Knowledge Sharing in Groups: Experimental Findings of How to Overcome a Social Dilemma

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Abstract: Shared databases are used for knowledge sharing in groups. The decision whether to contribute knowledge to such a database or to withhold it represents a public-goods dilemma. Each group member saves time and energy if s/he only uses the database to get information but does not contribute any information. But if all do so, the database is empty, and nobody has any benefit of it. An experimental environment enabling the study of this dilemma is described, and an overview of five experiments is given. They investigate the effect of the following factors: providing metaknowledge about the importance of the information, providing a bonus system to reward contributing, reducing costs for contribution, establishing prescriptive rules for the number of contributions, and providing feedback about the teammates' contribution behavior.

Knowledge Sharing in Groups - A Social Dilemma

The performance of a group working collaboratively depends on its ability to make use of the expertise of its different members. Therefore they have to share their distributed knowledge. A tool for doing this is a shared database. By entering information into the database, each group member can make his/her knowledge available to others, and each one can make use from the information that others contributed. Hence, shared databases can be especially useful in large organizations, in which similar tasks are accomplished by different people and departments. Often its members are locally distributed and do not have face-to-face contact to each other. Sometimes they even do not know each other personally.

Indeed, when shared databases are implemented for knowledge exchange sometimes specific problems arise. These are primarily of psychological nature. The main problem is that group members often are reluctant to share their knowledge because knowledge in groups is often seen as a kind of power which people do not want to give away. Considering this aspect, the decision to share knowledge with others by entering it into a shared database represents a typical instance of *social dilemma* (Dawes, 1980): A potential knowledge provider has no private benefit if s/he contributes information to the database. Instead, s/he only has private costs because s/he has to invest time and effort for writing down the information and entering it into the database. Hence, whereas all the other users can (at least potentially) benefit from one's knowledge-sharing behavior, the provider him/herself has no benefit at all. Instead s/he has personal costs. These costs lead to a situation where each individual personally achieves a higher benefit by not contributing any information. But by not sharing his/her personal knowledge a person behaves uncooperatively. And if all people behave in such a way, there is no knowledge sharing at all, and all people end up less well off and have more costs than if they cooperated. Thus, in terms of decision theory, withholding information is the *dominant strategy.* This means that it is the most efficient strategy for each individual, independent of what the others do. But at the same time withholding is a *pareto-inferior Nash Equilibrium*. This means that the group as a whole has a lower benefit if all group members withhold information than if all cooperate. These two features define a typical social dilemma: According to an individualistic rationality it is more efficient for each subject to withhold information, while according to the group's rationality it is more efficient if all individuals share their information.

Within the different types of social dilemmas, exchanging knowledge via shared databases is a *public goods dilemma*. Public goods are characterized by their *indivisibility* (Barry & Hardin, 1982), and *non-excludability* (Head, 1972). Indivisibility means that the amount and the quality of the information in a database (as public good) are not reduced if a person uses the information. Non-excludability means that the whole content of the database is in principle accessible to all members. Thus, nobody can be prevented from using the database – even if that individual contributed nothing. Because of this fact, a potential knowledge provider cannot have any founded expectation of a direct balance between his/her costs and his/her benefits of knowledge sharing. Thus, there is no reason for expecting reciprocity. An individual who contributes knowledge to a shared database can't expect to reciprocally obtain information from those people who use his/her contributions. Instead of such a *direct* exchange, there is a kind of *generalized exchange* (Markus, 1990; Yamagishi & Cook, 1993). Here a knowledge provider can only have a slight hope to possibly benefit from the amount of all others' contributions (Fulk, Flanagin, Kalman, Monge & Ryan, 1996; Markus & Connolly, 1990; Rafaeli & LaRose, 1993; Thorn & Connolly, 1987). Opposite to direct exchange, any member can benefit from his/her knowledge, even if s/he did not contribute anything to the database. This kind of *free riding* typically occurs in the described situation (Cress, Barquero, Buder & Hesse, i.p.). With respect to the individual rationality this is in fact the most individually effective strategy. The question arises how people nevertheless can be motivated to behave contrary to their individual rationality, and to share their knowledge - even if they reside in such a dilemma.

