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# ABSTRACT

## Living in Two Neighborhoods: Social Interactions in the Lab

Field evidence suggests that people belonging to the same group often behave similarly, i.e., behaviour exhibits social interaction effects. We conduct an experiment that avoids the identification problem present in the field. Our novel design feature is that each subject simultaneously is a member of two randomly assigned and identical groups where only members ('neighbours') are different. In both groups subjects contribute to a public good. We speak of social interactions if the same subject at the same time makes group-specific contributions that depend on their respective neighbours' contribution. We find that a majority of subjects exhibits social interaction effects.

JEL Classification: C91, H41, K42, H26

Keywords: social interactions, identification, experiments

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# 1. INTRODUCTION

It is a long-standing and fundamental problem of the social sciences to understand whether and how humans are influenced by the behaviour exhibited by the members of the social group they belong to. We speak of a "social interaction effect", if an individual changes his or her behaviour as a *function of his or her respective group members' behaviour*. There is now mounting evidence that neglecting such social interactions (or peer and neighbourhood effects) hinders a proper understanding of important economic and social problems: Among other phenomena, social interactions influence welfare participation [e.g., Bertrand et al. 2000], work place behaviour [Ichino and Maggi 2000; Falk and Ichino 2003] and unemployment [e.g., Topa 2001], affect the dynamics of urban poverty and crime [e.g., Case and Katz 1991; Glaeser et al. 1996; Katz et al. 2001], and have an impact on academic success [Sacerdote 2001].

Identifying social interaction effects with the usually available field data has proved to be notoriously difficult [Manski 1993, 2000; Akerlof 1997; Brock and Durlauf 2001]. Among the problems that need to be solved are (i) identifying the reference group for which social interaction effects are sought to be established (e.g., by identifying language networks as in Bertrand et al. [2000]), (ii) circumventing the problem of self-selection of group members by investigating randomly composed groups (e.g., Sacerdote [2001]), (iii) controlling for correlated effects that affect all group members in a similar way, and (iv) controlling for contextual effects like exogenous social background characteristics of group members.

In this paper we take a different route than the papers discussed above and provide a laboratory experiment to study the phenomenon of social interactions. We argue that the experimental laboratory provides the researcher with a valuable tool to study social interactions because it guarantees more control than any other available data source. The ideal data set would observe the same individual at the same time in different neighbourhoods, which are identical – apart from different neighbours. Obviously, this is impossible in the field. By contrast, in the lab it is possible to come very close to this 'counterfactual state'. In our experiment, we are able to *observe decisions of the same subject at the same time* in two economically identical environments. The only reason to behave differently in these two environments is social interactions, i.e., the fact that a person is systematically affected by the behaviour of his neighbours in the two environments. Our design circumvents the above-mentioned identification problems. Using the terminology of Manski [2000], in our study reference groups are well-defined; the set-up avoids the self-selection problem; subjects make simultaneous decisions in two economically identical environments, which controls for correlated effects, including experience; the decision problem is abstractly framed and decisions are taken anonymously, which avoids contextual effects. Moreover, our laboratory approach has the added advantage of eliminating measurement errors.

The decision variable in the two environments (group 1 and group 2) is a voluntary contribution to a standard linear public good. We have chosen a public goods environment mainly because many economically important decisions that are potentially affected by social interactions are characterized by external effects, such as compliance with social norms, behaviour at the workplace, tax compliance, and welfare participation. These decisions can be modelled as public goods games. In line with our definition, we speak of ‘social interactions’ if subjects differentiate their contributions depending on their neighbours’ contributions in their respective groups.

Our data lend strong support for the importance of social interactions: The *same* subject contributes more to group 1 than to group 2 if the average contributions of his neighbours in group 1 are higher than those of the neighbours in group 2 and vice versa. Econometric analysis reveals further that behaviour of neighbours in group 2 has only a very limited impact on decisions in group 1 and vice versa. We also analyze behaviour at the individual level and find that most subjects exhibit strong social interaction effects in their contribution behaviour. Yet there is substantial individual heterogeneity. Only four percent of the subjects display no social interactions at all.

The novel feature of our dual-membership experiment is that subjects are simultaneously members of two groups. This design feature is interesting because in reality multiple memberships are the rule rather than the exception. People are, e.g., at the same time taxpayers and voters, or members of different sports clubs and so on. It is an interesting and open question whether the fact of being in various groups vs. being just in one group systematically produces different contribution behaviours. If this were true, many findings of the experimental public goods literature would be in question. In the final part of the paper we therefore address this issue by comparing a standard single-membership design with our dual-membership design. It turns out that the contribution patterns are almost identical. This result suggests that the abstraction to study public goods behaviour in games where people are acting in only one group is a good approximation for the behaviour outside the lab where subjects typically interact in multiple groups. Our paper therefore contributes to the understanding of social interactions as well as to the understanding of voluntary contributions in general.

The paper is organized as follows. In Section 2 we will describe our experimental designs. Section 3 contains our hypotheses and Section 4 presents the results at an aggregate and an individual level. It also contains the comparison of contribution patterns in the designs with multiple and single memberships, respectively. Section 5 concludes.

## 2. EXPERIMENTAL DESIGN AND PROCEDURES

### 2.1. *Description of the design*

The philosophy and novel feature of our experimental design is to put the same person at the same time into two different, yet economically identical environments. Thus, it is only the behaviour of other neighbours in these environments that can explain possible behavioural differences in the two environments. Finding such a different behaviour is therefore evidence for social interactions.

The implementation of the ‘two neighbourhood’ design was straightforward (see Figure 1): Nine subjects formed a so-called matching group. Within such a matching group, all subjects were simultaneously members of two neighbourhoods called ‘groups’. Subjects were told that they were members of a ‘group 1’ and a ‘group 2’ (see the instructions in the Appendix). The two groups were formed such that each subject had two different neighbours in each group.

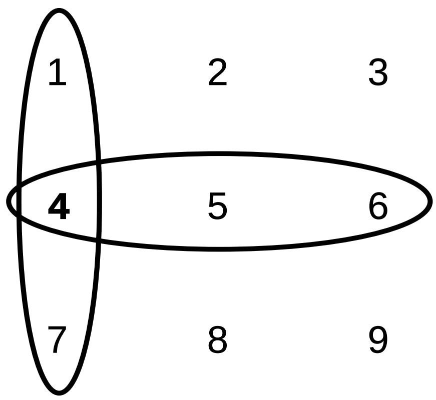


FIGURE 1
Our dual-membership design
Note: Numbers represent different subjects in the experiment.

