ISOLATING SOCIAL INTERACTION EFFECTS – AN EXPERIMENTAL INVESTIGATION[*]

ARMIN FALK, URS FISCHBACHER
University of Zürich[+]

SIMON GÄCHTER
University of St. Gallen[++]

First version: February 2002

Abstract

Field evidence suggests that agents belonging to the same group tend to behave similarly, i.e., behavior exhibits "social interaction effects". Testing for such effects is difficult because of severe identification problems. To isolate social interaction effects in a way that avoids these problems, we design an experiment where each subject simultaneously is a member of two randomly assigned groups with different group members. In both groups subjects play exactly the same public goods game. In our data we isolate "social interaction effects", i.e., a majority of subjects is very strongly influenced by the contributions of the respective group members.

Keywords: Social interaction, conditional cooperation, experiments.
JEL-Classification: H41; C91; K42; H26.

[*] Support by the EU-TMR project ENDEAR (FMRX CT98-0238) is gratefully acknowledged. Lukas Baumann, Michael Bolliger, Esther Kessler and Christian Thöni provided very valuable research assistance. We also received helpful comments from participants at seminars in Amsterdam, Berlin, St. Gallen and Zürich.
[+] Institute for Empirical Research in Economics, Blümlisalpstrasse 10, CH-8006 Zürich. E-mail: falk@iew.unizh.ch, fiba@iew.unizh.ch.
[++] FEW-HSG, Varnbüelstrasse 14, CH-9000 St. Gallen. E-mail: simon.gaechter@unisg.ch

I. INTRODUCTION

Humans are social animals and so it is intuitive that many people seem to be strongly influenced by the behavior exhibited by the members of the social group they are in. Understanding such “social interactions” (or “peer” and “neighborhood effects”) is a long-standing and fundamental problem of the social sciences. Why do people who belong to the same social group exhibit similar behaviors? There is now mounting evidence that neglecting social interactions hinders a proper understanding of important economic and social problems: Among other phenomena, social interactions determine criminal behavior (Glaeser, Scheinkman and Sacerdote [1996]), affect the dynamics of urban poverty and crime (Case and Katz [1991]; Ludwig, Duncan and Hirschfield [2001]; Katz, Kling and Liebman [2001]), influence welfare participation (Bertrand, Luttmer and Mullainathan [2000]) and work place behavior (Ichino and Maggi [2000]) 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; Glaeser and Scheinkman [2001]). Among the problems that had to be solved by the cited studies are (i) identifying the reference group for which group interaction effects are sought to be established (e.g., by identifying language networks as in Bertrand et al. [2001]), (ii) circumvent the problem of self-selection of group members by investigating randomly composed groups (e.g., Sacerdote [2001]), (iii) control for correlated effects that affect all group members in a similar way, and (iv) control for contextual effects like exogenous social background characteristics of group members. The latter two problems require very rich data sets, possibly at the individual level (see, e.g., Ichino and Maggi [2000]). After reviewing these problems Akerlof [1997, p. 1007] writes: “This identification problem can only be resolved at a sufficient level of detail that it is possible to impute individuals’ motives. For this reason we shall turn to ethnographies and biographies, which entail a level of thick description at which it may be possible to discern unambiguously the presence of social interactions.”

In this paper we take a different route than Akerlof [1997]. We argue that – in addition to ethnographic studies – the experimental laboratory can provide the researcher with a valuable tool to study social interactions in sufficient detail because the laboratory allows for controlling many problems that plague the field researcher who wants to establish evidence for behavior that reflects social interactions.

The novel idea of our experimental setup with which we aim at isolating the phenomenon of social interactions is that we put the same subject in two groups with different members. The decision each subject has to make is to contribute to a standard linear public good. The two public goods environments are separate, yet economically identical. This design circumvents the above-mentioned problems because (i) reference groups are well-defined and group members are randomly allocated, which avoids the self-selection problem; (ii) subjects have to make contribution decisions in two economically identical public goods environments, which controls for correlated effects; (iii) the public goods are separate which solves the problems of observing different group behaviors for reasons of a “constraint interaction” (i.e., different contribution behaviors in the two groups because of different budget restrictions); (iv) the decision problem is abstractly framed and decisions are taken anonymously, which avoids contextual effects. Moreover, our laboratory approach has the added advantage of minimizing measurement errors.

In our two-groups environment we speak of “social” or “group interactions” if subjects in their contribution behavior are significantly affected by their fellow group members’ contributions in their respective groups. Assume a subject is influenced by its fellow group members and decides to (roughly) match their contributions made in the previous period. For instance, if the other group members in Group 1 have contributed more in the previous period than the other group members of Group 2, then he/she will in the current period contribute more to Group 1 than to Group 2. The implication of our design is that subjects, who are influenced by their group members, will differentiate in their contribution behavior between groups. Thus, if we observe such a differentiating contribution behavior, it is strong evidence for social interaction effects, because the *same* person, in two economically *identical* environments, makes *different* contribution decisions that solely depend on the other group members’ behavior.

