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The Effect of Communication Media on Cooperation

Jeannette Brosig and Joachim Weimann
University of Magdeburg

Axel Ockenfels
Max Planck Institute for Research into Economic Systems, Jena

Abstract. *We examine how communication affects cooperation with the help of seven standard public goods experiments that only differ with respect to the medium of pre-play communication. Our treatments include bidirectional and unidirectional communication via (mostly electronic) auditory and/or visual channels. The results suggest that successful cooperation is attributable to the opportunity of 'coordinating' behavior in the communication phase. Furthermore, both the level and the stability of cooperation significantly interact with the communication medium, even though the content of communication is remarkably similar across the communication treatments.*

JEL classification: *C*91; *C*92; *H*41.

Keywords: Public good; experimental economics; communication.

1. INTRODUCTION

Extensive experimental research on dilemma games has produced a number of stylized facts that describe systematic deviations from Nash-equilibrium play. One of the few variables that is known to have a robust and strong positive effect on the level of cooperation is the opportunity to communicate (Sally, 1995). While public goods experiments stimulated the development of new theories that are able to organize many of the factors that influence the voluntary contribution patterns,[1] the finding that communication enhances

1. The list of relevant theories is long. A first group of theories captures voluntary contributions in public good experiments as the result of other-regarding preferences such as altruism (Andreoni, 1993, 1996; Sefton and Steinberg, 1996; Palfrey and Prisbrey, 1997), cooperative gain seeking (Brandts and Schram, 2001), or a concern for relative payoffs (Bolton and Ockenfels, 2000; Fehr and Schmidt, 1999). Other models combine the assumption of altruism with the supposition that players make mistakes (McKelvey and

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cooperation is, given its significance, not well-understood and under-represented in both the theoretical and empirical work on public goods games (see e.g. Ledyard, 1995).

This paper examines how the communication medium affects cooperation in a social dilemma. Because neither the economic theory of communication nor experimental economics in this area is sufficiently advanced to guide our research, we decided to explore in a first step a rather broad range of communication media. In particular, by gradually changing the communication medium we separate those features of face-to-face communication that are essential for the activation of cooperative behavior from other accompaniments of communication: Does communication enhance cooperation *per se*, regardless of whether interaction is face-to-face or not? Can the cooperation-enhancing effect of face-to-face communication be reproduced by an internet video-conference, or are electronic media inferior to non-electronic media? Can it be reproduced by an audio-conference, or is visual communication essential? Can unidirectional communication support cooperative outcomes, or is bidirectional communication necessary?[2] To what extent is visual identification, yielding an increased social closeness, a key component of face-to-face communication?[3]

Section 2 describes our experimental design. Section 3 gives an overview of the average level and stability effects across treatments, and then explores in more detail individual and group behavior. We demonstrate that the communication medium matters in systematic ways, and that the cooperation-enhancing effect of communication can be to a large extent attributed to

Palfrey, 1995; Palfrey and Prisbrey, 1997; Anderson *et al.*, 1998). Some of these models are also consistent with the empirical facts that voluntary contributions tend to decrease over time, depend positively on the marginal per capita return of the public good, and may increase with the number of players, as has been observed by Isaac and Walker (1988) and Isaac *et al.* (1994) among others. Further models include evolutionary approaches (Andreoni and Miller, 1993), learning models (Erev and Roth, 2001), models of strategic reputation building (in the tradition of Kreps *et al.*, 1982), and models of boundedly rational decision-making (Selten *et al.*, 1997). For reviews see Ledyard (1995) and Holt and Laury (1997).

2. Unidirectional communication media such as newspapers or TV shows are frequently used to reach large groups. Since economic public goods problems are often large-group problems (e.g. global environmental problems), the question whether large-group communication technologies exhibit similar positive effects as small-group communication technologies is of central interest. Our experiments will show that unidirectional communication is not able to increase cooperation in the same way face-to-face communication can. But, of course, we employ the same group size in all treatments in order to secure the comparability of uni- and bidirectional communication media. In this sense, our results do not directly speak to what happens in large groups. In addition, as one of the referees pointed out, multidirectional communication is common also in large groups.
3. Hypotheses along these lines can be found in Hoffman *et al.* (1996, 1999) and Bohnet and Frey (1999a, 1999b).

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the opportunity of coordinating behavior in the communication phase. Since the opportunity to coordinate varies with the communication medium, this partly (but not completely) explains our treatment effect. Section 4 briefly concludes our study with a discussion of the results and possible implications for theoretical and applied communication medium research. We caution from the start, however, that our study is exploratory, and that given the lack of theoretical and empirical research in this area, any firm conclusions about the impact of communication media are necessarily subject to further studies.

2. EXPERIMENTAL DESIGN

All experimental sessions consisted of three consecutive phases: the training phase, the communication phase, and the game phase. In the game phase, subjects played a standard four-person public-good game over ten rounds. In each round, every subject got an endowment of 2.00 DM (= 200 Pfennig) and had to decide how much of the endowment to 'keep' for oneself and how much to 'give' to the group. The individual group contribution x_i yielded a payment of $x_i/2$ for each subject. Thus, the individual payoff π_i per round was

$$\pi_i(x) = 200 - x_i + \tfrac{1}{2}\sum_{j=1}^{4} x_j$$

After each round, subjects were informed about their individual given and kept amounts in that round, their individual round payoff, and the sum of the amounts given by all four group members. (During the game phase, all feedback was calculated and provided through a computer network.) While not contributing in all decision rounds is the unique subgame-perfect equilibrium, group payoff could be doubled (and maximized) if all subjects gave their entire endowment to the group.

At the beginning of each session, the subjects were given the opportunity to practice the game described above in a training phase. In particular, they played 20 rounds of the game in which the computer simulated the decisions of the other three group members following a predetermined algorithm that was the same for all subjects. A full description of this simple algorithm was included in the instructions. (See Appendix A for all instructions.)

After having completed the training phase, the (pre-play) communication phase began. In total, we ran seven treatments that only differed with respect to the communication opportunities as shown in Table 1 and as described below. In all treatments, we used soundproof cabins that were endowed with an audio- and video-conferencing system (video camera, video monitor, microphone, headphone) and linked with each other by a separable audio and video network.

