline. In principle, the form of the message was free, the only restrictions to its content being that the communicator could neither identify himself, nor threaten the other group members, nor promise side-payments. To enforce compliance with these restrictions, all messages were screened before being sent.[12] Then, all of them were delivered simultaneously. It was common knowledge that (a) the messages were cheap talk (i.e., costless and non-binding), (b) all group members received exactly the same message from the group communicator, and (c) only after having read the communicator's

[12]Improper messages were to be screened out and their sender was supposed to be given a warning for misconduct, but as a matter of fact such a thing never happened.

message could the group members decide simultaneously on their individual contributions.

Participants in the one-shot treatments got at the end of the experiment feedback on (a) the number of ECU contributed by each group member (with the individual contributions being sorted in descending order), (b) the income from the project, and (c) their corresponding payoff. Participants in the repeated treatments received the same information at the end of each period.

Payoffs were quoted in ECU: 10 ECU = 400 (50) euro cents in the one-shot (repeated) treatments. Participants in the one-shot treatments earned on average €15.12, inclusive of a €2.50 show-up fee. Participants in the repeated treatments were paid in private their accumulated earnings at the end of the last period. Average earnings per subject were €20.60.

3 Results on the finitely repeated treatments

We ran three sessions per treatment (B_{10}, CC, and PC). Each session involved 24 participants. With group size equal to 4, we have 18 independent observations per treatment. The results are presented in two parts: first, the effects of one-way communication on contribution levels; and second, the communication's content and its relation to contribution choices.

3.1 The effects of one-way communication

Table 2 presents descriptive statistics of average group contributions.[13] The mean and median of the series in the CC and PC treatments are notably larger than their respective values in the B_{10} treatment. In addition, the standard deviation is smaller, which should not be surprising given that for CC and PC the median average group contribution is equal to the maximum contribution, namely 25.[14] The disparity in dispersion between the baseline and the communication-allowing treatments becomes more pronounced once

[13]The CC and PC independent observation series contain outlying observations at the lower tail of their distributions. Thus, in what follows, besides the conventional descriptive statistics (mean and standard deviation) we also report measures of location and scale which are robust to the presence of outliers.

[14]In fact, 73.33% (72.78%) of the average group contributions in the CC (PC) treatment equal the subjects' endowment. The corresponding percentage in the B_{10} treatment is 20.56%.

we consider robust measures of scale like the median absolute deviation about the median (MAD) and Rousseeuw and Croux's Q statistic.[15]

[Table 2 about here.]

Figure 1 shows how the time series of measures of location of the average group contributions respond to changes in our treatment variable. In panel A, the baseline treatment replicates standard findings (e.g., Ledyard 1995): the mean of the average group contributions begins at 57.1% of the endowment and declines with repetition (in the last period it stands at 18.8% of the endowment). In contrast, in the communication-allowing treatments the mean starts at very high levels (89.6% and 90.0% of the endowment in CC and PC, respectively) and remains fairly stable in all periods but the last (its period 9 value is 85.4% of the endowment in CC and 83.3% of the endowment in PC). This stability is clearer if we acknowledge that in the communication-allowing treatments the distributions of the average group contributions in each period are skewed to the left (i.e., they have relatively few low values, see Figure 2), and opt for their median values as better indicators of their central tendency. In periods 1 to 9, the medians of the average group contributions in the CC and PC treatments equal 25 (see Figure 1B). Furthermore, it is in period 9 that the difference between the median series of the baseline and communication-allowing treatments reaches its maximum value (that is 19.1 ECUs, or, alternatively, 76.5% of the endowment).

[Figure 1 about here.]

One-sided Wilcoxon rank sum tests with group contributions averaged over all 10 periods as independent observation units confirm that the communicator's presence raises contribution levels significantly ($p < 0.01$ in both CC vs B_{10} and PC vs B_{10} comparisons). The same holds if we compare average group contributions in any particular period; all p-values are well below the conventional significance levels (the largest of them, equal to 0.003, is associated with the sixth period comparison between B_{10} and PC).