Our main results are as follows. We find very strong evidence for social interactions. Our subjects differentiate their contribution decisions in a way that reflects the differences in contributions of the other members of the two groups. In other words, the *same* subject contributes more to Group 1 than to Group 2 if the average contributions of the other group members are higher in Group 1 than in Group 2. We also find evidence for group interaction effects within a particular group, i.e., subjects’ contributions within groups are correlated with the contributions of the other group members of that group. Our data also allow for an analysis at the individual level. We find that a relative majority of subjects exhibits strong social interaction effects in their contribution behavior. However, roughly a quarter of all subjects can be called “fixed agents” (to borrow the terminology from Glaeser et al. [1996]), because these subjects are unaffected by others.

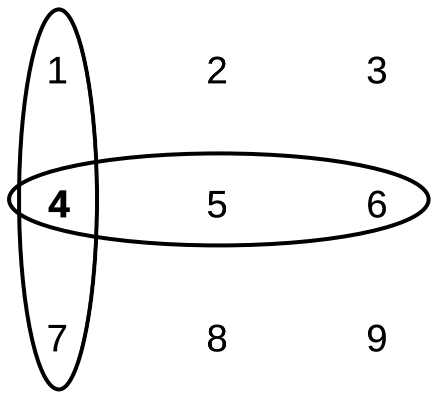
Our paper is organized as follows. In Section II we will describe our experimental design in sufficient detail. Section III contains our hypotheses and Section V presents the results at an aggregate and an individual level. Section V concludes.

II. EXPERIMENTAL DESIGN AND PROCEDURES

A. *Description of the design*

The environment in which our subjects had to make decisions was a standard linear public goods situation. Three subjects decided simultaneously upon the size of a public good, which was just the sum of all group members' voluntary contributions. The main distinguishing feature of our experimental design is that all subjects were simultaneously members of *two* groups, which provided two *distinct* public goods. Figure 1 illustrates our main design feature. Nine subjects formed a matching group. 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 group members in each group. The general construction principle was that each subject formed a group with the subjects of the same "row" and "column". For example, subject #4 formed a group with subjects #1 and #7 and *another* group with subjects #5 and #6. This construction principle ensured that the other group members in both groups were different subjects.

FIGURE 1: *Our two-groups design*



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 c_i^1 (c_i^2) denote *i*'s contribution to "Group 1" ("Group 2"). For both groups the following budget constraints had to hold: $0 \leq c_i^1 \leq 20$ and $0 \leq c_i^2 \leq 20$. 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) $$\pi_i = (20 - c_i^1) + a\sum_{j=1}^{3} c_j^1 + (20 - c_i^2) + a\sum_{k=1}^{3} c_k^2,$$

where *j* and *k* are indices for members of "Group 1" and "Group 2", respectively. In our experiment, a, the marginal per capita return of the public good, was set to 0.6. Thus, since a subject reaps only a marginal benefit of 0.6 for each token contributed to the public good, a selfish individual will free ride completely. Since the two public goods are completely independent of each other, this holds for both public goods.

Subjects were randomly allocated to the groups and remained paired for 20 periods. The subjects knew this. Moreover, full anonymity was maintained throughout the whole experiment. The experiment was computerized using the experimental software z-Tree (Fischbacher [1999]). 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 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.[1] Since in the very first period there is no history, this information was only displayed from periods 2 to 20.

Since our experiment – where subjects are simultaneously members of two groups – is without precedent, we also conducted a standard single-group linear public goods experiment with three group members. This experiment was exactly the same as our two-groups design except that subjects were only members of a single group and got only information on the average contribution of their group members. The payoff function also was exactly the same as (1), except that there was only one public good from which subjects received a payoff. These "single-group" experiments allow us to test to what extent previous robust results on contribution behavior in linear public goods environment also hold for our new design. This allows us to exclude arguments that our design has induced behavioral peculiarities that are absent in the previous experiments.

B. *Discussion*

We believe that our laboratory design solves the problems that plague most of the field research and therefore allows us isolating the phenomenon of *endogenous* group-interaction effects in the most clear-cut way.

1. Our computerized and simple experimental environment excludes measurement errors. As explained above, our single-group public goods environment allows controlling for design-induced group interaction effects.

[1] We decided to provide subjects with the history of previous decisions to make it easier for them to condition their contribution decisions on the history of play if they wish to do so. Of course, it would have also been possible to provide subjects with the complete history of contribution decisions. However, we were afraid of an "information overload" in particular in later periods. Since, most likely, subjects would have cognitively aggregated the history of contribution decisions for themselves anyway, we decided to provide them with the average of previous contribution decisions.

2. We control the relevant comparison group since all subjects only get information on the groups of which they actually are members.
3. Since in our two-group design the public goods are completely independent of each other, any observed difference in contribution behavior cannot be due to budget restrictions or any other form of "constraint interaction".
4. Since the *same* subject is a member of two groups, we also keep constant any personality-driven factors for different group behavior.
5. All subjects are randomly and anonymously allocated to the groups. Hence, any selection effect is excluded by design.
6. The economic characteristics of all groups are exactly identical. All have the same endowment and the same marginal payoff from both the private and the public good. Thus, we control for the economic background ("correlated effects") to isolate group interaction effects.
7. All decisions are taken anonymously which controls for "contextual effects".
8. We are able to identify individual types with respect to their responsiveness to their fellow group members' behavior.

C. *Procedures*

In total, 174 subjects, who made 3480 contribution decisions, participated in our experiments. In our "two-groups" design 126 subjects took part. They formed 14 independent matching groups of nine members each (see Figure 1). In our "single-group experiments" 48 subjects participated who formed 16 independent groups. 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. 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 41 Swiss Francs (≈ € 28). The experiments lasted approximately 1.5 hours.