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Table 1 Experimental treatments

Treatment	Verbal communication (i.e. transmission of linguistic messages)	Anonymous interaction (i.e. neither auditory nor visual identification of other group members)
Reference	No	Yes
Identification	No	No Visual identification
Lecture	Yes Passive (ca. 5 min.)	Yes
Talk-show	Yes Passive (ca. 5 min.)	Yes
Audio-conference	Yes Active (max. 10 min.)	No Auditory identification
Video-conference	Yes Active (max. 10 min.)	No Visual and auditory identification
Table-conference	Yes Active (max. 10 min.)	No Visual and auditory identification

Our goal is to decompose the cooperation-enhancing effect of communication as observed in earlier studies. In such a typical study (see e.g. Isaac *et al.*, 1985, and Isaac and Walker, 1988) the outcomes of two dilemma game treatments are compared, one with no communication at all and one typically with pre-play face-to-face interaction. However, since face-to-face interaction allows the partners to communicate via both *auditory* and *visual* channels, to *identify* each other, to *respond* to each other, and to exchange *unrestricted messages*, the change of behavior may be attributed to each (combination) of these options. To systematically study these features along with the potential scope of electronic face-to-face communication technologies, we examine the following seven treatments.

In the reference treatment, subjects played the standard public good game without pre-play communication. The identification treatment did not allow any form of verbal communication but only visual identification. Here, during the communication phase, subjects could only see each other for ten seconds on a screen divided into four quads each showing another group member. Any kind of visual signaling of game-relevant information was prohibited. Nevertheless, identification reduces what is sometimes called 'social distance' and therefore may increase the scope for reputation effects which in turn may yield more cooperation (see Hoffman *et al.*, 1996, 1999, and Bohnet and Frey, 1999a, 1999b). In contrast, the audio-conference treatment allowed auditory communication, but no visual identification. That is, subjects could talk to each other via microphone and headphone for a maximum of ten minutes but could not see each other. In the video- and table-conferences subjects were given the opportunity for both, visual and auditory communication. In the video-conferences subjects communicated

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with each other simultaneously via a video-conferencing system utilizing a combination of the equipment that was used in the identification and audio-conference treatments. In the table-conferences subjects were led into a separate room and seated around a table where they could talk with each other for a maximum of ten minutes. So, our study includes two different face-to-face communication treatments: the video-conference based on electronic communication channels (as feasible on the internet) and the table-conference that requires the communication partners to come together at the same place.

While the latter treatments allowed 'active' communication, i.e. subjects verbally communicated themselves, the treatments lecture and talk-show only allowed 'passive' communication, i.e. subjects were exposed to the communication of others and could not intervene. During the communication phase of the talk-show treatment, subjects were shown the videotaped discussion of another group that took part at the video-conference treatment. In the lecture treatment subjects saw a video-lecture given by a lecturer who was not involved in the experiments. In his talk, the lecturer explained the standard public good game, characterized both the subgame-perfect equilibrium and the outcome that maximizes group payoff, and described experimental results revealing that face-to-face communication has a substantial effect on the amount of the public good provided.[4] All subjects in either treatment saw the same video.

As far as verbal communication was permitted in the communication phase, the content of discussions was not restricted. In order to analyze the content and the course of the talk, all discussions were videotaped.

In all sessions, we tried to secure that subjects were not acquainted with each other and, as far as predestined by our design, had no contact with other group members either before, in the course of, or after the experiment. Therefore, we recruited subjects from a large variety of undergraduate courses in economics and business administration in different semesters. Also, in addition to their registration, subjects had to sign a form, stating that they will inform the experimenter when they notice that an acquaintance will take part in the same session. For the experiment, each subject was appointed to another room so that any contact between subjects before the experiments was ruled out. Having arrived at their rooms, subjects were led one after another to their cabins where they had to stay for the whole experiment, except in the table-conference treatment. At the end of the sessions, subjects were paid off one after another and left the cabins and the lab separately.

4. Since the outcome of these treatments may depend on the specific video chosen, we decided to exogenously create our own video (lecture) and, on the other hand, to choose an endogenously created video showing the communication phase of other subjects (talk-show). The fact that such differently created videos generate very similar outcomes, as we show below, makes us somewhat confident that our results concerning unidirectional communication are not too fragile. The transcript of the lecture treatment is included in Appendix D.

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The experiments were run with 140 undergraduate students of economics and management science at the *Laboratory for Experimental Economics in Magdeburg* (MaxLab). Each of the seven treatments was played with five groups. No subject in the experiment played any more than one of the seven treatments. No session lasted longer than 45 minutes. Overall, average payoffs were about 34 DM (approximately $17), with a minimum of 20 DM and a maximum of 45 DM.

3. EXPERIMENTAL RESULTS

3.1. Level and stability of cooperation

Figures 1a to 1c show the average contribution paths in all seven treatments in percent of the endowment (our partition of treatments is guided by observations that we will explain in a moment).

The figures strongly suggest that both the level and the stability of group contributions are influenced by our treatment variable. Figure 2 shows the *level of cooperation* per treatment (in the following denoted by l) measured by the overall average contribution, along with the average contribution per treatment in the first round only.

A Kruskal–Wallis test on the group level (five independent observations per treatment) reveals significant cooperation differences across treatments ($p = 0.005$). In particular, Figure 2 suggests that cooperation levels are significantly higher in video- and table-conferences compared to all other treatments. Pairwise comparisons confirm this conjecture for video- and table-conference (exact one-tailed Mann–Whitney U-tests, $p < 0.05$ for each pairwise comparison separately). On the other hand, cooperation levels do neither differ significantly between the two face-to-face treatments (video- and table-conference) nor across the other five treatments. Figure 1b suggests, however, that pre-play communication through lecture, talk-show, or audio-conference yield somewhat more group contributions than reference and identification – at least in the first rounds. The comparisons of overall averages and first-round averages in Figure 2 strengthen this impression. In fact, applying exact one-tailed Mann–Whitney U-tests on the group level, the first-round averages of lecture, talk-show, and audio-conference are significantly higher than the corresponding averages of reference and identification, respectively ($p < 0.05$ for five pairwise comparisons and $p < 0.06$ for one comparison), while at the same time the differences between lecture, talk-show, and audio-conference are not significant.

The *stability of cooperation*, in the following denoted by s, is defined as the average group contributions in the last five rounds, measured relative to what has been contributed on average in the first five rounds. Figure 3 shows the average stability for each treatment separately, and a Kruskal–Wallis test statistically confirms our finding that stability varies substantially across treatments ($p = 0.042$). According to our stability criterion, the no-verbal