[15] If $\{x_1, \ldots, x_n\}$ is a set of numbers, MAD $= b\ \text{med}_i|x_i - \text{med}_j x_j|$ (where med stands for median and b is a correction factor for consistency) is the most frequently used robust estimate of scale. However, MAD is aimed at symmetric distributions. The Q estimator, defined as the 0.25 quantile of the distances $\{|x_i - x_j|; i < j\}$, besides being suitable for asymmetric distributions, is more efficient than the MAD.

On the other hand, the frequency of communication opportunities does not appear to have any significant effect: it is not possible to reject the null hypothesis that the CC and PC groups of independent observations have identical distributions ($p = 0.32$; two-sided Wilcoxon rank sum test). The same result holds for individual periods (the smallest p-value is 0.30 in the third period).

Figure 2 draws for each individual treatment boxplots of the average group contributions observed in each period, and illustrates the participants' tendency in the communication-allowing treatments to contribute their entire endowment.[16] More specifically, in the CC treatment, 10 out of 18 groups are socially optimizing in periods 1 to 9 (one of them in periods 1 to 10). An equal number of groups are socially optimizing in PC in periods 1 to 9 (five of them in periods 1 to 10). In B_{10}, in contrast, two thirds of the groups never choose the socially efficient amount.

[Figure 2 about here.]

The aforementioned behavioral stability is corroborated by the results of Wilcoxon signed rank tests comparing the distributions of average group contributions in the first and ninth periods of each treatment. These tests detect no location shift different from zero in the case of CC and PC, but a significant period effect in the case of B_{10} ($p = 0.53$ for CC; $p = 0.36$ for PC; $p = 0.005$ for B_{10}; the reported significance levels correspond to the two-sided version of the test).

Finally, the end-period effect (defined here as the proportional change in either the mean or the median of the average group contribution series between periods 9 and 10) is weaker in the communication-allowing treatments. The communicator is able to either "prime" a cooperative rule that stays in place even in the final period or influence preferences towards *perfect* conditonal cooperation.[17]

To conclude, the results of this section can be summarized as follows:

Result 1: *One-way communication significantly increases contributions to the public good and renders them relatively stable in all periods but the last.*

[16] The boxplots corresponding to periods 2 to 9 (2 to 8) in CC (PC) collapse to a single value as all five statistics that they typically depict (lower non-outlier value, first quartile, median, third quartile, and higher non-outlier value) equal 25.

[17] Section 5 elaborates on these two alternative explanations.

Result 2: *Whether the communicator can send a message prior to the first period only or prior to all periods bears no influence on contribution behavior.*

3.2 The communication content

Our categorization scheme of the communicators' arguments is described in Table 3 (the methodological details are given in Appendix A). The relative frequencies of observing the argument(s) implied by each category are reported in Table 4. To facilitate between-treatment comparisons, relative frequencies for *CC* are calculated separately for the first and then all subsequent periods.

[Table 3 about here.]

[Table 4 about here.]

All first-period messages can be classified into at least one of our categories, which we interpret as a sign that the communicators took their task seriously. This attitude translates in the present case into high first-period contributions, which in turn have a lasting positive effect on the groups' performance.[18]

A comparison between the third and fourth columns of Table 4 reveals that the choice of first-period arguments is only marginally affected by the communication conditions. The vast majority of communicators propose a specific contribution (category 1) and stress the importance of conformity within the group (category 2). Indeed, these two arguments are always concurrent: the communicator seems to understand that if there are conditionally cooperators in the group, contributing the suggested amount favors cooperation.

In both treatments, first-period suggestions are often accompanied by calculations of the associated payoffs (category 4). Communicators also try to motivate the others by drawing their attention to the payoffs that can be achieved under full cooperation (category 5). Arguments that rationalize suggestions on the grounds of either satisfaction (category 6) or fairness

[18]The significance of first-period play in social dilemma games is well documented (e.g., Keser and van Winden 2000).