III. HYPOTHESES

Before we proceed to the results, we shortly discuss our hypotheses and how we are going to test them. We start with the standard economic hypothesis. In our environment, under the assumption of rationality and selfishness, the standard hypothesis predicts zero contributions to the public good, i.e., full free riding. In the stage games this is obvious since it is a dominant strategy to contribute nothing. This free-rider prediction holds for both the single-group and the two-groups experiments. In our finitely repeated games it holds with backward induction.

In this paper we are primarily interested in group interaction effects, i.e., in finding out to what extent own contributions vary with the contribution behavior of the other group members. However, even if the standard hypothesis is rejected, we do not yet have evidence for group interaction effects. For example, motives like "warm glow", or simply errors, which both are completely independent of others' contributions, might account for non-zero contributions (see e.g., Andreoni [1990], [1995a], [1995b], and Palfrey and Prisbrey [1997]). Thus, the standard prediction is just a special case of no group interaction effects in behavior; contributions for reasons of a "warm glow", or errors, reject the standard prediction but reflect no group interaction effect.

The alternative hypothesis is that subjects will be affected in their contribution behavior by the contributions of their fellow group members in the respective groups. Thus, evidence for social interactions requires different contributions by the *same* individual in the two groups if the other group members of both groups have made different contributions in the previous period.

We are now in a position to give a formal expression of our social interaction hypothesis. Let c_i^1 (c_i^2) introduced above denote subject *i*'s contribution in the current period *t* to Group 1 (Group 2) and let g_i^1 (g_i^2) denote the average contribution of *other* group members in Group 1 (Group 2) in period *t* – 1. We are in particular interested in how the difference in contributions between the two groups in the current period, i.e. ($c_i^1 - c_i^2$), is related to the difference in contributions of the *other* group members in the previous period, i.e., ($g_i^1 - g_i^2$).

Let us first discuss the "No Group Interaction Hypothesis". If the standard hypothesis of full free riding ($c_i^1 = c_i^2 = 0$) would fully explain behavior, ($c_i^1 - c_i^2$) = 0 for all ($g_i^1 - g_i^2$). However, also if people – e.g., for reasons of a "warm glow" – are willing to make positive contributions to the public good (i.e., $c_i^1 = c_i^2 > 0$), ($c_i^1 - c_i^2$) = 0 for all ($g_i^1 - g_i^2$). By contrast, if behavior would be perfectly influenced by the other group members, ($c_i^1 - c_i^2$) = ($g_i^1 - g_i^2$), i.e., the difference in current contributions between Group 1 and Group 2 would perfectly match the group differences in the previous period. We require the hypotheses to hold in statistical terms only. Thus, we can formulate our hypotheses as follows:

NO GROUP INTERACTION HYPOTHESIS. *For reasons of warm glow, altruism or errors subjects may make positive contributions to the public goods but they are unrelated to the difference in the other group members' contribution in the previous period, i.e.,* corr[($c_i^1 - c_i^2$), ($g_i^1 - g_i^2$)] = 0. *The standard hypothesis of zero contributions to the public good is just a special case of this hypothesis.*

GROUP INTERACTION HYPOTHESIS. *The larger the difference in contribution of other group members between 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. *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*).

IV. RESULTS

We start with our main research question: Do subjects exhibit a contribution behavior in their groups that depends on their respective group members' contribution? We first investigate our "(No) Group Interaction Hypotheses" at the aggregate level and for each of our fourteen matching groups. We then test an argument that group interaction effects may also occur within groups. Last we will identify subjects' proclivity for exhibiting group interaction effects.

A. *Are there group interaction effects?*

Figures 2 – 4 and Table 1 provide the support for our main result:

Result 1. *Our data strongly reject the "No Group Interaction Hypothesis" in favor of our Group Interaction Hypothesis. On average, subjects' contribute more to the group that has contributed more in the previous period.*