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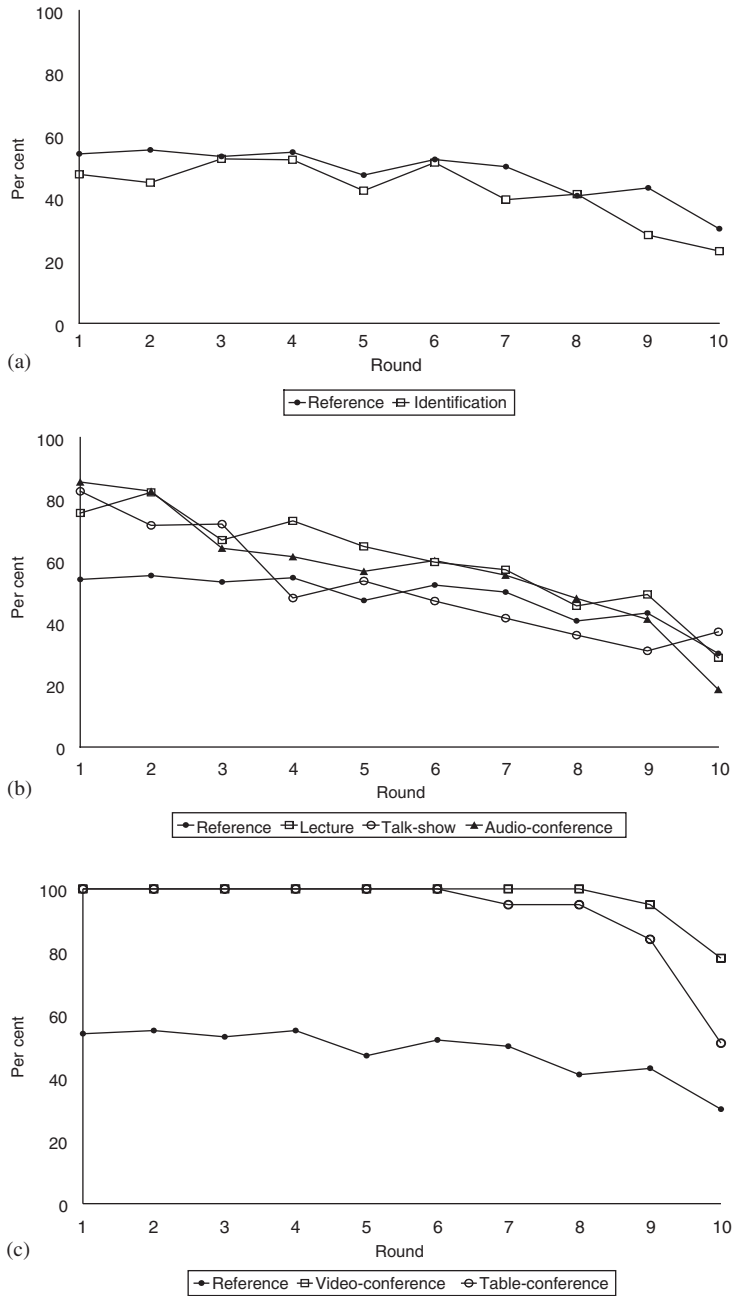

Figure 1 (a) Average contributions in reference and identification. (b) Average contributions in reference, lecture, talk-show, and audio-conference. (c) Average contributions in reference, video-conference and table-conference

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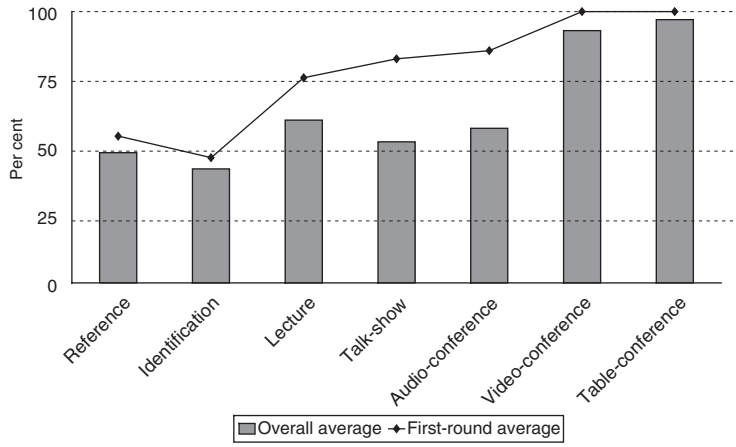

Figure 2 Overall average contributions and average contributions in the first round

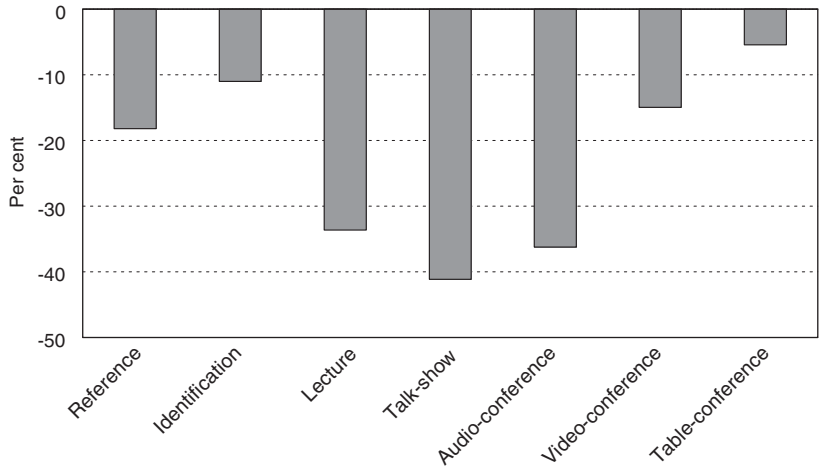

Figure 3 Stability of cooperation

treatments and the face-to-face treatments are similarly stable ($s > -20$ per cent), no significant differences occur. On the other hand, lecture, talk-show, and audio-conference are considerably less stable ($s < -30$ per cent). In particular, pairwise comparisons on the group level reveal that each of these treatments is significantly less stable than each of the face-to-face treatments (exact one-tailed Mann–Whitney U-tests, $p < 0.05$), though the comparison with each of the non-verbal treatments yields no significant results on the 5 per cent level.

We conclude that the medium of pre-play communication significantly affects both cooperation level and stability of cooperation behavior. Table 2 and Observation 1 summarize our findings.

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Table 2 Classification of treatments by level and stability of cooperation

	Classes	Cooperation level	Stability of cooperation
Class 1	*No verbal communication* (reference, identification)	Low: $l < 50\%$	High: $s > -20\%$
Class 2	*Passive communication* (lecture, talk-show) *and audio-conference*	Intermediate: $50\% \leq l \leq 60\%$	Low: $s < -30\%$
Class 3	*Face-to-face communication* (video- and table-conference)	High: $l > 90\%$	High: $s > -20\%$

Observation 1 [level and stability effect]. The seven communication treatments can be divided into three classes that differ significantly with regard to the level and/or the stability of cooperation.