(category 7) are infrequent. The same applies to arguments that draw peoples' attention to the possible repercussions of their actions (category 10), in particular the likely effects of free riding on overall behavior. Notice that unilateral promises (category 9) occur just twice in *CC*.

In *CC*, the communicator in all ten groups that start with and retain (at least till period 9) an average group contribution of 25 invokes in the first period the efficiency *and* conformity arguments.[19] These arguments do not appear in tandem in the first-period messages sent within groups numbered 2, 3, and 8, but each one of these groups achieves full contribution once its communicator has jointly invoked them. Hence, in *CC*, the conjunction of efficiency and conformity arguments seems to drive group contribution to the maximum.

In *PC*, the arguments of categories 2, 3 *and* 4 are mentioned in all groups where average group contribution remains fixed at 25 for (at least) the first nine periods.[20] In groups that do not consistently cooperate fully (that is groups 8, 9, 15 and 17), the communicators do not make an efficient suggestion and/or do not calculate the associated payoff.[21] Thus, in *PC*, the efficiency argument needs to be supplemented not only by conformity suggestions but also by payoff calculations in order that one-way communication has a strong impact on contribution levels.

The analysis of messages in the remaining periods of *CC* aims to answer two questions. The first is what communicators do in the face of initially high contribution levels. This topic is fraught with difficulties as (a) 27% of the messages sent in periods 2 to 10 are either empty or do not include arguments relevant to our categorization, and (b) in comparison to first-period messages, communicators attach less weight to all subsequent ones. Our data indicate that once the efficient outcome has been achieved, the communicator sooner or later understands that group contribution will re-

[19]These are the groups numbered 4, 5, 6, 7, 9, 12, 14, 16, 17 and 18. The same holds for group 11 where average group contribution equals 25 for periods 1 to 8, and group 13 where deviations from maximum average contribution are (with the exception of period 6) no larger than 0.25 ECU.

[20]These are groups 1, 2, 4, 6, 7, 10, 11, 12, 14 and 16. The same happens with groups 5 and 13, where one group member deviates from maximum contribution in the first period ($c_{24,1} = 24$ in group 5 and $c_{53,1} = 20$ in group 13).

[21]Here we provide a general description rather than exact rules. For example, even if the criteria of categories 2 to 4 are satisfied, the members of group 18 contribute fully just in periods 2 to 6. And the absence of payoff calculation does not prevent the members of group 3 to contribute fully in periods 1 to 8.

main maximum even with minimal correspondence effort from his part. So most of the messages, if any, suggest to keep on with the same behavior (category 1), and/or praise past behavior (category 12).

The second issue of interest is how communicators react to low contributors. In the three groups where first-period contributions are less than suggested, this is communicated to the other group members in the second period (category 11). In group 10, the communicator uses a trigger strategy (category 9) and his threats prevent free riding in all but the final period. In group 1, the communicator's appeal to fairness (category 12) fails to stabilize contributions. Finally, the communicator of group 15 undercuts (in the first period) his own suggestion. The group achieves full contribution in the following three periods, but average contribution declines dramatically following a second attempt by the communicator to free ride.

4 One-way communication without strategic play

We ran one session per treatment (B_1 and C). Each session involved 32 participants. Since there is no path dependence, we consider the individuals' contributions independent observations.[22]

Figure 3A draws histograms of the two data sets of contributions. While the distribution of the B_1 data is skewed to the right, that of the C data is bimodal (with more than 50% of the data points falling into the two extreme classes).

[Figure 3 about here.]

Figure 3B graphs empirical estimates of the cumulative distribution functions for the distributions that generated the two treatments' contribution data.[23] The B_1 treatment probability function rises steeply for $c_i \leq 15$ (over 90% of the observations are less than or equal to 15) and levels off for the remaining values. In the C treatment, in contrast, less than 50% of the observations are lying within the $[0, 15]$ range. Following the introduction of one-way communication, the mean (median) contribution rises from 6.9

[22] The analysis of the effects of one-way communication can be replicated using average group contributions, with the results remaining qualitatively the same.