For example, in Figure 1, subject 4 formed a group with subjects 1 and 7 and another group with subjects 5 and 6.[1] Likewise, subject 9 formed a group with subjects 3 and 6 and another group with subjects 7 and 8.

Within each of the two groups subjects had to make a contribution to a standard linear public good. We chose a public goods environment for two reasons. First, many economically important decisions that are potentially affected by social interactions are characterized by external effects, like tax compliance, compliance with social norms or behaviour at the workplace. This type of situations can be modelled as public goods games (see, e.g., Coleman [1990]). Second, our design is biased against finding a social interaction effect, since, as we show below, the unique strict equilibrium of the stage game (under standard preferences) is one in dominant strategies. We would like to point out, however, that the general idea of the dual-membership design is not confined to public goods games. Our dual-membership design can be applied in other contexts as well, e.g., in coordination games (see Friedman and Cassar [2004] on a general discussion of related designs). Social interactions in games with multiple equilibria would imply that the same subject coordinates on different equilibria, depending on the respective neighbours' behaviour.

The public goods of the two groups were technologically completely independent of each other. Each subject was endowed with 20 tokens in each group and could invest up to 20 tokens into the public good of the respective group. Let $G_i^1$ be the set of the members of player *i*'s group 1 and let $G_i^2$ be the set of the members of player *i*'s group 2. For example, individual 4 from Figure 1 lives in the two neighbourhoods $G_4^1 = \{1,4,7\}$ and $G_4^2 = \{4,5,6\}$. Let $c_i^1$ ($c_i^2$) denote *i*'s voluntary contribution to group 1 (group 2). For both groups the following budget constraints had to hold: $0 \le c_i^1 \le 20$ and $0 \le c_i^2 \le 20$. If a subject decided, e.g., to invest 10 tokens in group 1 she could nevertheless only invest at most 20 tokens in group 2. Any token not invested in the public good of the respective group was automatically invested into a private good. Thus, for each subject *i* the payoff function was as follows:

(1) $$\pi_i = (20 - c_i^1) + \alpha \sum_{j \in G_i^1}^{3} c_j^1 + (20 - c_i^2) + \alpha \sum_{k \in G_i^2}^{3} c_k^2 ,$$

[1] In the experiment subjects had no labels. We use the numbering of subjects in Figure 1 only for expositional reasons.

where $j$ and $k$ are indices for neighbours of group 1 and group 2, respectively. In our experiment, $\alpha$, the marginal per capita return of the public good, was set equal to 0.6; the social marginal return therefore was 1.8. Thus, since $\alpha < 1 < 3\alpha$, a selfish individual has a dominant strategy to free ride completely, while total payoffs are maximized if everybody fully invests into the group account.

Subjects were randomly allocated to the groups and remained paired for 20 periods. Subjects knew this (see Andreoni and Croson [forthcoming] on a discussion of such ‘partner’ designs). At the beginning of each period, subjects had to make their contribution decisions for both public goods on the same screen. The screen was separated into two vertical parts (called ‘group 1’ and ‘group 2’) and contained an input box for each group. On the same screen where subjects had to make their simultaneous contribution decisions, subjects were also informed for both group 1 and group 2 about (1) the average contribution of all respective group members (2) their respective incomes in the previous period and (3) the respective average group contribution over *all* previous periods. Full anonymity between subjects was maintained throughout the whole experiment. The experiment was computerized using the experimental software z-Tree [Fischbacher 1999].

In the final part of our paper we address the question whether being a member of two groups affects contribution behaviour. In order to compare contribution patterns in the dual-membership design with behaviour in a standard public goods game, we also conducted a standard single-group linear public goods experiment with three group members (‘single-membership’ design). This experiment was exactly the same as our dual-membership design except that subjects were only members of a single-group and got only information about the average contribution of their group members. The payoff function was exactly the same as (1), except that there was only one public good to which they could contribute and from which subjects received a payoff.

### 2.2 *Discussion of the dual-membership design*

The purpose of our study is to identify social interaction effects, which requires extensive control. We argue that a laboratory environment allows a degree of control, which is impossible to reach in the field.

First, we control for any *self-selection effect*. This is achieved by the fact that subjects were randomly allocated to their groups and that we observe the same subject’s behaviour in two different groups. Even without random allocation, this latter feature alone circumvents self-selection problems.

Second, we control for *correlated effects*, i.e., for the possibility that neighbourhood characteristics influence behaviour [Manski 1993]. In our experiment the two environments in which subjects make their decisions are economically identical. In each group all subjects have the same action space, the same endowment and budget constraint, the same information conditions and the same material incentives. Both groups are completely independent of each other, i.e., a decision in group 1 does not change the endowment, the action space or the incentives in group 2. Moreover, groups are equal in size and each neighbour faces the same economic incentives. The dual-membership design also controls for correlated effects that might be caused by the fact that different sessions are conducted at different dates and times. Even more importantly, it controls for experience and learning. When a subject decides how much to contribute to the two groups she has exactly the same experience for both decisions. This cannot be achieved in a single-membership design.

Third, we control for *contextual effects*, i.e., for the fact that a person may show a different behaviour in the two groups because of the socio-economic composition of the two groups [Manski 1993]. Control in this respect is ensured by the fact that experimental subjects were very homogenous with respect to their socio-economic background and, more importantly, interaction was anonymous.

Fourth, while in the field one can only speculate about the relevant group of comparison and try to find some good proxy (language group, neighbours of the same block, zip code etc.) the lab environment controls the available information. Subjects receive information only about the behaviour of those groups they actually belong to. This implies, e.g., that subjects cannot compare to any other group. Fifth, our computerized lab environment excludes measurement errors. Finally, our dual-membership design permits a *within-subject* observation of a social interaction effect. This is impossible with a single-membership design.

### 2.3 *Procedures*

In total, 174 subjects participated in our experiments. In the dual-membership design 126 subjects, who made 5040 contribution decisions, took part. They formed 14 independent matching groups of nine members each (see Figure 1). In the single-membership experiments 48 subjects participated who formed 16 independent groups. No subject participated in more than one treatment. All experiments ran for 20 rounds and subjects new this. The experiments were conducted in the computer lab at the University of St. Gallen. Most subjects were first-semester undergraduate students of law, economics and business administration. None of them had participated in a public goods experiment before. After reading the instructions subjects had to solve a set of computerised control questions that tested their understanding of payoff calculations.  The experiment started only after all participants had answered all questions correctly.