- [Class 1] *no verbal communication*: visual identification alone has no measurable effect on cooperation. Both no-verbal communication treatments (reference and identification) yield the same low and stable cooperation rates.[5]
- [Class 2] *passive communication and audio-conference*: the passive treatments (lecture and talk-show) and the audio-conference result in significantly higher first-round contribution levels compared to the class 1 treatments. Since cooperation is substantially less stable, however, overall contribution rates are only slightly higher.
- [Class 3] *face-to-face communication*: in both face-to-face treatments (table- and video-conference) subjects reach nearly full and stable cooperation rates.[6]

3.2. Coordination in the active communication treatments

The analysis of the transcripts in our active communication treatments (audio-, video-, and table-conference) reveals that the communication patterns are quite insensitive to the communication medium.[7] In a typical communication phase some subjects first observed that it would be best if all group members contribute their whole endowment in every round. As to legitimate this observation, the payoffs for full cooperation were computed

5. The reference and identification treatments both also lead to results that are consistent with those typically observed in public goods experiments in which subjects are not put into isolated booths.
6. In Section 4, we will come back to the observation that the audio-conference performs significantly worse than the face-to-face treatments.
7. Communication phase data are included in Appendix C. The data do not reveal the dynamics of communication that might also have influenced behavior. Full transcripts (in German) are available from the authors upon request.

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and, qualitatively or quantitatively, compared to payoffs that would follow after no cooperation. In addition, some groups computed the maximal individual payoff from free-riding.

The group discussions showed that, after having completed the training phase, most subjects understood the basic conflict between individual and collective rationality. There were, however, a few subjects who still misunderstood the underlying incentives of the stage game or the experimental parameters like the number of rounds to be played in the game phase. The other group members clarified such misunderstandings.

Once the dilemma structure was common knowledge, naturally the question arose of how to arrive at the efficient outcome. All but one group emphasized that cooperation of *all* is a necessary requirement for persistent cooperation. Moreover, in most groups subjects explicitly pronounced threats not to cooperate unless *all other* group members cooperate.[8] No group, however, speaks to the unraveling problem inherent in the repeated dilemma game and only one group (group 5, video-conference) explicitly recognizes that deviation in the last round cannot be punished any more. In this group all subjects promised to fully cooperate until round 9; in all other groups all subjects promised to cooperate (either explicitly in *all* rounds or not).

In sum, subjects expressed a willingness to cooperate conditioned on not being exploited. The use of promises together with threats in the communication phase apparently serves to *coordinate* the attempt to reach persistent cooperation. Without the opportunity to coordinate behavior, it may be difficult to solve the dilemma since the presence of conditionally cooperative subjects suggests that cooperation tends to collapse when (initial) individual behavior is divergent or noisy.[9] Note also that the possibility to coordinate behavior in a way that yields less than maximal group payoffs sometimes came up. For instance, in one group it was proposed to coordinate on 1 DM, and in other groups players thought about a complex dynamic cooperation rule with alternating contributions. Such ideas were, however, overruled very soon.

From a standard theoretical point of view, talk is cheap. The question then is whether subjects actually transform their promises and threats into payoff-

8. One might call these subjects 'conditional cooperators'. Sorts of conditional cooperation have recently been observed in public goods experiments without communication opportunities (Weimann, 1994; Bolton *et al.*, 2000; and Ockenfels and Weimann, 1999) and are also theoretically discussed in reciprocity models (Rabin, 1993), models of 'unfairness aversion' (Bolton and Ockenfels, 2000; Fehr and Schmidt, 1999), or by the theory of cooperative gain seekers (Brandts and Schram, 2001). While these models differ substantially with respect to the reference point on which cooperation is conditioned, they all suggest that people tend to cooperate less when others cooperate less.
9. Of course, full cooperation cannot occur in equilibrium of the standard economic model of rational and selfish subjects, but it may well occur – at least in the first rounds of the game – in one among multiple equilibria in theories of social preferences, in which fair and selfish players may coexist (see in particular the discussion in Bolton and Ockenfels, 2000, p. 188). In this sense, the term 'coordinate' seems to be appropriate.

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Table 3 Cooperation pattern in group 1 of the audio-conference treatment

Round	Subject 1	Subject 2	Subject 3	Subject 4
1	200	200	0	200
2	200	200	0	200
3	0	0	100	0
4	200	0	0	50
5	0	0	0	0
6	0	0	0	100
7	0	0	10	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

relevant behavior. The answer is 'yes'. As promised, the large majority (95 per cent) of subjects in the active communication treatments started with full cooperation. Any deviation from efficient cooperation is usually followed by a breakdown of full cooperation of other players after not more than two rounds.[10] A typical example is given in Table 3. It shows that, after having observed that not all subjects kept their promise in round 1, subjects give the efficient outcome only one other chance before cooperation collapses. We summarize our findings in the following observation:

Observation 2 [coordination]

(1) In the *communication phase* of the active communication treatments subjects assert both a willingness to fully cooperate and a willingness to stop cooperative play if deviations from the multilateral promises should occur (conditional cooperation). Furthermore, lacks of understanding of the incentives or experimental parameters are eliminated.
(2) In the *game phase*, subjects generally complied with both their promises and threats: all subjects in the face-to-face treatments and most subjects in the audio-conferences start cooperatively and cooperation generally collapses after free-riding has been observed. Successful cooperation therefore directly mirrors successful coordination in the communication phase.

3.3. The influence of the communication medium

Our previous analysis demonstrates that the communication phase is mainly used to coordinate conditionally cooperative strategies. However, as shown before, the level and stability of cooperation varies substantially with the

10. Only in group 5 of the audio-conference treatment did one subject manage to exploit others over more than two rounds. All individual data can be found in Appendix B.

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communication medium. Hence, coordination appears to be a stimulating but by no means the only influence of communication on efficiency-enhancing cooperation. What additional requirements are needed to make coordination through communication particularly successful? The following analysis further elaborates on the interaction between cooperation behavior and communication medium.

Figure 4 shows the proportion of individual contributions that remain constant from round to round, a measure for *individual stability*.[11] The data displayed in Figure 4 show that individual stability ranges from a treatment average of 26.1 per cent in identification up to 97.2 per cent in table-conference. Pooling the treatments within the classes as described in Table 2, individual stability over time is highest after face-to-face communication, significantly lower after passive communication and audio-conference, and again significantly lower when there were no opportunities for verbal communication.[12] Comparisons of group behavior on the treatment level reveal that while nine out of 16 possible treatment comparisons across the three classes are significant at the 5 per cent level, no pairwise treatment comparison within the classes yields significance (so that our pooling over communication classes can be statistically justified).[13] This further justifies our earlier classification in Table 2.

Subjects tend to change their decisions more frequently when there are no verbal communication opportunities. However, Figure 3 showed that the cooperation level in the non-verbal treatments is as stable as in the face-to-face treatments. This implies that individual decision instability in the non-verbal treatments is largely neutralized on the aggregated level.