[23] The empirical cumulative distribution function $F(c_i)$ gives the proportion of observations in a sample which are less than or equal to c_i.

(5.0) to 14.6 (17.5). Formal testing confirms that the two underlying probability distributions are stochastically different (the p-value of the two sample Kolmogorov-Smirnov test is less than 0.01), implying that strategic play can not be the driving engine of the effectiveness of one-way communication.

Thus, the answer to the fourth question of Table 1 can be formulated as follows:

Result 3: *One-way communication stimulates contributions even when subjects are denied the possibility to play strategically.*

Finally, Table 5 reports the occurrence frequencies of the arguments that apply to one-shot communication.[24] Among all groups with an average group contribution at least equal to 65% of the endowment (the groups numbered 1, 2, 3, 4, 7 and 8), all but two communicators (in groups 3 and 7) mention the arguments pertaining to categories 2, 3, and 4. The absence of the efficiency suggestion in the messages sent within groups 5 and 6 is associated with lower average group contributions. These results parallel our findings for the *PC* treatment, and confirm the importance of advancing the efficiency and conformity arguments, as well as of exemplifying payoff computations, to contribution levels.

[Table 5 about here.]

5 Conclusions

In this paper, we have studied the effects of one-way communication in a voluntary contribution experiment. While it is commonly accepted that the cooperation-enhancing effect of communication hinges on the mutual exchange of promises, we find that enabling one group member to send a free-form text message to his co-players increases contributions significantly. This finding does not depend on the frequency of communication. Thus, contrary to what Jerdee and Rosen (1974) and Frohlich and Oppenheimer (1998) maintain, communication is effective even in the absence of verbal reinforces. Furthermore, it does not depend on strategic play, meaning that communication is effective even if there is no prospect of future interactions.

[24] All messages can be classified into at least one category, attesting once again the communicators' commitment to reasoned arguments.

Unidirectional communication technologies where subjects are exposed to the speech of out-groups are considered inappropriate for enhancing cooperation (Brosig et al. 2003). However, the origin of the message in our experiment is internal to the group, so that both the communicator and the recipients of the message engage in common endeavors and share the same "fate". Social identity theory may explain why an in-group (rather than an out-group) communicator is effective (see, e.g., De Cremer and van Knippenberg 2002). Yet, the practical implications of our results are worth pointing out: a low-cost communication medium, like the internet, may be a suitable platform for addressing issues raised in social dilemma problems. Even with projects where many individuals interact via long distance, what seems to do the trick is the presence of a collaborator who sends a timely message to the others exhorting them to cooperate.

We advance two possible, albeit not mutually exclusive, explanations of our findings. The first explanation, which is in line with the arguments of, e.g., Kerr et al. (1997) and Balliet (2010), suggests that the communicator's messages activate an internalized norm of cooperation that enduringly increases the individuals' propensity to contribute, thereby affecting their behavior even when no further interactions are expected. Our analysis of the content of the communicator's messages reveals that efficiency and conformity may constitute such norms. The second potential explanation relates to the premise that in the presence of a communicator, who either influences preferences towards *perfect* conditional cooperation (in the sense that everyone wants to match the average contribution) or affects the conditional cooperators' expectations about the others' behavior, the original game is perceived as a coordination game with multiple Pareto-ranked equilibria (e.g., Foss 1999; Bicchieri 2006). In this case, the communicator merely serves as an efficient coordination device.

While the above explanations may be useful in interpreting our results, further research is needed in order to fully understand why one-way communication is so effective in establishing mutually beneficial cooperative relationships.

A Categorization methodology

Our categorization methodology follows Cooper and Kagel (2005) and Sutter and Strassmair (2009). Initially, two researchers examined independently a sample of the messages and established their own distinct sets of preliminary categories.[25] Each category represents one or more arguments that the communicator is likely to invoke, and each message may belong to more than one category. After consultations, the two researchers agreed upon the final set of categories shown in Table 3.