FIGURE 2: *Group interaction effects between Group 1 and Group 2*

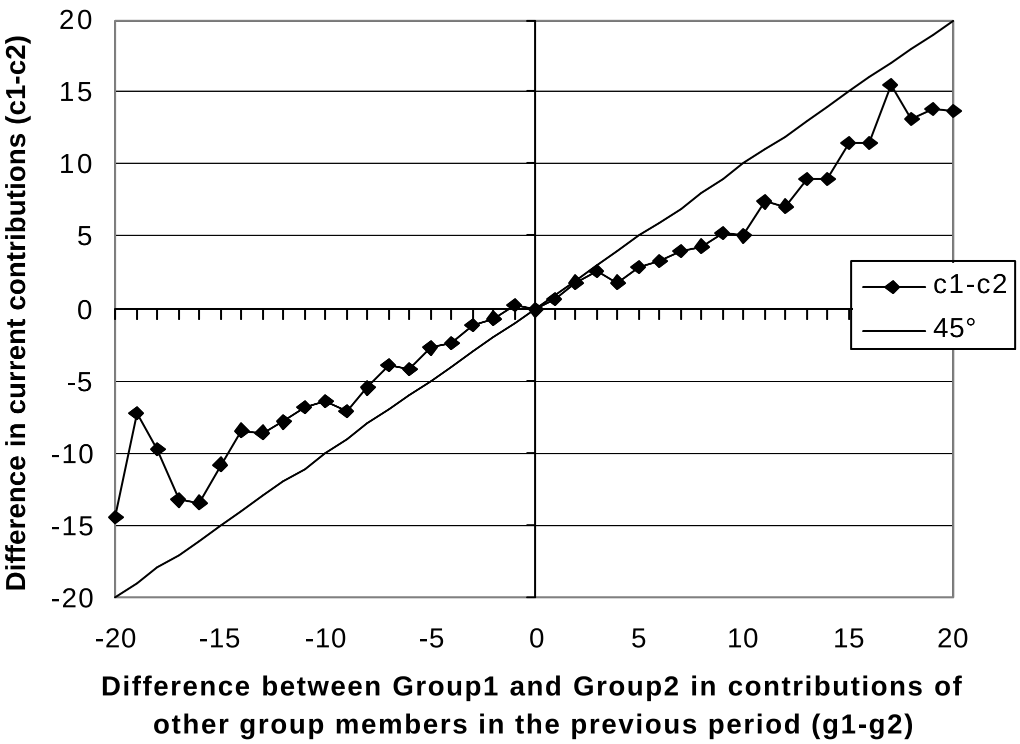


Figure 2 plots the average difference in current contributions ($c_i^1 - c_i^2$) as a function of the difference of the other group members' contributions in the respective groups in the previous period ($g_i^1 - g_i^2$). While the No Group Interaction Hypothesis predicts this graph to fluctuate around ($c_i^1 - c_i^2$) = 0, we find a very strong positive relationship between ($c_i^1 - c_i^2$) and ($g_i^1 - g_i^2$). 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. Interestingly, the graph lies above the 45°-line for $g_i^2 > g_i^1$ and below the diagonal for $g_i^1 > g_i^2$ and it crosses exactly at $c_i^1 = c_i^2$ if $g_i^1 = g_i^2$. Thus, people make no difference in contribution behavior in the current period, if both groups contributed the same amount in the previous period and they only "imperfectly" match the contributions of the group that has contributed more in the previous period.

FIGURE 3: *The probability of contributing more (or the same) to Group 1 (Group 2) as a function of* ($g_i^1 - g_i^2$) *– Logit estimates*