Figure 5 complements our findings with respect to individual stability on the group level. It shows the overall round average, and the minimum and

11. Formally, the stability of subject i's behavior is defined as $\sum_{t=2}^{20} \Delta_i^t/19$ where $\Delta_i^t = 1$ if $x_i^t = x_i^{t-1}$ and $\Delta_i^t = 0$ else. Other measures of individual stability such as the variance of individual contributions yield very similar conclusions.
12. Applying exact two-tailed Mann–Whitney U-tests on the group level, the comparison between face-to-face communication treatments and passive communication/audio-conference treatments yields $p = 0.019$, and the comparison between non-verbal communication treatments and passive communication/audio-conference treatments yields $p = 0.000$.
13. The individual stability result is reflected in the distributions of relative frequencies of extreme contributions chosen across treatments. Here, an individual contribution x is said to be extreme if the subject resolves the tension between group efficiency and individual rationality by choosing either $x = 200$ or $x = 0$. The average proportion of extreme decisions differs up to a factor three across treatments. In particular, the relative frequency of extreme decisions is highest in the face-to-face treatments, lower in the passive treatments and audio-conference ($p = 0.008$), and lowest in the non-verbal treatments ($p = 0.001$). Only in the non-verbal treatments, the number of full free-riders exceeds the number of full cooperators, while free-riding is almost non-existent in the face-to-face treatments. Comparisons of group behavior on the treatment level yield significance at the 5 per cent level for 11 out of 16 possible treatment comparisons across the three communication classes, while again no treatment comparison within the classes yields significance.

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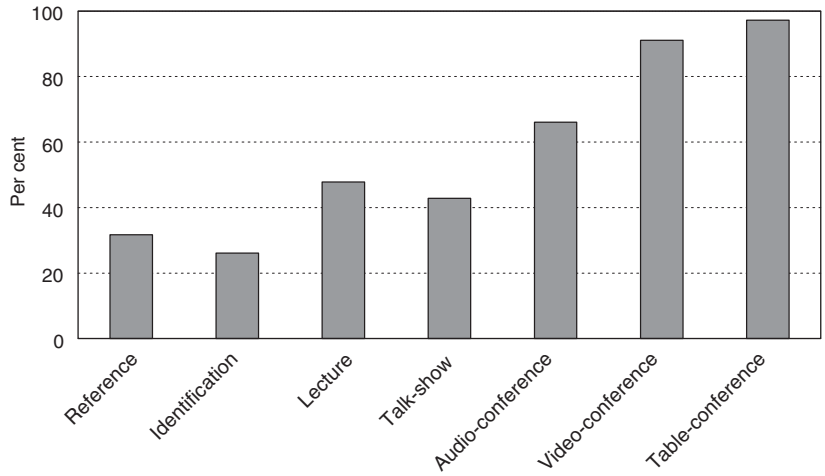

Figure 4 Individual stability across treatments (measured as the average proportion of individual contributions that remain constant from round to round)

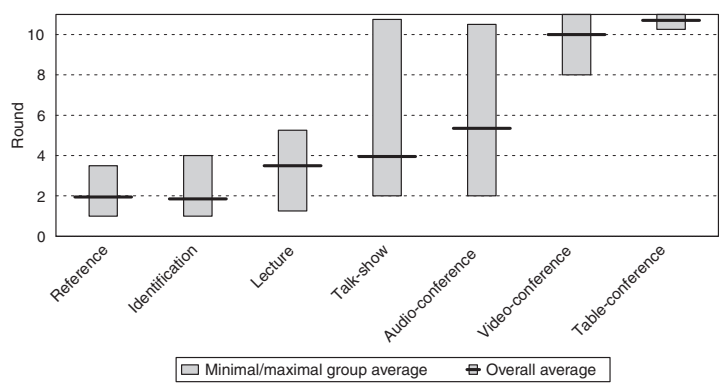

Figure 5 Average round of first defection

maximum round average of first deviation from full cooperation of the five groups per treatment. For instance, all subjects of group 2 of the identification treatment deviate from the very beginning, i.e. all group members choose $x < 200$ in round 1 yielding one as the average round of first defection (minimal group average), the four subjects of group 3 on average deviate first in round 4 (maximal group average), and the overall average round of first deviation over the five groups is 1.85. If a subject chooses $x = 200$ in all ten rounds, the corresponding round of first defection is defined as 11.

In the non-verbal treatments the overall average of the round of first defection is smallest, in the passive treatments and the audio-conference it is higher ($p = 0.004$), and it is maximal in the face-to-face treatments ($p = 0.000$).

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Comparisons of group behavior on the treatment level yield significance for 12 out of 16 possible treatment comparisons across the three communication classes, while no pairwise treatment comparison within a class yields significance. Furthermore, note that groups behaved quite homogeneously if either face-to-face communication or if no (verbal) communication was allowed, while the passive treatments and the audio-conference exhibit relatively divergent successes of coordination across groups.

Now, we are ready to present a congruent picture of the influence of the communication medium on cooperation behavior that emerges from Figures 1 to 5 together with Observations 1 and 2. When there are *no verbal communication* opportunities coordination is not easily possible and noise with respect to choices and beliefs is more likely. Therefore it is not surprising that individual contributions vary strongly from the first round on so that it is almost impossible to get locked in efficient cooperation.[14] The cooperation level is, however, remarkably stable, though highly inefficient. Apparently, visual communication alone, as allowed in the identification treatment, is not a substitute for verbal communication.[15]

In the *passive communication* treatments, coordination is more likely since unidirectional communication transmits information about the coordination efforts of others, either by reporting about respective experimental phenomena in a lecture or by directly viewing the communication phase of another group. Consequently, passive communication has some positive effect on efficiency in the first rounds and leads to somewhat more individual stability. However, due to coordination failure in some groups, average cooperation is considerably less stable than in the face-to-face treatments and soon reaches the cooperation level of the non-verbal communication treatments. While the *audio-conference* appears to be somewhat more successful than passive communication, the differences with respect to both level and stability effects are weak and not statistically significant.

Face-to-face communication, on the other hand, significantly dominates the level performance of all other communication treatments and the stability performance of the passive communication treatments and the audio-conference. Note that this is not due to a decrease in the 'social distance' (see Hoffman *et al.*, 1996, 1999; Bohnet and Frey, 1999a, 1999b) or to an increase of 'group identity' (see e.g. Kramer and Brewer, 1986; Dawes *et al.*, 1988) through visual identification, since the identification treatment controls for these explanations. The overwhelming predominance of face-to-face communication is also not due to the possibility that subjects fail to

14. Behavior is, however, not (only) randomly determined. Subjects generally tend to adjust their contributions in the direction of average contributions. The Spearman rank correlation coefficient between $x_t^i - x_{t-1}^i$ and $x_{t-1}^i - \bar{x}_{t-1}$ for $t = 2, \ldots, 10$ and all i in all treatments is -0.448 ($p < 0.01$, two-sided).