An Experimental Investigation of the Knowledge-sharing Dilemma

Despite of the importance of this question for organizations, virtual seminars, newsgroups or mailing lists, only little empirical research was done in controlled settings. And situations where shared databases are used in the field are highly complex. There lots of factors determine the contribution behavior: For example, group and sub-group influences, the topic of information exchange, or individual and group aims. In contrast, our aim here is to introduce an experimental environment, where such different factors can be studied in a highly controlled and experimental way. In dilemma research this is typically done by creating a situation where people are paid off according to their decisions. By setting up such a pay-off matrix all costs and benefits people have from cooperation or defection are made comparable.

Thus we developed an experimental setting where sharing knowledge sets up such a dilemma. For each subject the dilemma arises through the amount of money people can earn during the experiment. On the one side, each subject earns the more, the less information s/he contributes to the shared database. Thus, withholding is a dominant strategy. On the other side the mean payoff for all group members is higher if all decide to contribute than if no one does. Thus, withholding information is a pareto-inferior Nash Equilibrium.

These situational characteristics were realized through the following task: In the experiment of about one hour each participant works in a six-person team on the task of calculating salaries of salespeople. Each salary is composed of two values: a base salary which is calculated in the first phase of a trial, and the provision, which is calculated in the second phase. In the *first phase* a subject earns 0.25 Euro for each base salary s/he calculated. After each calculation a person has to decide whether s/he wants to contribute this result to the shared database. The transfer to the database costs time (15 sec.). Because the two phases are time-limited (9 and 12 minutes), the more one contributes, the less base salaries one can calculate, and - consequently - the less one earns.

In the *second phase*, each group member has to calculate the *total salary* of as many salespeople as possible. In this phase a participant gets 0.30 Euro for every total salary s/he calculated. But for the calculation of a salesman's total salary the base salary is needed. If a participant did not calculate it in the first phase, and if this value was not contributed to the database by at least one of the other group members, s/he has to calculate it in the second phase. By doing this s/he will lose time. Thus, being collaborative and contributing base salaries to the database in the first phase may facilitate the performance of the other group members in the second phase. But according to his/her own payoff, a person has no benefit from contributing a base salary to the database. (In the second phase a person has the base salaries s/he calculated in the first phase anyway). Concerning the benefit of the others, it is not sure if others really need a specific base salary because a person doesn't know which total salaries others will calculate in the second phase. Moreover, persons can't be sure that the information they contribute is really unique because other group members could have calculated the base salaries of the same salesperson, too. So it is possible that the database contribution of a base salary has no use for others. Therefore, the experiment reproduces a typical feature of knowledge exchange where the information a person has might be redundant or even unnecessary for others.

In an experimental session each participant is presented three times with such a task (each task being divided into two phases as described earlier). In fact, there are no real groups. Instead, the behavior of the other five group members is simulated for each participant. By doing this, the interference of other factors deriving from the variability of real groups can be avoided.

After the experiment participants are paid according to their individual performance. They get money for each calculated basic salary and total income. As the task is very easy and the amount of calculated salaries and incomes only depends on a person's speed and his/her own and the group's (simulated) contribution behavior, the payoff function can be mathematically set up (Cress, Barquero, Buder, Schwan & Hesse, 2003). Figure 1 shows the money a participant earns as a function of his/her contribution rate xi (0: s/he does not contribute anything; 1: s/he contributes every basic salary s/he calculated) and the mean contribution rate xo of the other five group members.

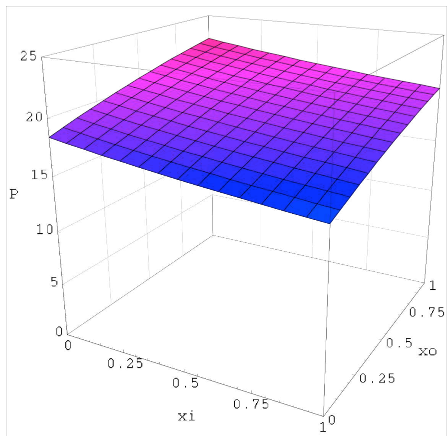

Figure 1. A subject's payoff (in €) as a function of the individual contribution rate xi and the mean contribution rate xo of the other five group members.