During the experiments income was counted in ‘Guilders’, which were translated to Swiss Francs at the end of the experiment (at an exchange rate of 1 Guilder = 3 Rappen). On average, subjects earned 33 Swiss Francs (≈ US$ 22 ≈ € 22). The experiments lasted approximately 70 to 80 minutes.

## 3. HYPOTHESES

We start with the standard economic hypothesis. Under the assumption of rationality and selfishness, the standard hypothesis predicts zero contributions to both public goods, i.e., full free riding. In the stage games this is obvious since it is a dominant strategy to contribute nothing. In our finitely, 20 times repeated games it holds with backward induction.

In contrast to the standard economic prediction it is known from many public goods experiments that some people cooperate, at least in early periods of an experiment. Is the mere fact of observing cooperation in our experiment already an indication for the existence of social interaction? The answer to this question depends on the motives and the pattern of cooperation. For example, motives like “warm glow”, and confusion might to some degree account for non-zero contributions (see e.g., Andreoni [1990, 1995]; Sefton and Steinberg [1996]; Palfrey and Prisbrey [1997]; Brandts and Schram [2000]; Houser and Kurzban [2002]). However, both warm glow and errors are *independent* of the contributions of other group members. A person who contributes for reasons of warm glow contributes the same amount in both groups, independent of the cooperation levels in these groups. To the contrary, social interactions mean that subjects' contributions are affected by the contributions of their neighbours. This conditional cooperation pattern, or more generally, the influence of expected contributions of others on own contributions, has been discussed, e.g., in Sugden [1984], Andreoni [1995], Offerman et al. [1996], Croson [1998], Keser and van Winden [2000] or Fischbacher et al. [2001]. Applied to our context it requires that the same individual contributes more in the neighbourhood that has contributed more in the past.

To state the alternative hypotheses more formally, let $c_i^1$ denote subject *i*'s contribution in period *t* to group 1 and let $g_i^1$ denote the average contribution of *i*'s neighbours in group 1 in period $t$ – 1. Analogously, $c_i^2$ denotes subject *i*'s contribution in period *t* to group 2 and $g_i^2$ denotes the average contribution of *i*'s neighbours in group 2 in period $t$ – 1. *Social interactions* require that *corr*[($c_i^1 - c_i^2$), ($g_i^1 - g_i^2$)] > 0, i.e., the larger the contribution difference of the neighbours of group 1 and group 2 in the previous period, the larger is the difference in current contributions of a group member to the two groups. In contrast, if there are *no* social interactions, we should see no such correlation. This may be the case either if there is full free riding ($c_i^1 = c_i^2 = 0$) or if people – e.g., for reasons of a warm glow – are willing to make positive contributions to the public good, which are however independent of ($g_i^1 - g_i^2$). We summarize our hypotheses as follows:

NO SOCIAL INTERACTIONS HYPOTHESIS. *The difference in the contributions are uncorrelated to the difference in the neighbours' contributions in the previous period, i.e.,* corr[($c_i^1 - c_i^2$), ($g_i^1 - g_i^2$)] = 0..

SOCIAL INTERACTIONS HYPOTHESIS. *The larger the difference in contributions of neighbours in group 1 and group 2 in the previous period, the larger is the difference in current contributions of a group member to the two groups, i.e.,* corr[($c_i^1 - c_i^2$), ($g_i^1 - g_i^2$)] > 0. *Accordingly, the likelihood in the current period to contribute more to group 1 than to group 2 depends positively on* ($g_i^1 - g_i^2$) (*and vice versa for group 2*).

## 4. RESULTS

In our discussion of the results we first present data at the aggregate level and for each of our fourteen matching groups. We then identify subjects' individual proclivity for exhibiting social interaction effects. We conclude this section by comparing the cooperation patterns in our dual-membership design with those in the single-group design.

### 4.1 *Aggregate analysis*

Our main result is that the data strongly reject the *No Social Interactions Hypothesis* in favour of the *Social Interactions Hypothesis*. On average, subjects contribute more to the group that has contributed more in the previous period. Support for this result comes from Figures 2 – 4 and Table 1. Figure 2 plots the average difference in current contributions ($c_i^1 - c_i^2$) as a function of the difference of the neighbours' contributions in the respective groups in the previous period ($g_i^1 - g_i^2$).