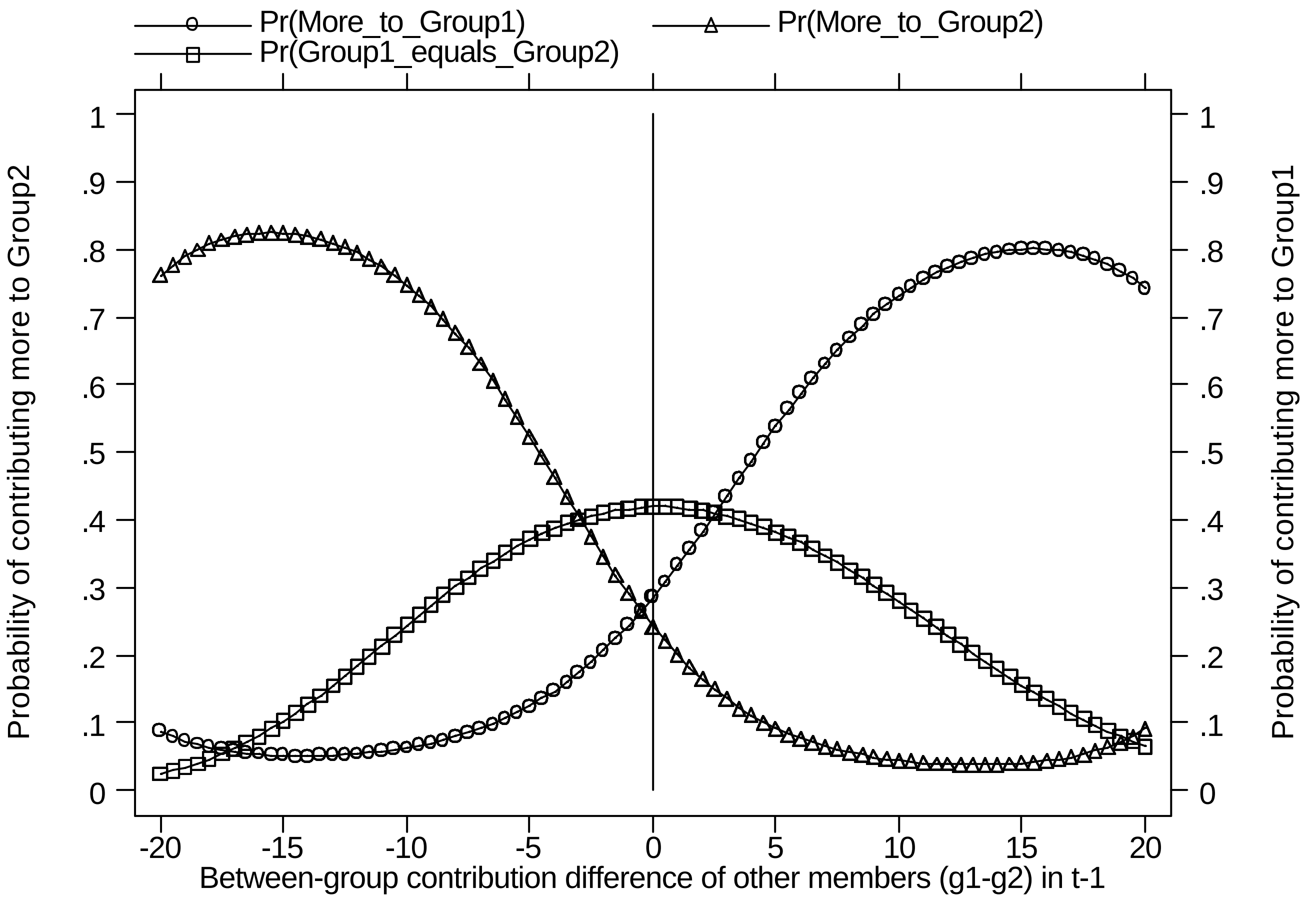
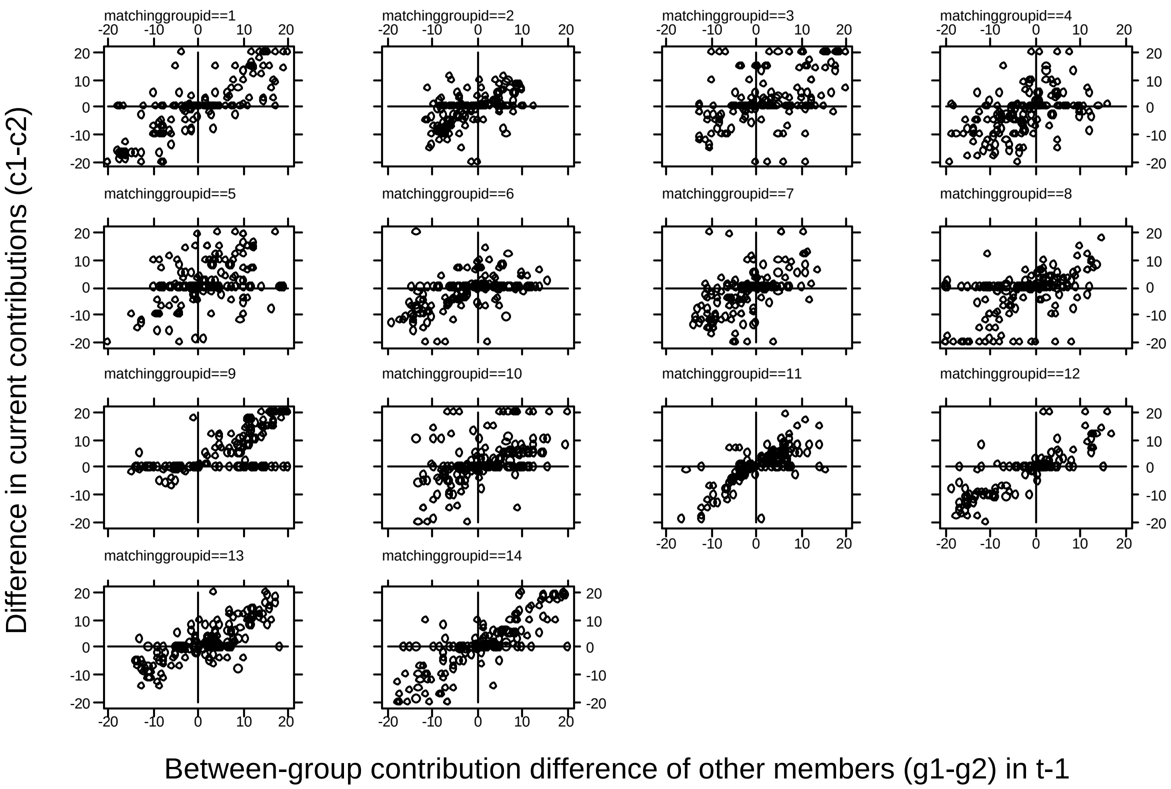


Figure 3 looks at the group interaction effects from another angle. As a function of ($g_i^1 - g_i^2$) it shows the estimated probability of contributing (i) more to Group 1 than to Group 2; (ii) more to Group 2 than to Group 1; and (iii) the same amount to both groups. Specifically, we have estimated the following three cubic Logit models k = 0, 1, 2: $m^k = a_{k0} + a_{k1}? + a_{k2}?^2 + a_{k3}?^3 + e_k$; where ? ≡ ($g_i^1 - g_i^2$). m^k is a binary variable: m^0 equals 1 if a subject contributes the same amount to both groups (i.e., $c_i^1 = c_i^2$) and 0 otherwise; m^1 equals 1 if a subject contributes more to Group 1 than to Group 2 (i.e., $c_i^1 > c_i^2$) and 0 otherwise; and m^2 equals 1 if a subject contributes more to Group 2 than to Group 1 (i.e., $c_i^1 < c_i^2$) and 0 otherwise. The figure shows the estimated Logit probabilities of m^k.