The figure illustrates the way the experimental situation represents a social dilemma: The subject's payoff declines with growing xi but simultaneously grows with growing xo. That means, that a subject earns the more, the more his/her group mates contribute. And s/he earns the less, the more s/he contributes herself. Thus, his/her individual payoff is highest with xo=1 and xi=0. This is the situation in which all other group members contribute every basic salary and the focused subject contributes nothing, and free-rides.

Overview of a Series of Experiments

With this experimental environment we carried out a series of experiments, and tested the effect of the following factors:

- providing metaknowledge about the importance of the information
- providing a bonus to reward contributing
- reducing the costs for contribution
- establishing prescriptive rules for the number of contributions
- providing feedback about the teammates' contributions behavior.

In the following we will in short describe the experimental manipulations we induced for each experiment. Our primary aim is not to describe the experiments in detail; instead we want to give a broader overview of the effects of these manipulations. This allows us to evaluate the effectiveness of different treatments for reducing free-riding in the knowledge-sharing dilemma.

In all following experiments the participants were university students who were paid for their participation. We allowed no psychology students to take part in the experiment because we were afraid that they could perhaps recognize that the groups were faked. The number of subjects in each experimental condition was about 20.

1. Providing Metaknowledge about the Importance of Information

In a first experiment we varied the importance of the salary information. Therefore we introduced two different kinds of base salaries: After calculation of a base salary in the first experimental phase, the result appeared with a probability of 50% as red field. This red color denoted that this salary was above the mean. This showed that this salary was of high importance because the subjects know that the total incomes of those salesmen with high base salaries had to be calculated first in the second phase. Therefore, the probability that a red base salary was needed in the second phase was higher than the probability that a non-red base salary was needed. Salaries below the mean didn't change their color after calculation. This denoted that they were not as important in the second phase.

In the experiment the contributions of more and less important salaries were compared in a within-design. As Figure 2 shows, the experiment revealed a significant main effect of importance. On average subjects contributed much more important than less important salaries.

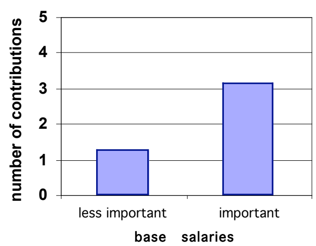

Figure 2: Mean number of contributed less important and important base salaries.

The very strong effect could be replicated in diverse other experiments. In situations where contribution costs for more and less important information were equal, subjects selected their database contributions according to their importance. This reflects that a person's decision to contribute is not only based on considering his/her individual payoff but also on considering the payoff of the others. By primarily contributing highly useful information the contributors individually have no more costs, but they enable higher benefits for others. With respect to the individual payoff, withholding important information is still dominant. But if one decided to provide information at all, it is more effective to provide important than non-important information. Thus, providing more important information than less important is in line with an individual rationality, too (Cress, i.p.; Cress, Buder, Vogt & Hesse, subm.).

2. Providing a Bonus to Reward Contributing

A second experiment dealt with the effect of a use-related bonus system. This is a kind of bonus-system where people receive a bonus each time one of his/her contributions are used by one of their group mates. With this bonus system it should be in the interest of each person to primarily contribute information that is useful for others, because a contributor only receives the bonus, if his/her contributions are in fact needed by others.

In the experiment three different bonus levels were compared:

- in the first condition no bonus was given at all,
- in the second condition a cost-compensating bonus was given (which was 5 Cent per each use), and
- in the third condition a cost-exceeding bonus was given (which was 10 Cent per each use).

With the cost-compensating bonus an individual didn't have any incentive for withholding information. With a cost-exceeding bonus the dilemma didn't actually exist any more. Instead, contributing *all* important information was the most effective strategy. But in the experiment the subjects only knew that they would receive a bonus of 5 or 10 Cent, but they weren't explicitly informed if the bonus level was higher or lower than the costs for cooperation.