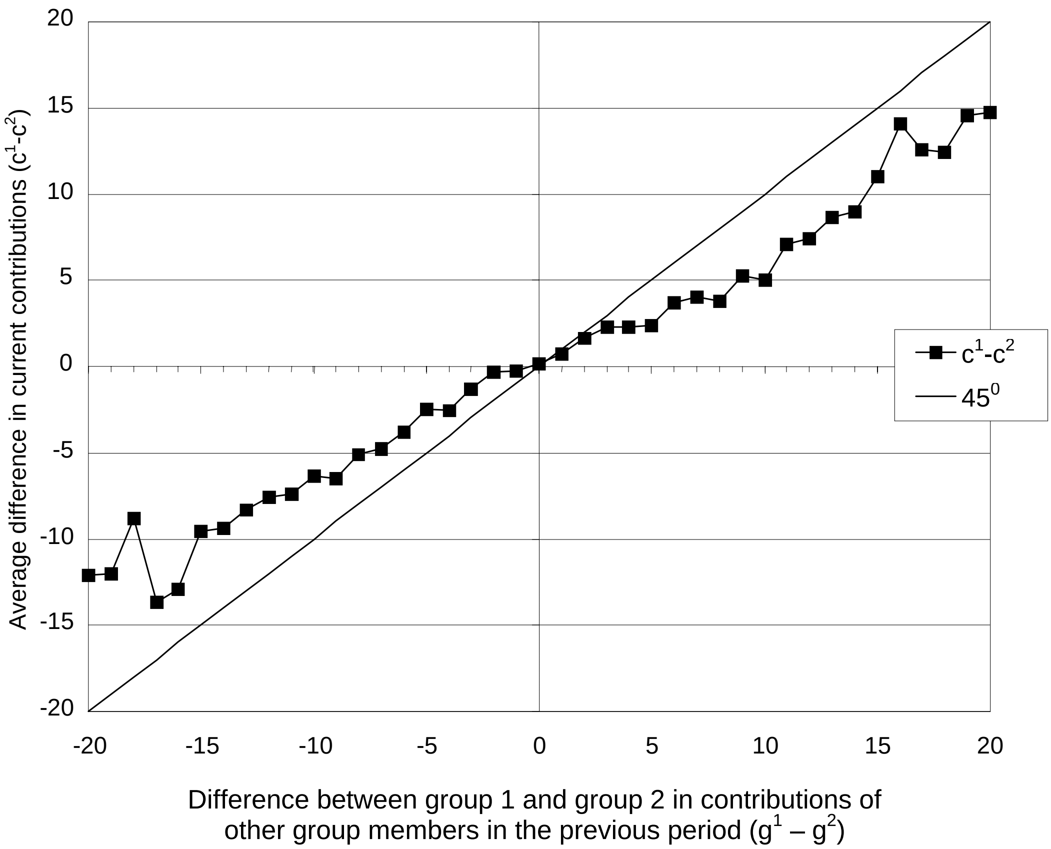


FIGURE 2
Social interaction effects: Difference in own contribution as a function of the neighbors' contributions in the two groups

While the *No Social Interactions Hypothesis* predicts this graph to fluctuate around $(c_i^1 - c_i^2) = 0$, we find a strong positive relationship between $(c_i^1 - c_i^2)$ and $(g_i^1 - g_i^2)$. Specifically, corr[$(c_i^1 - c_i^2)$, $(g_i^1 - g_i^2)$] = 0.63. Put differently, people tend to contribute more to group 1 than to group 2 (i.e., $c_i^1 > c_i^2$) if $g_i^1 > g_i^2$ and vice versa.

Figure 3 looks at the social interaction effects from another angle. As a function of $(g_i^1 - g_i^2)$ it shows three graphs, indicating the probability of (i) contributing more to group 2 than to group 1, (ii) contributing the same in both groups and (iii) contributing more to group 1 than to group 2. Figure 3 is based on all data from all matching groups and uses intervals for $(g_i^1 - g_i^2)$. The intervals were determined such that each interval includes roughly the same number of observations. For each interval the three graphs add up to a probability of 1.

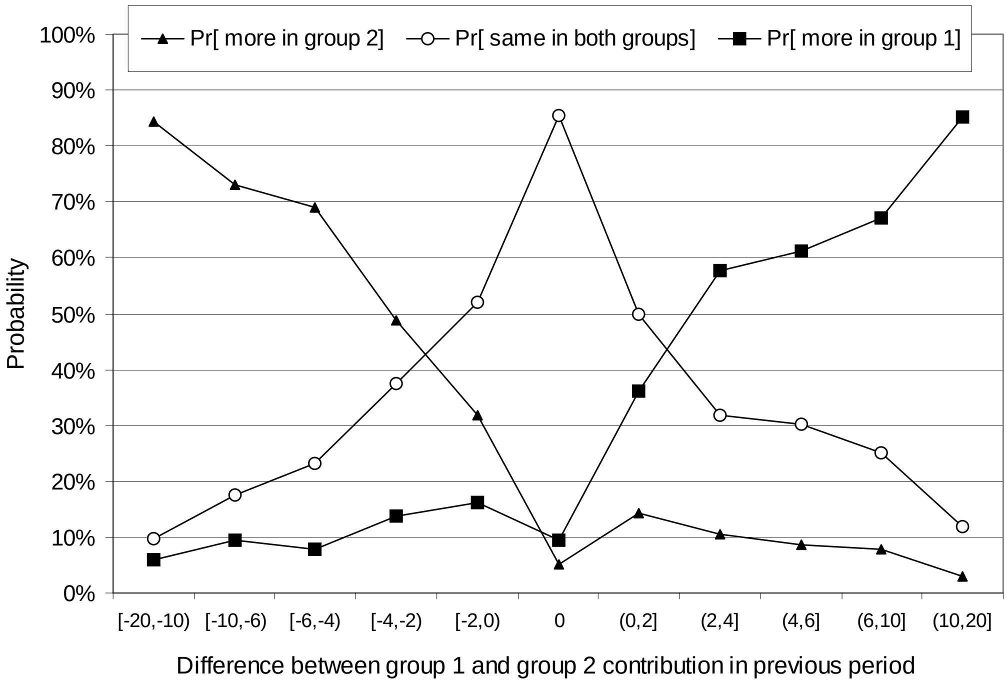


FIGURE 3
The probability of contributing more to group 1, more to group 2 or the same amount in both groups as a function of $(g_i^1 - g_i^2)$

Several observations can be made in Figure 3. First, the probability of contributing more to group 1 than to group 2 is very low if $g_i^1 < g_i^2$ and is slightly increasing in $(g_i^1 - g_i^2)$. For $g_i^1$

$- g_i^2 = 0$, the probability is about 10 percent. For $(g_i^1 - g_i^2) > 0$ the probability is strongly and monotonically increasing in $(g_i^1 - g_i^2)$, reaching roughly 85 percent for high values of $(g_i^1 - g_i^2)$. Second, the probability to invest more in group 2 than in group 1 as a function of $(g_i^1 - g_i^2)$ is almost exactly the mirror image of the probability to invest more in group 1. Third, the probability to contribute the same amount in both groups is the higher the smaller the absolute value of $(g_i^1 - g_i^2)$. It reaches its maximum of roughly 85 percent for $g_i^1 - g_i^2 = 0$. Note that even for very small deviations from $g_i^1 - g_i^2 = 0$ (intervals [-2,0) and (0,2]), the probability sharply drops from 85 to about 50 percent. Taken together Figure 3 strongly supports the existence of social interaction.

Remember that our design involves matching groups of nine subjects. These matching groups form the strictly independent observations of our data set. Figure 4 looks at our hypotheses at the level of matching groups by providing scatter plots of $(c_i^1 - c_i^2)$ as a function of $(g_i^1 - g_i^2)$ for each of our fourteen matching groups.