Then three undergraduate research assistants coded (once again separately) the total of the messages one by one: if one message contained the argument(s) specified by some category, then that category was assigned the value of 1 (otherwise, it was assigned the value of 0). The average correlation coefficient between the assistants' codings ranged from 0.70 to 0.80 (0.81 to 0.89) for the first-period messages sent in CC (PC), and from 0.75 to 0.79 for the messages sent in periods 2–10 in CC.[26] We can not compute such correlations coefficients in the case of C, as the assistants often coded with the same value all the available messages. As an alternative we report that the number of times all coders agreed on 1 relative to the number of times that at least one of them decided on 1 equals 0.85.[27]

Finally, the coders gathered, discussed their individual assessments and arrived at a common coding (the results are reported in Tables 4 and 5 for the repeated and one-shot treatments, respectively).

[25] Since the experiment was conducted in German, the categorization was undertaken by Johannes Weisser and Matthias Uhl, a German native speaker familiar with all details of the experiment.

[26] The correlation coefficient values reported by Cooper and Kagel (2005) and Sutter and Strassmair (2009) are somewhat smaller, implying that our categorization procedure was more clear-cut.

[27] The corresponding ratios for the PC, CC (period 1) and CC (periods 2–10) treatments are 0.79, 0.83 and 0.61, respectively.

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Table 1: Research questions and appropriate methodology

Research question	Answering approach
1) Is one-way communication effective?	Compare CC with B_{10}
	Compare PC with B_{10}
2) Does communication frequency matter?	Compare CC with PC
3) What kind of arguments are used?	Study the messages' content
4) Does strategic play matter?	Compare C with B_1

Note: Questions 1 to 3 are addressed in the context of finitely repeated games, question 4 in the context of one-shot games.

Table 2: Summary statistics of average group contributions across our finitely repeated treatments

Treatment	Mean	Std. dev.	Median	MAD	Q
B_{10}	12.27	8.73	11.62	11.68	8.16
CC	22.15	5.94	25.00	0.00	0.00
PC	21.75	6.68	25.00	0.00	0.00

Note: 180 observations per treatment.

Table 3: Description of the communication content categories

Category	Argument	Description
1	Suggestion	Suggestion (point or interval) of how much to contribute to the project (period 1), or appeal to keep on with the same behavior (periods 2-10). The suggestion, whether implicitly or explicit, must be unambiguous.
2	Conformity	Emphasis on the need that all group members conform to the suggestion.
3	Efficient suggestion	Implicit or explicit suggestion to contribute the whole endowment.
4	Payoff calculation	Calculation of the (period or overall) payoff associated with the proposal.
5	Group payoff maximization	Explicit argument that the suggested amount maximizes the group payoff, or conjecture that participants are interested in maximizing the group payoff.
6	Satisfaction	Explicit argument that people should be content with following (or with having followed) the communicator's suggestion.
7	Fairness	Explicit reference to fairness or just behavior.
8	Team spirit	Statement promoting the willingness to cooperate as part of a team.
9	Promise	Pledge to contribute some specific amount.
10	Trigger	Anticipation of potential behavioral dynamics.
11	Notification of low contributors	Implicit or explicit notification of those who contributed less than suggested and/or request to increase their contribution.
12	Praise	Praise of observed actions.

Table 4: Relative frequency of the arguments' presence in PC and CC

Category	Argument	PC	CC	
		$t = 1$	$t = 1$	$t > 1$
1	Suggestion	0.94	0.94	0.57
2	Conformity	0.94	0.94	0.13
3	Efficient suggestion	0.83	0.78	0.51
4	Payoff calculation	0.78	0.67	0.04
5	Group payoff maximization	0.50	0.78	0.01
6	Satisfaction	0.28	0.11	0.03
7	Fairness	0.22	0.17	0.02
8	Team spirit	0.44	0.28	0.09
9	Promise	0.00	0.11	0.03
10	Trigger	0.06	0.17	0.01
11	Notification of low contributors	-	-	0.09
12	Praise	-	-	0.31