Figure 3 presents the number of contributed important and less important base salaries in all three conditions. It shows that individuals with a bonus system contributed more base salaries of high importance but fewer salaries of low importance than those without any bonus system. This indicates that subjects not receiving a bonus tended to select their contributions with less attention to importance than subjects in the two bonus conditions. Thus, providing a bonus can not enhance the *quantity* of database contents, but it enhances the *quality*. With a use-related bonus system more information which is potentially useful for others is provided than without such a bonus system.

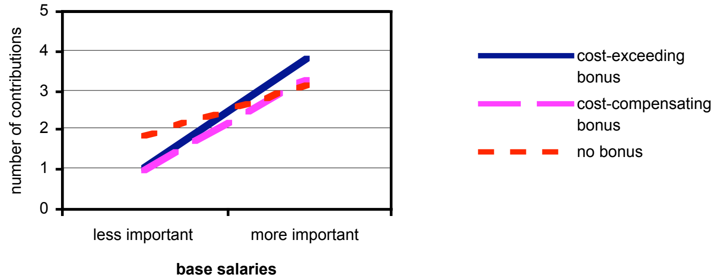

Figure 3: Mean number of contributed important and less important base salaries without a bonus, with a cost-compensating bonus, and with a cost-exceeding bonus.

3. Reducing the Costs for Contributions

In the previous experiment the payoff structure of the dilemma was manipulated by reducing the dominance of withholding. With a bonus, contributing was made more efficient. The following experiment manipulates the dilemma structure by reducing contribution costs. These costs (the time it takes to transfer a base salary to the database) directly influence the dilemma. The higher the costs, the more dominant the withholding strategy becomes.

For investigating the effect of contribution costs two conditions were compared: one experimental group with low contribution costs (5 seconds) and one with high contribution costs (15 seconds). As expected, the experiment revealed a significant effect of costs. With high costs less information was contributed than with low costs. Additionally to this main effect, the experiment revealed a different development of contribution behavior over time. This is presented in Figure 4:

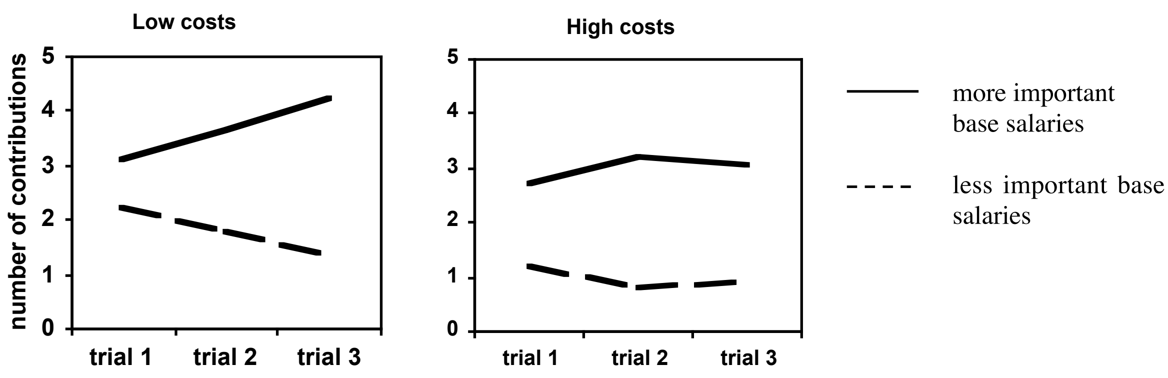

Figure 4: Mean number of contributed important and less important base salaries in each of the three trials.

Subjects with low transaction costs showed a less selective contribution behavior in the first trial, which constantly increased across the second and third trial. In contrast, subjects with high costs selected their contributions to a higher degree already from the first trial on. This level of selection increased a bit in the second trial and remained stable in the third trial.