15. The observation that visual identification has no significant effect on behavior implies that reputation effects are not the driving force of the cooperation-enhancing effect of communication.

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take the chance to coordinate on the efficient outcome in the other active communication treatment. As stated earlier, *all* subjects involved in active communication promised to fully cooperate. This leaves us with the communication medium *per se* as the decisive influence on the success of cooperation. Observation 3 summarizes our findings:

Observation 3 [communication medium]. Cooperation behavior significantly and systematically depends on the *communication medium*. The absence of (verbal) communication opportunities circumvents efficient coordination and leads to noisy individual behavior. Passive communication somewhat improves the success of coordination in early rounds, but cooperation often breaks down soon. Active communication is especially successful if players can use both auditory and visual channels. Then, efficient and stable cooperation emerges. The predominance of face-to-face and video-conference performance is, however, neither due to a decrease of social distance nor due to differences in the communication contents, but apparently caused by the communication medium *per se*.

4. CONCLUSIONS

Our results strongly suggest that people use pre-play communication as a coordination device for (conditionally) cooperative strategies. The success of coordination efforts, however, depends ultimately on the specific communication medium. First, unidirectional communication technologies are rather ineffective means to enhance cooperation, even in the rather small groups of our experiments. As a consequence, there is only little hope that the members of large groups manage to coordinate their behavior with the help of unidirectional communication technologies alone. Second, it does not make a difference if people talk face-to-face sitting at the same table or watching each other on a video screen. A video-conference is as useful to employ the favorable features of face-to-face communication as a 'real' conference. So, new electronic communication technologies may have a good chance to partly substitute old communication channels that require people to be near to each other in a physical sense. What is crucial, however, is that there is face-to-face communication; in particular, audio communication (without face-to-face interaction) and identification (without active communication) perform significantly worse. Frank (1987, 1988) speculates that one critical feature of face-to-face communication is that it provides a variety of channels of communication, such as facial expression, that are not available in our audio-conferences.[16] Identification in principle allows for

16. Ockenfels and Selten (2000) and Brosig (2002) tested implications of Frank's theory. While Brosig found some supportive evidence in prisoners' dilemma games, a scenario similar to the present experiment, Ockenfels and Selten could not find any evidence for type detection in a two-person bargaining context.

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detecting (physical) signals in line with Frank's theory, but identification makes it much harder to coordinate behavior compared to the active communication treatments. We speculate that the particular success of face-to-face interaction has also something to do with human evolution and socialization. During the evolution of human beings, face-to-face was the only available form of communication. Also, we are socialized in small groups that usually interact (and cooperate) face-to-face. Hence, both our evolutionary heritage and our social embossing are likely to have taught us to rely on those we see when we talk to them.

APPENDIX A. INSTRUCTIONS (TRANSLATION FROM GERMAN)

Instructions

Preliminary remark: You are participating in an experimental analysis of individual decision-making. In five minutes, we will come to you for answering open questions. If you have further questions during the experiment, please switch on the camera on the monitor. *Note that you may not use the computer until we have invited you.*

During the experiment you will make a sequence of decisions. In doing so you will earn money in cash. The exact amount will depend on your decisions. The total amount of money is paid off at the end of the experiment. Both your decisions and your payoff remain a secret, meaning that no other subject will be informed about it.

Decisions: You are in a group of four. At present, the other three group members are sitting like you in a cabin in front of a computer terminal. All group members have received the same instructions.

In ten consecutive rounds, you have to make the following identical decision: In each round you get an initial endowment of 2 DM. You have to decide, how many DM you will 'keep' and how many DM you will 'give'. Each given amount x yields an amount of $x/2$ for every member of the group (the person giving the amount inclusive). The amount of money you don't give, you can keep for yourself.

Your payoff per round summarized in a formula is:

$$2 \text{ DM} - \text{your given amount} + \tfrac{1}{2} * \text{sum of all given amounts in the group}$$

Example: Suppose, in a round all group members give 1 DM. Then your payoff per round is 2 DM – 1 DM $+ \frac{1}{2}$4 DM = 3 DM. Note that you can give an arbitrary amount between 0 DM and 2 DM in each round and that all group members are faced with the same decision context in all ten rounds. After each round you are informed about your kept amount, about your given amount, about the sum of amounts given by *all* four group members, and your payoff per round.

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Training rounds: Before making your decisions, you are given the opportunity to complete 20 training rounds. In these rounds, the given amounts of the other group members are *simulated*:

- In rounds 1–5 the simulated sum of amounts given by the others is 0 DM.
- In rounds 6–10 the simulated sum of amounts given by the others is 2 DM.
- In rounds 11–15 the simulated sum of amounts given by the others is 4 DM.
- In rounds 16–20 the simulated sum of amounts given by the others is 6 DM.

That is, you can get to know for different simulated sums of money given by the other three group members the consequences of your own given amount.

Rounds relevant for your payoff:

[This part is different with regard to the seven treatments of the experiment.]

Reference: Your decisions after the training rounds are relevant for your payoff. Please wait for further instructions.

Identification: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to see the other three group members on a video-monitor for ten seconds. Please wait for further instructions.

Lecture: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to watch a video. The video shows a lecture in which your decision is explained in more detail. Please wait for further instructions.

Talk-Show: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to watch a video. The video shows another group whose members had to make the same decisions like you. Before group members decided about their given amounts they were given the opportunity to communicate with each other via a video-conferencing system. The video shows this communication phase. Please wait for further instructions.

Audio-Conference: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to communicate with each other. Communication takes place via microphone and head-phone which are in your cabin. Communication must not last longer than 15 minutes, but you are free to finish earlier. Please wait for further instructions.

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Video-Conference: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to communicate with each other. Communication takes place via a video-conferencing system. Communication must not last longer than 15 minutes, but you are free to finish earlier. Please wait for further instructions.

Table-Conference: Before you make your payoff-relevant decisions after the training rounds, you are given the opportunity to communicate with the other three group members. Communication takes place in a separate room. Communication must not last longer than 15 minutes, but you are free to finish earlier. Please wait for further instructions.

[This last part is the same for all experiments.]

Keep in mind that you make your decision secretly in a cabin and that your earning is paid off confidentially. (*Only in the relevant treatments:* Except in the communication phase,) you will not meet your group members.

In order to avoid influence on other subjects in future experiments, please do not talk to others about this session. We thank you for your cooperation!

Otto-von-Guericke-University Magdeburg
Faculty of Economics and Management

Herewith I commit to participate in an experimental session

		MaxLab
		Magdeburg Laboratory of Experimental Economics
on:	Monday, 18.01.1999	Building 22, Room C 213
at:	1 p.m.	Tel.: (0391) 67-18762
in:	Building 22, Room C 213	Fax: (0391) 67-12971
		E-mail: jeannette.brosig@ww.uni-magdeburg.de

The session will last about 1 hour.