Table 5: Relative frequency of the arguments' presence in C

Category	Argument	Frequency
1	Suggestion	1.00
2	Conformity	0.88
3	Efficient suggestion	0.75
4	Payoff calculation	1.00
5	Group payoff maximization	0.50
6	Satisfaction	0.00
7	Fairness	0.12
8	Team spirit	0.62
9	Promise	0.38

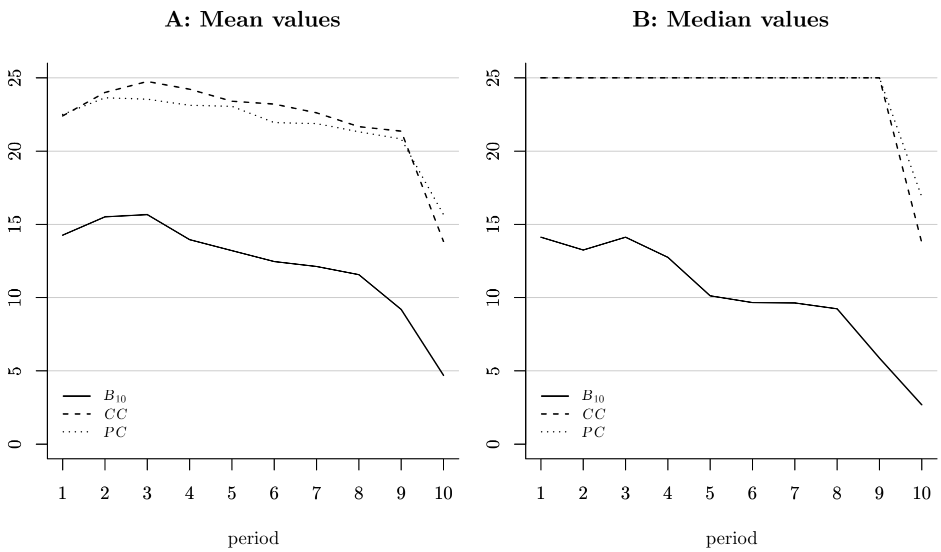

Figure 1: Mean and median of average group contributions over time (finitely repeated treatments; 18 observations per period).