4. Establishing Prescriptive Rules

Is it possible to motivate people to share their knowledge by establishing rules which prescribe how much information one has to contribute as a minimum? The next experiment investigated such prescriptive rules and compared two groups: In one group the subjects were requested for at least eight contributions ("high rule") and subjects of the other group were requested for at least three contributions ("low rule"). In both groups subjects were aware that they could not be sanctioned if they violated the rule.

Figure 5a (left figure) shows that subjects with the high prescriptive rule contributed more than those with the low rule - but only in the first trial. The difference disappeared for the second and third trial. And even during the first trial, subjects contributed much fewer base salaries than the rule required. Whereas the high rule demanded eight contributions, they contributed only about five.

In a following experiment we used a pop-up window to make the rule more salient. Whenever one person had calculated a base salary it appeared showing the following text: "During this trial you should contribute 3 (respectively 8) base salaries. Till now you have contributed … salaries". Thus, each time a subject had to decide if s/he wanted to contribute, s/he was reminded on the rule and could realize to what degree s/he had accomplished it. When a person fully accomplished the rule and had contributed 3 (respectively 8) salaries the window didn't appear during that trial any more.

The results of this experiment are shown in Figure 5b (right figure). Now a significant main effect across all trials occurred. In all trials subjects with high rules contributed more than those with the low rules. But even with the pop up window making the rule salient, subjects didn't fully accomplish to the high rule. They entered significantly less than the eight prescribed contributions.

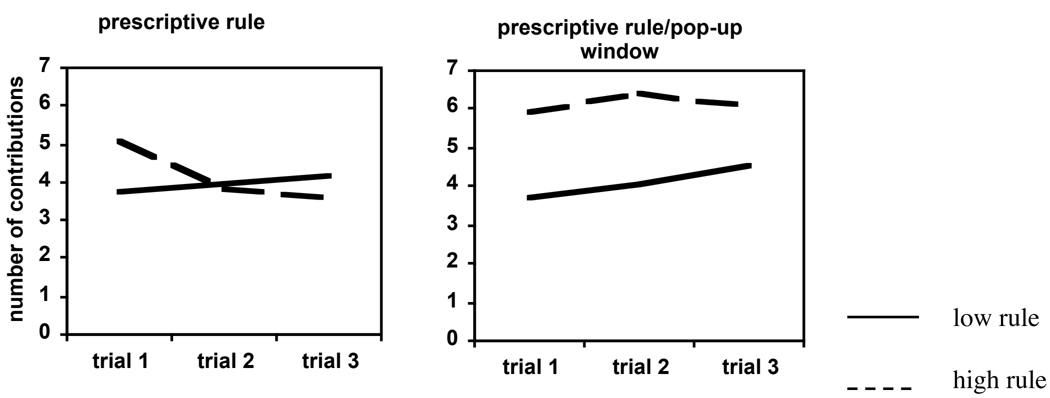

Figure 5a (left): Mean number of contributed base salaries of subjects with high and low rule.
Figure 5b (right): Mean number of contributed base salaries of subjects with high and low rule, which was made salient through a pop-up window.

5. Providing Feedback about the Teammates' Contribution Behavior

In the next experiment we provided subjects with feedback about their teammates' contribution behavior. After each trial each subject received a histogram with two bars: the first showed the number of his/her own contributions and the second showed the mean number of contributions made by the five teammates. This feedback was intended to induce a social comparison between one's own behavior and the behavior of the others. For studying the effect of this feedback the information of the teammates' cooperativeness was varied. In the experimental group with highly cooperative teammates subjects received a feedback that the others on average contributed eight salaries, whereas in the experimental group with less cooperative teammates subjects received a feedback that the other on average contributed only three salaries.

The experiment revealed a highly significant effect of this feedback. Figure 6 shows the mean number of contributions in both conditions.

Figure 6: Mean number of contributed base salaries of subjects with feedback about cooperative teammates and less cooperative teammates.