Several observations can be made in Figure 3. The probability of contributing more to Group 1 than to Group 2 is very low if $g_i^1 < g_i^2$ and – except for the extreme deviations of –20 to –15 – is increasing in $(g_i^1 - g_i^2)$. For $(g_i^1 - g_i^2) > 0$ the probability of contributing more to Group 1 is strongly increasing and equals roughly 80 percent at $(g_i^1 - g_i^2) = 15$. For larger deviations the probability to invest more in Group 1 than in Group 2 decreases again. The probability to invest more in Group 2 as a function of $(g_i^1 - g_i^2)$ is just the mirror image of the probability to invest more in Group 1. The probability that a subject contributes the same amount in both groups is highest at $g_i^1 = g_i^2$ and flattens out symmetrically for both positive and negative $(g_i^1 - g_i^2)$.

Remember that our design involves matching groups of nine subjects (see Figure 1). These matching groups form the strictly independent observations of our data set. Figure 3 looks at our hypotheses at the level of matching groups by providing a scatterplot 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 3: *Group interaction effects between Group 1 and Group 2 per matching groups*



The first observation from Figure 3 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 artifact of aggregation. Figure 3 also reveals that in all matching groups a considerable number of decisions lies on the line ($c_i^1 - c_i^2$) = 0 for any ($g_i^1 - g_i^2$). These are contribution decisions that are unaffected by the differences in group behaviors. We will return to this observation in our analysis of individual behavior.

We are now in a position to provide more formal support for our Group Interaction Hypothesis. A first and very conservative statistical test proceeds as follows. We first split the data at ($g_i^1 - g_i^2$) = 0 and calculate for each matching group the average ($c_i^1 - c_i^2$) for ($g_i^1 - g_i^2$) < 0 and for ($g_i^1 - g_i^2$) ≥ 0. It turns out that in *all* fourteen matching groups the average of ($c_i^1 - c_i^2$) is smaller if ($g_i^1 - g_i^2$) < 0 than if ($g_i^1 - g_i^2$) ≥ 0. A sign test shows that the likelihood that this change in sign in all fourteen matching groups is a mere coincidence is p = 0.0001 (two-sided). The non-parametric Wilcoxon signed-ranks test, which also takes the amount of the changes into account, also reveals that this change is highly significant (p = 0.001, two-sided).

Table 1 records the results of robust OLS regression analyses. Since within a matching group contributions are not independent, we have calculated robust standard errors that allow for correlated errors. In all three models the dependent variable is ($c_i^1 - c_i^2$). As regressors we include the period index to capture any time effect and, as separate variables, g_i^1 and g_i^2. We did not include ($g_i^1 - g_i^2$) as a regressor because we did not want to force the same parameter onto g_i^1 and g_i^2. The first model in the second column strongly supports our previous arguments. The robust standard errors are extremely low, which leads to very high t-values (of t=24.3 and t=14.0). Moreover, the estimated coefficients of g_i^1 and g_i^2 are mirror images. The observed group interaction effect does not vanish over time, since “period” is not significantly different from zero.[2] The second and third model also include two variables about which subjects were regularly informed during the experiment: $g_i^1(1,\ldots t-1)$ and $g_i^2(1,\ldots t-1)$. These variables denote the average contribution of the other group members over *all previous* periods. Thus, these variables contain the whole history of contributions of the other group members. Using these more encompassing variables as regressors in the second and the third model does not change the main result by much.

---

[2] A scatterplot of ($c_i^1 - c_i^2$) against ($g_i^1 - g_i^2$) separately for each period shows that group interaction effects do not vanish over time. To further check the robustness of this finding, we have also estimated all models with period dummies. In all models they are jointly statistically insignificant. Even in the last period we find highly significant group interaction effects.

TABLE 1: *Group interaction effects between groups – own difference in contribution to Group 1 and Group 2 as a function of the difference other group members' contribution in Group 1 and Group 2 in* t – 1.

Dependent variable:	$c_i^1 - c_i^2$	$c_i^1 - c_i^2$	$c_i^1 - c_i^2$
Independent variable:	coefficient (robust std. error)	coefficient (robust std. error)	coefficient (robust std. error)
Constant	-0.517 (0.539)	-1.270 (1.132)	-0.614 (0.806)
period	0.018 (0.024)	0.026 (0.045)	0.018 (0.031)
g_i^1	0.681*** (0.028)	-	0.506*** (0.063)
g_i^2	-0.643*** (0.046)	-	-0.503*** (0.086)
$g_i^1(1, t–1)$		0.807*** (0.030)	0.260*** (0.079)
$g_i^2(1,\ldots t–1)$		-0.724*** (0.070)	-0.224** (0.102)
	N=2394 F(3,6)=291.0*** R^2=0.44	N=2394 F(3,6)=204.4*** R^2=0.37	N=2394 F(3,6)=305.0*** R^2=0.45

Note: ***, **, * denote significance at the 1-, 5- and 10-percent level, respectively.

In summary, our results provide very strong and unambiguous evidence for the importance of social interaction effects. On average, subjects are very strongly influenced by the contribution decisions of their fellow group members. This holds both at the aggregate level as well as in all of our matching groups.