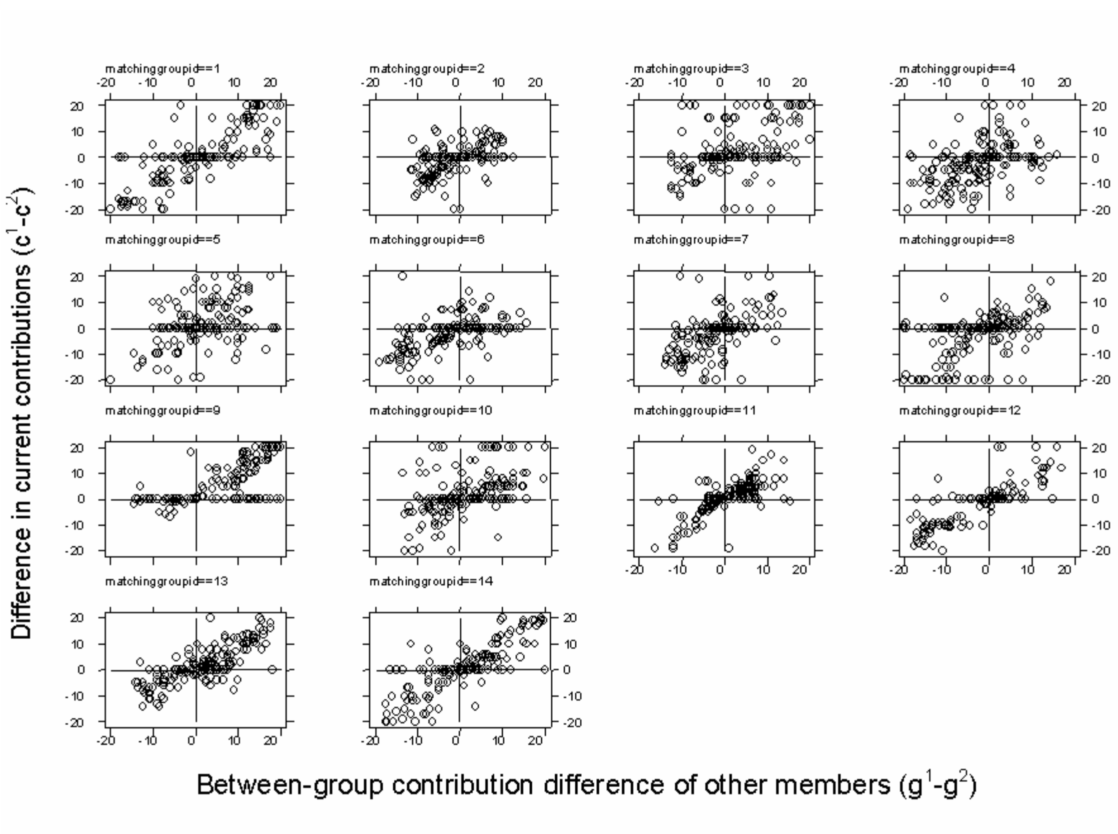


FIGURE 4
Social interaction effects between group 1 and group 2 per matching groups

The first observation from Figure 4 is that the relationship we find at the aggregate level holds for *all* fourteen matching groups. In all our matching groups the bulk of observations is in the upper right and the lower left quadrants (defined by $(c_i^1 - c_i^2) = 0$ and $(g_i^1 - g_i^2) = 0$). Thus, the observation of Figure 2 is not an artefact of aggregation. Figure 4 also reveals that in all matching groups there is a certain number of contribution decisions with $c_i^1 - c_i^2 = 0$ also for $g_i^1 - g_i^2 \neq 0$. These are contribution decisions that are unaffected by social interactions. We will return to this observation in our analysis of individual behaviour.

In the following we test the statistical significance of the observed social interaction effects. As a first test, note that we observe in all 14 matching groups a strictly positive correlation between $(c_i^1 - c_i^2)$ and $(g_i^1 - g_i^2)$. With no social interactions the probability of finding a strictly positive correlation in one matching group is (slightly smaller than) ½. The probability of finding a positive correlation in all 14 matching groups without social interaction is therefore smaller than $½^{14}\approx 0.00006$. As a second test, Table 1 (first column) records the results of an OLS regression analysis. Since within a matching group contributions are not independent, we have calculated robust standard errors that allow for correlated errors within matching groups. The dependent variable is $(c_i^1 - c_i^2)$. This variable is regressed on $(g_i^1 - g_i^2)$, i.e., the difference in neighbour's contributions in the previous period. To study possible time effects, we also include the period index and interact "period" with $(g_i^1 - g_i^2)$.

The regression strongly supports our previous arguments. The coefficient on $(g_i^1 - g_i^2)$ is positive and the robust standard errors are extremely low, which leads to a very high *t*-value ($t = 11.25$). Moreover, the observed social interaction effect does not vanish with more experience, since the interaction term period*$(g_i^1 - g_i^2)$ is not significantly different from zero.[2,3]

So far we have shown that subjects differentiate their contributions according to the contributions of their respective neighbours such that $corr[(c_i^1 - c_i^2), (g_i^1 - g_i^2)] > 0$ holds. However, we have not yet looked at *how* this positive correlation comes about. In particular it

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3. Because the groups are identical we expect an intercept of zero (measured by the constant) and we do not expect that the intercept will be different from zero in later periods (measured by the variable 'period'). This is also what we observe.

4. Regressions restricted to single periods provide a further test for the stability of our results over time. For all periods, the regressions have a highly significant coefficient for $(g_i^1 - g_i^2)$ and an insignificant constant.

is interesting to know whether the behaviour of the neighbours in group 2 has an impact on contribution behaviour in group 1 and vice versa. For example, it could be that the more the neighbours contribute in group 2 the less a person is inclined to contribute in group 1. In order to study the impact of the neighbours' contributions in group 1 (group 2) on own contributions in group 2 (group 1) we report two further regressions in Table 1.

TABLE 1
*Social interactions: Explaining contributions with the behaviour of neighbours*

| | Dependent variable | | |
|---|---|---|---|
| Independent variable | $c_i^1 - c_i^2$ | $c_i^1$ | $c_i^2$ |
| $g_i^1 - g_i^2$ | 0.605***<br>(0.054) | | |
| period | 0.007<br>(0.023) | -0.103***<br>(0.018) | -0.121***<br>(0.024) |
| period * ($g_i^1 - g_i^2$) | 0.005<br>(0.005) | | |
| $g_i^1$ | | 0.750***<br>(0.061) | 0.069<br>(0.045) |
| $g_i^2$ | | 0.021<br>(0.037) | 0.663***<br>(0.046) |
| constant | -0.022<br>(0.416) | 2.901***<br>(0.672) | 3.418***<br>(0.776) |
| | N=2394<br>F(3,13)=144.9***<br>$R^2$=0.44 | N=2394<br>F(3,13)=101.4***<br>$R^2$=0.46 | N=2394<br>F(3,6)=185.0***<br>$R^2$=0.37 |

Note: ($c_i^1 - c_i^2$) measures own difference in contribution to group 1 and group 2 in period *t*; ($g_i^1 - g_i^2$) is the difference in neighbours' contributions in group 1 and group 2 in *t – 1*; *** denotes significance at the 1-percent level; robust standard errors clustered on matching groups in parentheses.