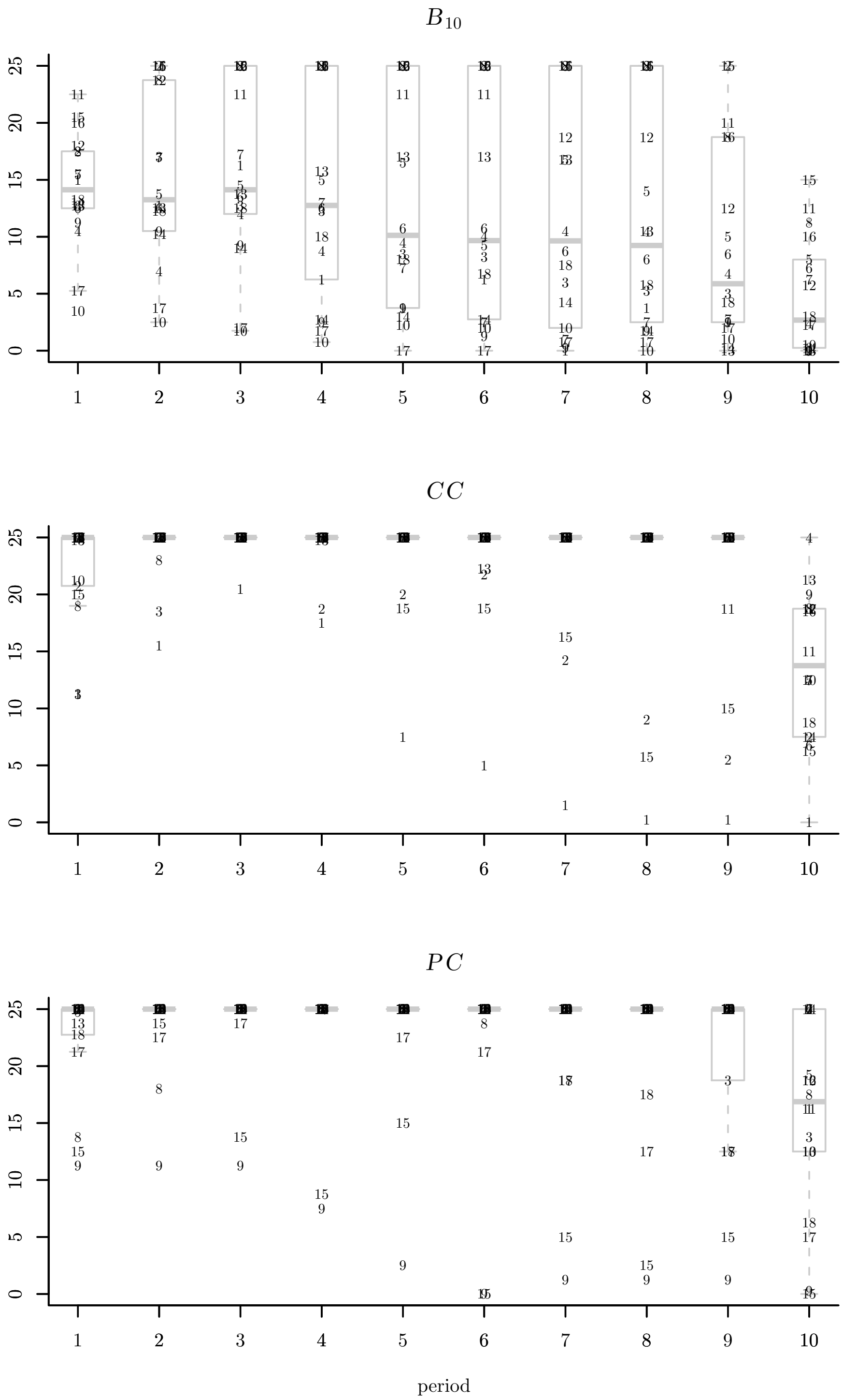

Figure 2: Average group contribution in all periods (finitely repeated treatments).

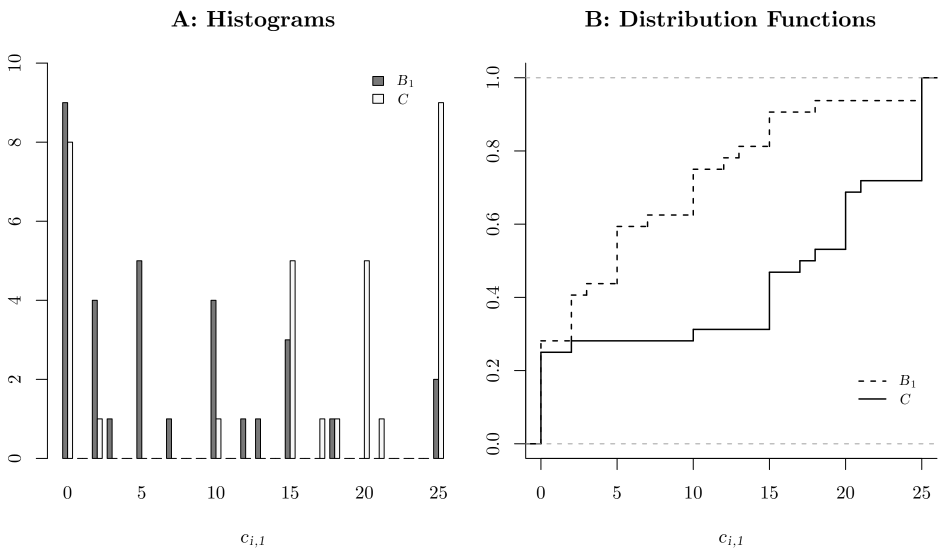

Figure 3: Histograms and empirical cumulative distribution functions of individual contributions in the one-shot treatments.