B. *Group interaction effects within groups*

The strong group interaction effect that we observe between the groups begs the question whether subjects are also influenced by the decisions of their fellow group members *within* a group. *Ceteris paribus*, a subject may be willing to contribute more *within* a particular group the more the other group members have contributed.[3] Our design allows us to test for such an interaction effect as well. Moreover, we can compare behavior in our two-group and our single-group design. We have conducted the single-group experiment to have a benchmark against

[3] Recent theories of fairness and reciprocity predict this. See Fehr and Schmidt [1999], Bolton and Ockenfels [2000], Dufwenberg and Kirchsteiger [1998], Falk and Fischbacher [1999] and Charness and Rabin [2002].

which to evaluate within-group effects that might be unique to the two-groups design. We state our hypothesis more formally as:

WITHIN-GROUP INTERACTION HYPOTHESIS: *The contribution of a group member is positively correlated with the average contribution of the other group members in the previous period, i.e.,* $\text{corr}\,(c_i^k, g_i^k) > 0,$ where k = 1,2. *This also holds in the single-group experiments.*

Figure 5, which plots the own contribution as a function of the average contribution of the other group members in the previous period in the respective group, and Table 2 provide the support for our next result.

Result 2. *We also find strong evidence for our Within-Group Interaction Hypothesis, which holds very similarly in the two-groups and the single-group experiment.*

FIGURE 5: *Group interaction effects within groups*

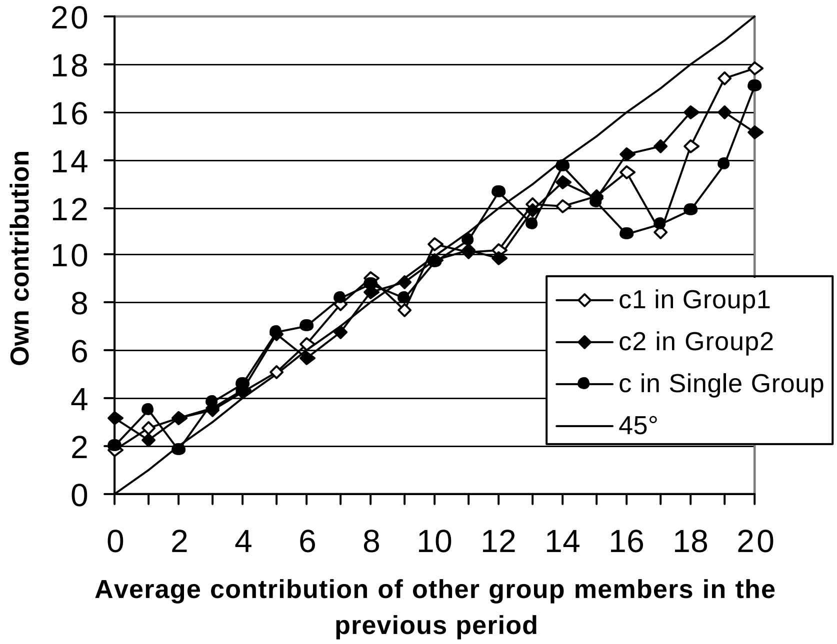


Figure 5 depicts c_i^k as a function of g_i^k, for k = 1,2, and c_i as a function of g_i in our single-group experiments. Two results are noteworthy from Figure 5. First, we have also very strong evidence for within-group interaction effects. The higher the average contribution of the other group members within a particular group in the previous period, the higher is the contribution in that group in the current period. This result is consistent with recent fairness theories and arguments and evidence in Croson [1998], Sonnemans, Schram and Offerman [1999], Keser and van Winden [2000], Fischbacher, Gächter and Fehr [2001] and Falk and Fischbacher

[2002]. Moreover, it suggests that motives like "warm glow" and "errors" that are *independent* of the other group members' contribution decision, cannot be the whole story behind people's contributions to public goods. Second, there is basically no difference between the within-group interaction effects in the two-group design and the single-group design. Thus, the within-group interaction effect observed in our main design is not influenced by the two-groups procedure.

Table 2 provides statistical support (using OLS with robust standard errors adjusted for matching groups) for the results of Figure 5. There are several noteworthy results.

TABLE 2: *Group interaction effects within groups – own contribution as a function of other group members' contribution in* t – 1.

	Single-group experiments	Two groups experiments	
Dependent variable:	c_i	c_i^1	c_i^2
Independent variable:	coefficient (robust std. error)	coefficient (robust std. error)	coefficient (robust std. error)
Constant	4.244*** (1.106)	2.901*** (0.672)	3.418*** (0.776)
period	-0.145*** (0.032)	-0.103*** (0.018)	-0.121*** (0.024)
g_i	0.673*** (0.088)	-	-
g_i^1	-	0.750*** (0.061)	0.069 (0.045)
g_i^2	-	0.021 (0.037)	0.663*** (0.046)
	N=912 F(2,15)=53.43*** R^2=0.37	N=2394 F(3,13)=101.4*** R^2=0.46	N=2394 F(3,6)=185.0*** R^2=0.37

Note: ***, **, * denote significance at the 1-, 5- and 10-percent level, respectively.

First, the coefficients of the other group members' average contribution in the previous period (i.e., g_i, g_i^1 and g_i^2) are highly significantly positive and very similar in their magnitudes. This supports the impression one gets from Figure 5. Second, in the two-groups design, the average contributions of the other group members in the other group do not influence within-group interaction effects in a given group. Third, as in basically all public goods experiments, contributions decline over time (see Ledyard [1995] for a survey). Fourth, to the extent that the constant measures something like "warm glow", i.e., contributions that are independent of others' contribution decisions, we also have evidence for "warm glow". However, the highly significantly positive coefficient on others' average contribution in the previous period really suggests the importance of within-group effects as an important determinant of contribution decisions.