The regression in column 2 shows that while the contribution decision in group 1 ($c_i^1$) is strongly and positively influenced by the behaviour of neighbours in group 1 ($g_i^1$), the behaviour of neighbours in group 2 ($g_i^2$) has only a slightly positive and clearly insignificant effect. Likewise, the third regression model shows that $c_i^2$ is strongly influenced by $g_i^2$ but hardly so by $g_i^1$. Note that the correlation between, e.g., $c_i^1$ and $g_i^1$ is not a strict test for the existence of social interactions. Finding such a correlation could be due to, e.g., correlated effects with respect to time. If all subjects for whatever reason would reduce their contributions from one period to the next we would find such a correlation. In our dual-membership design we observe two contribution decisions at the same time, thereby ruling out correlated time effects. Ruling out these correlated effects is impossible in a standard single-membership design. In both models the coefficient on ‘period’ is negative and highly significant. This indicates the general downward trend in contributions (compare also Figure 6).

Taken together the regressions in columns 2 and 3 reveal that there are hardly any spillover effects from one neighbourhood to the other. A subject’s decision to contribute in group 1 is not significantly influenced by the behaviour of group 2 neighbours and vice versa. This is an interesting result. It suggests that when deciding on an action that affects people in a particular group, behaviour of this group’s members is very important but behaviour of people in other groups is largely irrelevant. For example, the willingness of a person to contribute to his tennis club may not be affected by the behaviour of his fellow soccer club members. As long as groups are separated and external effects are confined to a particular group, we expect social interactions to be confined to that very group as well.

## 4.2 *Individual heterogeneity*

In our aggregate analysis we have provided evidence for the importance of social interaction effects. On average, subjects are very strongly influenced by the contribution decisions of their respective neighbours. In this section we study social interactions at the individual level. As the preceding figures already suggest, it is not likely that all subjects display the same interaction effects. Rather we expect that some subjects are strongly affected by social interactions while others are affected to a lesser extent – if at all. Figure 5 investigates this individual heterogeneity. It shows the relative frequency of subjects who exhibit a particular intensity level of social interactions. This intensity level is measured with simple OLS-regressions for each individual, where $c_i^1 - c_i^2$ is regressed on $g_i^1 - g_i^2$ for periods 2 to 20, setting the constant to zero. Figure 5 shows the distribution of these coefficients, where each individual coefficient is rounded to a multiple of 0.2. A coefficient equal to one means that a subject perfectly matches the difference $g_i^1 - g_i^2$, while a coefficient of zero implies no social interactions.

Figure 5 offers several interesting insights. First, 83 percent of the subjects show a positive coefficient. Thus, in line with our previous arguments, the majority of individuals shows social interactions. Second, there is pronounced individual heterogeneity, i.e., subjects are very differently prone to social interactions. Third, five subjects (four percent) have a coefficient of exactly zero (see the light grey column at 0). Of these five subjects three are completely selfish, i.e., they always defect while two always contribute independently of the other group members' decisions.

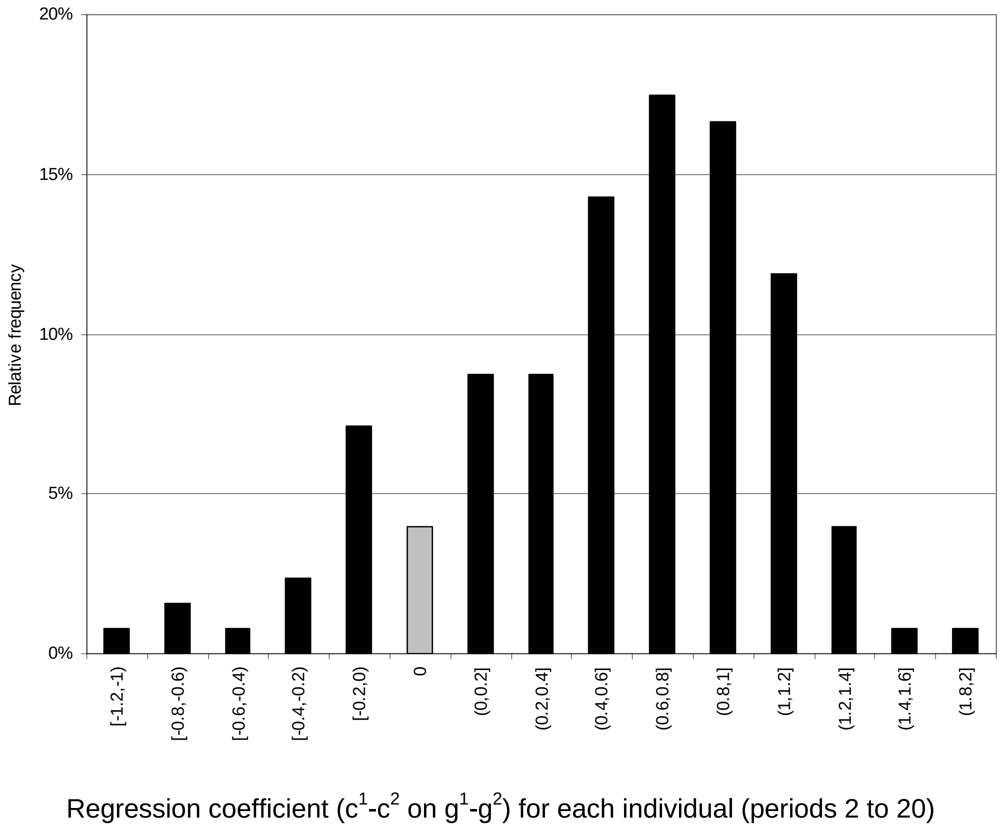


FIGURE 5
Social interaction effects at the individual level

4.3 *Multiple memberships and cooperation patterns*

Finally we compare the contribution patterns in the design where subjects are members of two groups with the pattern that evolves if subjects are members of only one group.[4] In order to