- I was informed that only those could take part in a session who are not acquainted with me. If I notice that friends or acquaintances will participate in the same session (same day and same time), I will inform MaxLab immediately.
- I was informed that non-attendance may circumvent running the session. If I do not call off 24 hours before the session begins or if I do not take part without good reason, I will be liable for the loss amounting to at least 100 DM.

Date: Address/Telephone/E-mail:

Name: Signature:

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APPENDIX B. DATA

Reference

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	150	200	80	100	530	0	25	0	0	25	50	200	100	140	490	200	20	100	200	520	200	100	100	200	600
2	160	200	200	80	640	25	0	100	0	125	30	40	200	120	390	100	100	110	200	510	0	200	150	200	550
3	170	200	130	50	550	80	50	0	0	130	60	160	200	120	540	200	11	100	200	511	0	151	50	200	401
4	160	200	50	120	530	30	0	0	0	30	70	170	200	130	570	100	167	90	100	457	100	150	150	200	600
5	150	100	50	0	300	100	2	0	15	117	100	180	200	130	610	100	0	100	100	300	100	166	100	200	566
6	150	100	100	80	430	0	50	0	0	50	85	200	200	140	625	100	36	0	200	336	200	102	150	200	652
7	150	100	80	90	420	0	10	0	0	10	83	200	200	150	633	0	83	130	200	413	0	151	175	200	526
8	160	110	60	55	385	18	0	0	20	38	95	150	200	110	555	0	62	100	0	162	100	119	70	200	489
9	150	100	0	110	360	10	0	0	0	10	80	150	200	120	550	100	10	100	100	310	200	0	100	200	500
10	150	0	0	0	150	40	0	0	0	40	60	100	0	130	290	0	78	200	100	378	200	0	150	0	350

Identification

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	200	100	50	100	450	0	101	50	13	164	0	200	50	200	450	20	120	50	100	290	200	100	100	150	550
2	41	150	50	0	241	50	150	100	7	307	0	200	50	200	450	0	100	0	50	150	200	100	150	200	650
3	100	100	75	50	325	80	101	0	0	181	200	200	120	200	720	50	50	75	100	275	200	100	150	150	600
4	31	50	60	150	291	50	0	50	24	124	200	200	150	200	750	20	200	50	80	350	200	50	125	200	575
5	143	100	100	100	443	0	101	0	3	104	200	200	100	200	700	7	0	50	140	197	0	50	100	100	250
6	42	150	80	0	272	30	200	100	7	337	200	200	70	200	670	100	150	75	0	325	200	0	100	150	450
7	52	100	80	100	332	70	99	170	15	354	0	180	0	0	180	20	145	50	0	215	200	0	150	150	500
8	153	100	100	200	553	0	102	57	72	231	0	130	70	1	201	140	110	65	0	315	200	0	50	100	350
9	177	100	100	10	387	0	101	34	5	140	0	150	160	1	311	0	160	80	0	240	0	50	0	0	50
10	8	0	100	0	108	50	106	0	2	158	2	150	85	1	238	0	40	99	0	139	0	0	130	150	280

Lecture

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	150	200	130	200	680	150	100	200	100	550	200	200	200	0	600	100	200	200	200	700	150	200	144	0	494
2	200	200	150	200	750	200	150	0	100	450	200	200	200	0	600	150	200	200	200	750	200	200	190	150	740
3	200	200	200	200	800	100	125	0	100	325	0	200	100	0	300	100	200	200	200	700	200	200	50	99	549
4	200	200	120	200	720	120	125	0	100	345	100	200	100	100	500	150	200	180	200	730	100	200	200	127	627
5	99	200	0	200	499	110	83	0	100	293	0	200	200	100	500	100	180	200	200	680	200	150	150	120	620
6	99	150	70	200	519	100	140	0	100	340	0	200	0	0	200	170	180	200	200	750	200	0	200	180	580
7	99	175	100	200	574	115	96	0	100	311	100	200	100	0	400	100	180	195	200	675	200	0	90	41	331
8	67	200	0	200	467	20	76	0	100	196	100	200	100	0	400	50	180	150	200	580	0	0	100	80	180
9	98	150	50	200	498	50	30	0	0	80	0	200	100	0	300	180	180	100	200	660	100	200	10	122	432
10	0	175	0	99	274	0	0	0	0	0	0	200	50	0	250	100	150	100	200	550	50	0	10	20	80

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Talk-show

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	200	60	200	200	660	20	200	200	200	620	200	200	200	100	700	50	75	200	200	525	200	200	200	200	800
2	200	50	190	150	590	100	200	100	200	600	200	200	0	150	550	100	25	0	200	325	200	200	200	200	800
3	200	50	200	50	500	150	180	50	151	531	50	200	200	150	600	100	50	100	200	450	200	200	200	200	800
4	100	50	200	50	400	50	0	100	0	150	200	0	0	150	350	100	100	25	0	225	200	200	200	200	800
5	100	50	101	150	401	10	200	0	100	310	75	100	110	125	410	0	25	200	0	225	200	200	200	200	800
6	100	0	150	10	260	70	0	100	101	271	30	150	150	150	480	0	75	0	0	75	200	200	200	200	800
7	0	50	50	50	150	100	100	0	0	200	15	200	150	150	515	0	0	0	0	0	200	200	200	200	800
8	0	0	190	20	210	0	0	50	0	50	1	0	200	150	351	10	25	0	0	35	200	200	200	200	800
9	0	0	101	140	241	20	0	0	101	121	50	0	0	0	50	10	0	20	0	30	200	200	200	200	800
10	0	50	200	50	300	10	200	20	107	337	1	100	100	0	201	0	50	0	0	50	200	200	0	200	600

Audio-conference

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	200	200	0	200	600	200	200	200	200	800	200	200	200	200	800	200	200	200	25	625	200	200	200	0	600
2	200	200	0	200	600	200	200	200	200	800	200	200	200	200	800	150	200	145	10	505	200	200	200	0	600
3	0	0	100	0	100	200	200	200	200	800	200	200	200	190	790	0	109	150	20	279	200	200	200	0	600
4	200	0	0	50	250	200	200	200	200	800	200	100	200	200	700	10	0	50	50	110	200	200	200	0	600
5	0	0	0	0	0	200	200	200	200	800	170	200	200	200	770	0	0	99	1	100	200	200	200	0	600
6	0	0	0	100	100	200	200	200	200	800	200	200	200	200	800	60	50	0	1	111	200	200	200	0	600
7	0	0	10	0	10	200	200	200	200	800	200	150	200	200	750	0	29	31	1	61	200	199	200	0	599
8	0	0	0	0	0	200	200	200	200	800	200	200	200	200	800	0	0	0	1	1	200	120	0	0	320
9	0	0	0	0	0	200	200	200	200	800	150	50	200	200	600	0	0	50	1	51	0	200	0	0	200
10	0	0	0	0	0	0	0	200	200	400	100	0	0	100	200	20	11	0	1	32	0	110	0	0	110