After the first trial - when the subjects got feedback about the others' behavior - the two groups assimilated to their teammates' behavior. Indeed, persons with highly cooperative teammates didn't fully assimilate to their cooperativeness. In the second and third trial they still contributed significantly less than the faked group members who contributed 8 salaries. In contrast, the groups with low-cooperation group members *fully* assimilated to their faked teammates. In this group there was no significant difference to the three contributions of their co-worker.

These results show that people in the database situation in fact adapt to the behavior of their teammates. If they perceive them as highly cooperative, people over time become more cooperative as well. If they perceive them as very uncooperative, people become more egoistic, too. But the results show that this adaptation to the cooperativeness of the others' isn't equally strong in both conditions. The assimilation to a low social norm of cooperativeness seems to be stronger than the assimilation to a higher level. It could be interpreted in a way that the sucker effect seems to be easier than the effect of social facilitation. This could perhaps be explained by the specific features of knowledge exchange via shared databases. In this highly anonymous situation, where the behavior of each group members can't be identified by the others, the group members can't detect the free riders. Therefore, the social pressure for behaving as cooperatively as the others is reduced through anonymity. In contrast, in situations, where the group behaves very uncooperatively, people assimilate to the group norm not because of a feeling of social pressure, but because of a feeling of exploitation. But this feeling isn't reduced through the high anonymity of database communication.

General Discussion

All reported results show that free riding in fact is a serious problem in knowledge exchange via shared databases. Averaged across all experiments, subjects calculated about 12 basic salaries in each trial and contributed about 30%-50% of them. This means that they withheld the other 50%-70% of their information. But some of the treatments which were introduced in the experiments could change this - at least a bit.

First of all: In the first three experiments two different kinds of information were used (less and more important information), and subjects contributed much more information of high importance than information of low importance. Thus, if a subject once decided to contribute s/he did this in a way that the others had the highest benefit. This shows that subjects didn't behave competitively with the motivation of maximizing the difference between their own and the others' outcome. Instead, they selected their database contributions with consideration of what the others need. This selection could be enhanced through a use-related bonus system. With low costs this selection is reduced, but only at the beginning of the experiment. When the subjects get more experienced, the selection increases.

Second, we observed that none of our manipulations was able to eliminate free riding completely. Neither a treatment, which objectively reduced the dominance of withholding by providing a cost-compensating bonus, nor a cost-exceeding bonus, which objectively turned contribution into a dominant strategy, was able to reduce free riding fully. It seems that subjects subjectively have a bias to perceive such a situation as a dilemma, even if objectively it isn't. Thus, a bonus-system can't totally solve the dilemma. Instead, subjects assess the costs higher than the rewards they get through a bonus (Cress, Buder, Vogt & Hesse, sub.). This leads us to the third point:

Third: The possibility to influence subjects' contribution behavior through a structural change of the dilemma (through reducing costs or providing bonuses) seems to be more limited than through social factors. Here we have to consider the strong effect of the feedback about the cooperativeness of the teammates. Obviously, in the very anonymous situation of knowledge-exchange via database, social cues become highly relevant.

What do these results mean for actual knowledge-exchange settings where subjects are not paid? We assume that subjects in real knowledge-exchange situations feel the dilemma even stronger: In the experiment the payoff for contributors and defectors only differed in a few Euros. In real knowledge-exchange settings benefits and costs are more multifaceted and thus they become even more relevant. For example, a person who shares his knowledge in an organization does not only lose time. He could perhaps also lose social power through having knowledge the others don't have. Additionally, in real groups the individual payoffs can vary much stronger. In settings, where subjects have to cooperate with people they personally know, social factors become more influential than in the presented experiment. If the feedback about the teammates' contribution behavior is effective with strangers, it should be even more influential in settings with real groups and less anonymity.

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Acknowledgments

This work was supported by grant of the Deutsche Forschungsgemeinschaft (DFG) awarded to the F.W. Hesse and U. Cress. The project is part of the DFG-Special Priority Program "Net-based Knowledge Communication in Groups". We thank Beatrice Barquero, Katrin Vogt and Juergen Buder for their work in this project, and Julia Wahl, Tatjana Taraszow, Tina Betschinger, Kim Stalbovs and Michael Sobkiw for conducting the experiments.