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[7.] To our knowledge, all public goods experiments conducted so far, study the contribution behaviour of subjects who are members of just one group. There are some public goods studies where subjects could observe what members of another group contributed (e.g., Bardsley and Sausgruber [2003]; Carpenter and Matthews [2003]). In Carpenter and Matthews subjects could even punish members of another group. The goal of these studies is different from ours. Bardsley and Sausgruber want to disentangle conformism and reciprocity; and Carpenter and investigate the impact of multiple memberships we compare the contribution patterns of our dual-membership design with that of a standard single-membership design. Parameters in both experiments are exactly identical (see Section 2). The only difference is that while subjects make two decisions in two different groups in the dual-membership design, they make just a single contribution decision in the single-membership design. Figure 6 shows the evolution of average contributions in both treatments by pooling data from all matching groups.

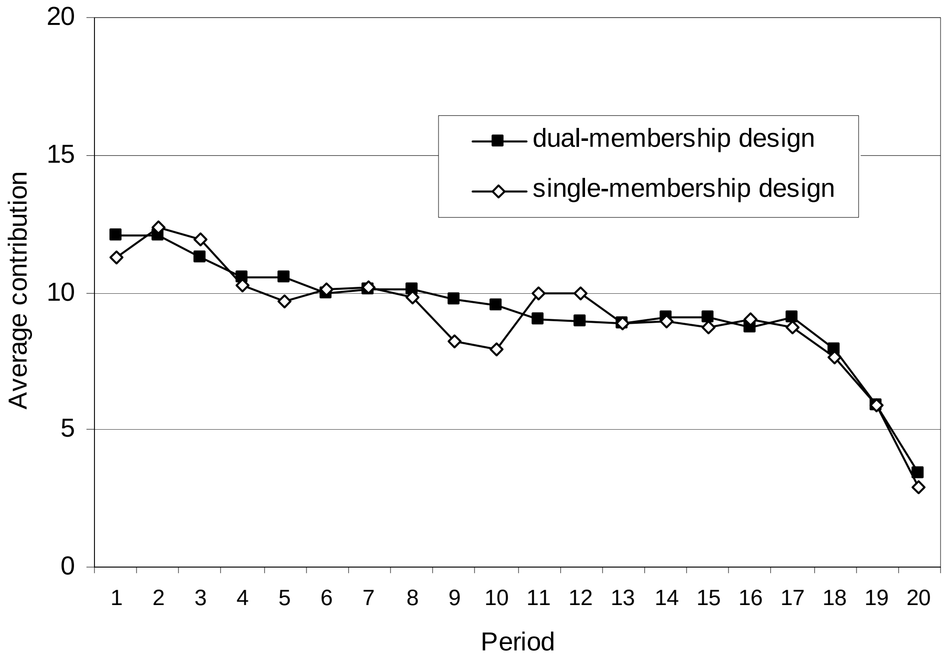


FIGURE 6
Cooperation patterns in the dual-membership and the single-membership design: Average contributions over time

The result is striking: The contribution patterns between the two treatments are almost indistinguishable. In both treatments, average contributions start at about 12 tokens (60 percent of the endowment), show a slow downward trend until period 17 and a sharp drop in the final three periods. Final average contribution levels are about 3 tokens (15 percent). A Mann-Whitney test on matching groups reveals that contributions in both treatments are not significantly different (p=1.000).

The results from Figure 6 are very informative. The fact that subjects interact in two groups, does not lead to a contribution pattern different from what we usually see in single-

Matthews investigate "social reciprocity". Our neighbourhood design is also related to studies that investigate local interaction structures in the context of cooperation games (e.g., Eshel, Samuelson and Shaked 1998; Kirchkamp and Nagel 2001), and network structures (e.g., Charness, Corominas-Bosch and Frechette 2003).

group public goods experiments. The similarity in contribution patterns is in line with our findings reported in columns 2 and 3 of Table 1. Here we saw that the behaviour of neighbours from *other* groups did not significantly influence behaviour, i.e., people decide on their contributions on a group level. Methodologically this is good news as it shows that the abstraction to study public goods behaviour in games where people are only acting in one group is a good approximation for the behaviour in reality, where subject simultaneously interact in more than one group.

## 5. SUMMARY

Identifying social interaction effects is a notoriously difficult task [Manski 1993, 2000]. After reviewing the problems, Manski [1993, p.541] writes: "The only ways to improve the prospects for identification are to develop tighter theory or to collect richer data. (…) Empirical evidence may also be obtained from controlled experiments (…). Given that identification based on observed behaviour alone is so tenuous, experimental and subjective data will have to play an important role in future efforts to learn about social effects".

In recent years, the availability of rich microeconomic field data sets has led to considerable progress. In the typical field research paper, identifying a social interaction effect usually amounts to finding a significant coefficient of the group dummy variables (that capture the social groups one is interested in) – after circumventing self-selection problems and after controlling in a multiple regression model for variables that arguably capture the most important correlated and contextual effects. Yet, the approach is only *indirect*: Any variance that cannot be attributed to the correlated and contextual effects is attributed to social interaction effects. The problem of omitted variables can never be completely circumvented.

In our paper we introduce an experimental design that provides us with *direct* evidence of social interaction effects in the context of a public goods game. The design has the advantage that it can be easily applied to other games as well, e.g., games with multiple equilibria. By way of our design we directly control for self-selection, and correlated and contextual effects.

Our results are clear and unambiguous. First, subjects' average contribution behaviour is systematically influenced by social interactions. Subjects contribute more to group 1 than to group 2 if the respective neighbours in group 1 contribute more than in group 2 and vice versa. Second, our individual data analysis reveals substantive heterogeneity. Subjects' inclination to display social interactions is very different and four percent show no social interactions at all.

In our view this evidence complements the results from field studies in an informative direct way.

Our design also allows us to investigate the impact of multiple group memberships on cooperative behaviour. We find that the fact that subjects interact in more than one group does not lead to a contribution pattern that differs from the one exhibited in a single-group environment. This suggests that studying contribution behaviour in single-group designs is appropriate despite the fact that in reality subjects are typically members of many groups.