Video-conference

Round	Group 1					Group 2					Group 3					Group 4					Group 5				
	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum	S 1	S 2	S 3	S 4	Sum
1	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800
2	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800
3	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800
4	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800
5	200	200	200	200	800	200	200	200	200	800	198	200	200	200	798	200	200	200	200	800	200	200	200	200	800
6	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800	200	200	200	200	800
7	200	200	200	200	800	200	200	200	200	800	0	200	200	200	600	200	200	200	200	800	200	200	200	200	800
8	200	200	200	200	800	200	200	200	200	800	200	200	200	0	600	200	200	200	200	800	200	200	200	200	800
9	200	200	200	200	800	200	200	200	200	800	150	200	0	0	350	200	200	0	200	600	200	200	200	200	800
10	200	200	200	200	800	0	200	200	200	600	98	50	0	0	148	200	200	0	1	401	10	100	0	0	110

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Table-conference

Round	Group 1				
	S 1	S 2	S 3	S 4	Sum
1	200	200	200	200	800
2	200	200	200	200	800
3	200	200	200	200	800
4	200	200	200	200	800
5	200	200	200	200	800
6	200	200	200	200	800
7	200	200	200	200	800
8	200	200	200	200	800
9	200	200	200	200	800
10	200	200	10	200	610

Group 2				
S 1	S 2	S 3	S 4	Sum
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800

Group 3				
S 1	S 2	S 3	S 4	Sum
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	0	200	200	600

Group 4				
S 1	S 2	S 3	S 4	Sum
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	0	600
200	99	200	0	499

Group 5				
S 1	S 2	S 3	S 4	Sum
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
200	200	200	200	800
0	200	200	200	600

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APPENDIX C. COMMUNICATION PHASE DATA

		Content of communication										
		Intro-duction of players	Preferred solution: $x = 200$	Calculation payoff full cooperation	Agree-ment necessary	Calculation max. indiv. payoff	Threat	Last round effect	Agree-ment	Lacks of under-standing	Time	Results
Table-con.	1	X	X	X	X	–	X	–	All $x = 200$ (always)	–	2:52 min.	All $x = 200$ until the 9th round
	2	–	X	X	X	X	X	–	All $x = 200$ (always)	X	4:34 min.	All $x = 200$ until the 10th round
	3	–	X	X	X	X	X	–	All $x = 200$	–	3:48 min.	All $x = 200$ until the 9th round
	4	–	X	X	X	–	–	–	All $x = 200$	–	0:42 min.	All $x = 200$ until the 8th round
	5	–	X	X	X	–	X	–	All $x = 200$	–	1:25 min.	All $x = 200$ until the 9th round
Video-con.	1	X	X	X	X	–	X	–	All $x = 200$	X	10:04 min.	All $x = 200$ until the 10th round
	2	–	X	X	X	X	–	–	All $x = 200$ (always)	X	2:56 min.	All $x = 200$ until the 9th round
	3	–	X	–	X	–	–	–	All $x = 200$	–	0:26 min.	All $x = 200$ until the 6th round
	4	X	X	X	X	–	X	–	All $x = 200$	X	3:27 min.	All $x = 200$ until the 8th round
	5	X	X	X	X	X	X	X	All $x = 200$ (until the 9th rd.)	X	5:26 min.	All $x = 200$ until the 9th round
Audio-con.	1	X	X	X	X	X	X	–	All $x = 200$	X	2:22 min.	3 $x = 200$ until the 2nd round
	2	–	X	–	X	–	X	–	All $x = 200$	–	0:59 min.	All $x = 200$ until the 9th round
	3	–	X	X	X	X	X	–	All $x = 200$ (always)	X	2:35 min.	All $x = 200$ until the 8th round
	4	X	X	–	–	–	–	–	All $x = 200$ (always)	–	0:54 min.	3 $x = 200$ in the 1st round
	5	X	X	–	X	–	X	–	All $x = 200$ (always)	–	1:56 min.	3 $x = 200$ until the 7th round

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APPENDIX D. TRANSCRIPT OF THE LECTURE TREATMENT (TRANSLATION FROM GERMAN)

The task you are confronted with can be characterized as a dilemma situation. As you can easily calculate on the basis of the payoff formula you are provided with, the group payoff will be greatest if each of you contributes 2 Mark. In this case, everybody in the group will get back 4 Mark yielding a group payoff of 16 Mark or, aggregated over the ten rounds, 160 Mark. On the other hand, each of you can increase his own payoff by not contributing at all, regardless of the contributions by the other group members. That is the dilemma situation.

However, further considerations can lead to the following conclusion: if I contribute nothing, then the others might not be willing to contribute either. In this sense, it is possibly reasonable to contribute. But observe that this does not hold for the last round. That is, in the last round nobody has an incentive to contribute. But if this is true, then, of course, one can infer that this holds also true in the ninth round. This is the case, because if it is known that in the tenth round absolutely nobody will contribute, then nobody has a reason to contribute in the ninth round since contributions cannot motivate others to contribute in the tenth round. If this holds true in the ninth round, then it holds also true for the same reason in the eighth round, etc. By the so-called backward induction procedure one finally comes to the conclusion that if you behave rationally and if you know that all other players also behave rationally, nobody ever will contribute. But then each of you earns only 2 Mark per round. Recall that if you do not follow this reasoning, if your group contributes everything instead, everybody earns 4 Mark per round.

That is the dilemma. It is individually rational for each of you to contribute nothing. But then you get a solution, in which everybody only earns 2 Mark instead of 4 Mark.

Now, in experiments like those you are participating in, it has been observed that subjects did not always contribute 2 Mark per round. On average, they contributed about half as much. On the other hand, we conducted experiments in which subjects received the opportunity for pre-play communication about the game. These subjects, after all, managed it to always contribute 2 Mark from the first round until the ninth round. But, in the tenth round, in some of these groups contributions decreased.

Well, you do not have the opportunity to communicate, but you only watch this film. You have now to decide on how you will behave in this dilemma situation.

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Corresponding author: Joachim Weimann, University of Magdeburg, P.O. Box 4120, 39016 Magdeburg, Germany. Tel.: + 49-391-6718547; fax: + 49-391-6712971; e-mail: joachim.weimann@ww.uni-magdeburg.de

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