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## APPENDIX: EXPERIMENTAL INSTRUCTIONS

*The following instructions were originally written in German. We document the instructions we used in the dual-membership design. The instructions in the single-membership design were adapted accordingly. They are available upon request.*

You are now taking part in an economics experiment, which has been financed by various science foundations. If you read the following instructions carefully, you can, depending on your decisions, earn a considerable amount of money. It is therefore very important that you read these instructions with care.

The instructions that we have distributed to you are solely for your private information. **It is prohibited to communicate with the other participants during the experiment.** Should you have any questions please ask us. If you violate this rule, we shall have to exclude you from the experiment and from all payments.

During the experiment we shall not speak of Francs but rather of Guilders. During the experiment your entire earnings will be calculated in Guilders. At the end of the experiment the total amount of guilders you have earned will be converted to Francs at the following rate:

**1 Guilder = 3 Rappen.**

At the end we will pay in cash the money you have earned during the experiment.

The experiment is divided into different periods. In total, the experiment consists of 20 periods. Every participant is always a member of **<u>two</u> groups** (group 1 and group 2). Both groups contain 3 participants, that is, besides you there are two further participants in each group. Please notice that the two participants in group 1 are other participants than the two participants in group 2. **Therefore, besides you there is no further person who is also a member of group 1 and of group 2.**

The composition of the groups will stay the same during the whole 20 periods. **Therefore you will be for 20 periods with the same participants in group 1 and in group 2.** The following pages describe the course of the experiment in detail:

### Detailed Information on the Experiment

At the beginning of each period each participant receives **20 points** for group 1 as well for group 2. In the following we call this his or her **endowment**. Your task is to decide how to use your endowment. You have to decide in group 1 as well as in group 2, how many of your 20 points you want to contribute to the **project** and how many you want to keep for yourself.

Your period income in a group depends on how many points you contribute to the project and how many points are contributed to the project by the two other participants. **Your income in a group** consists of two parts:

(1) The points which you have kept for yourself (**“Income from points kept”**) whereby **1 point = 1 Guilder**, and
(2) The **“income from the project”**. This income is calculated as follows:

| |
|---|
| Your income from the project =<br>0.6 x the total contribution of all group members to the project. |

Your income per period in group 1 or group 2, respectively, is therefore:

**(20 – your contribution to the project) + 0.6*(total contributions to the project).**

The income of each group member from the project is calculated in the same way. This means that each group member receives the same income from the project. Suppose the sum of contributions of all group members is 50 points. In this case each group member receives an income from the project of 0.6*50=30 Guilders. If the total contribution to the project is 8 points, then each group member will receive an income of 0.6*8=4.8 Guilders from the project.

For each point, which you keep for yourself you earn an income of 1 Guilder. Suppose you contributed this point to the project instead. The total contribution to the project would then rise by one point. Your income from the project would rise by 0.6*1=0.6 points. However, the income of each other group member would also rise by 0.6 points each, so that the total income of the group would rise by 0.6*3=1.8 points. Your contribution to the project therefore also raises the income of the other group members. On the other hand you earn an income for each point contributed by the other members to the project. For each point contributed by any member you earn 0.6*1=0.6 points.

**The calculation of incomes is exactly the same in group 1 and group 2.**

At the beginning of each period the following **input screen** will appear:


In the top left corner of the screen appears the **period number**. In the top right corner there is a **clock in seconds.** It shows how much time remains for you to make a decision on the distribution of your points.

The screen is divided into two parts. On the left, you find the information concerning group 1, and on the right the information for group 2. First you can see the amount you have invested into the project in the previous period ("Your contribution in the previous period"). Beneath you find the average contribution of the respective group in the previous period. If in the previous period the contributions of the three group members have been, for instance, 10, 15 and 20, the number beside "average group contribution in the previous period" will be 15. Beneath you will find your income in the previous period.

A bit further down you can see the "average group contribution of all previous periods". This number shows the total average contribution of all group members of a respective group over all previous periods. If, for example, the average contribution in period 1 were 3, in period 2 it were 2 and, e.g., 1 in period 3, in the fourth period the number in this line would be 2. The "group average contribution over all previous periods" is therefore a short summary of the previous history in a group. The higher the average contribution in a group has been up to now, the higher the value in this line will be.

Still a bit further down you can enter your contribution. As already mentioned, your **endowment in each of the two groups will always be 20 points**. You choose in each of the two groups your contribution for each group, by entering a number between 0 and 20 in the particular window. You can activate this window with a mouse-click. As soon as you have defined both of your contributions, you have also decided how many points you are going to keep for yourself, that is to say (**20 – your contribution**). If you have entered your contribution in both groups, you have to press the **OK-button** (mouse-click). As long as you have not pressed the OK-button, you can still revise your decision in this period.

Please notice: **group 1 and group 2 are two totally independent groups.** Therefore you can make your contribution decisions in group 1 and group 2 absolutely independently from each other, i.e., you decide separately for both groups. **Your contribution in group 1 can be higher, equal or lower than your contribution in group 2.** You have an endowment of 20 points in each group and each period.

Remark: In the first period your screen contains only the possibility to choose your contribution. Since in the first period there is no previous period and therefore further information (like “your contribution in the previous period”) cannot yet be shown.

After all group members have made their decisions, a period is over. After that you get back to your input screen. On this screen you can see the contributions of the previous period of both groups and your income in both groups. You can also see the average contribution of both groups up to now. You can then make your new contributions in group 1 and group 2. In total there are **20** periods. Do you have any questions?

## *Control questionnaire*

Please answer all the questions and write down the whole calculation process. If you have any questions please contact us!

**1st Question**

In group 1 neither you nor the other participants contribute to the project.

In group 2 you contribute 20 points and also the other group members contribute 20 points. What is

Your income in group 1? ...

The income of the other members in group 1? ...

Your income in group 2? ...

The income of the other members in group 2? ...

**2nd Question**

In group 1 all the members together contribute totally 30 points to the project.

In group 2 also all the members contribute totally 30 points to the project. What is

Your income in group 1, if you contribute 10 points on top of the 30 points? ...

Your income in group 2, if you contribute 0 points on top of the 30 points? ...

**3rd Question**

In group 1 you contribute 16 points to the project. What is

Your income in group 1, if the other participants contribute 34 points on top of the 16 points? ...

Your income in group 1, if the other participants contribute 4 points on top of the 16 points? ...