C. *Individual behavior*

While Results 1 and 2 record very strong evidence in favor of the Group Interaction Hypotheses, the question arises to what extent this also reflected at the individual level. As mentioned, Figure 3 reveals that a considerable amount of contribution decisions seems to have been independent of ($g_i^1 - g_i^2$). It is conceivable that there are some subjects who are not at all influenced by their group members, e.g., because they decide to free ride regardless of others' contribution. In the context of their study on social interaction effects in criminal behavior Glaeser et al. [1996] identify so-called "fixed agents", who are uninfluenced by others. Our design allows us as well to identify "fixed agents". Moreover, we can also check to what extent a subject exhibits group interaction effects both within and between groups.

In our individual data analysis we proceed as follows. A subject is classified as exhibiting a positive group interaction effect *within a particular group* if the Spearman rank correlation coefficient *?* between the own contribution in a group *k* and the average contribution of the other group members in group *k* in the previous period is significantly positive at the 5 % level (i.e., if $r(c_i^k, g_i^k) > 0$, where *k* = 1,2). A subject is said to show a positive group interaction effect *between Group 1 and Group 2* if the Spearman rank correlation of the difference in contributions between Group 1 and Group 2 is significantly positively correlated (at the 5 % level) with the difference in average contributions of the other group members in the previous period [i.e., *?*(($c_i^1 - c_i^2$), ($g_i^1 - g_i^2$)) > 0]. Table 3 provides the support for our third result.

Result 3. *A large majority of subject shows either within and/or between group interaction behaviors. Roughly a quarter of subjects can be classified as "fixed agents" who are not influenced by their group members.*

The second and third columns of Table 3 classify subjects according to their group interaction effects *between* groups. It turns out that 68/122 ≈ 56 percent contribute monotonically more in that group to which fellow group members have contributed more in the previous period. The rest of the subjects does not show a monotonic relationship between ($g_i^1 - g_i^2$) and ($c_i^1 - c_i^2$).

The rows in Table 3 show to what extent subjects react *within groups* on their fellow group members' contribution decision in the previous period. Fifty-five subjects show a group interaction effect in both groups and another 35 subjects exhibit group interaction in one of the two groups. Thus, in total 90/122 ≈ 74 percent of the subjects exhibit some group interaction effect. The other 32 subjects do not react in either group on their fellow group members' contribution level.

TABLE 3: *Number of subjects who exhibit positive group interaction effects within and/or between Group 1 and Group 2*[4]

Group interaction effects *within*	Positive group interaction effects *between* Group 1 and Group 2: Yes	No	Total
Group 1 and Group 2	47	8	55
Group 1 or Group 2	19	16	35
neither group	2	30	32
Total	68	54	122

Note: For the definition of group interaction effects see the description in the text.

It is now interesting to see how subjects' group interaction behavior within a group relate to the group interaction between groups. The large majority of all subjects (47/55) who show group interaction effects within both groups also exhibit significant group interaction effects across groups. The mirror image, which comprises 30/32 persons, are subjects who do not exhibit group interaction effects both within and between groups. These subjects can be called "fixed agents" (Glaeser et al. [1996]), because they do not exhibit *any* systematic group interaction effect. Slightly more than half of the 35 subjects who exhibit a group interaction effect only in one group also show a group interaction effect across group and the other half does not. Thus, except for the "fixed agents", 75 percent of the subjects show *some* group interaction effect either within or between groups.

V. SUMMARY

In many social and economic situations it appears that there are strong social interaction effects in the sense that the members of the same social group tend to behave similarly. However, identifying social interactions is a notoriously difficult task (Manski [1993, 2000]) 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

[4] Three subjects exhibit negative group interaction effects either in Group 1 or Group 2. One subject shows a negative correlation both within and between groups.

tenuous, experimental and subjective data will have to play an important role in future efforts to learn about social effects".

In this paper we have presented an experimental design that is a step in the direction suggested by Manski [1993]. In our experiment we deliberately have created an artificial situation in which each subject is a member of two separate, yet economically identical groups with different members. The decision situation in both groups was the provision of a linear public good in which standard arguments predict a special form of no social interactions: full free riding by all agents. Our design allows us to control for self-selection, and correlated as well as contextual effects that make the identification of social interaction effects difficult with the usually available field data. Thus, if we observe the *same* subject contributing differently to the *identical*, yet separate public goods of the two groups as a function of the other group members' behavior in both groups, we have unambiguous evidence for social interaction effects. Our three main results establish the importance of social interactions in our experiment:

1. On average people contributed more to the group in which the other group members have contributed more. Thus the No Group Interaction Hypothesis that follows from the standard hypothesis of full free riding but also from motives like "warm glow" is unambiguously rejected in favor of our Group Interaction Hypothesis.
2. We also find strong evidence for Within-Group Interactions: Within a group people's contributions increase in the contributions of other group members in the previous period.
3. At the individual level we find that approximately 25 percent of the subjects can be called "fixed agents" since the other group members do not affect their contribution behavior. Roughly 40 percent exhibit both within and between group interaction effects.

References

Akerlof, George (1997). “Social Distance and Social Decisions.” *Econometrica* 65(4), 1005-1027.

Andreoni, James (1990). “Impure Altruism and Donations to Public Goods: A Theory of Warm Glow Giving.” *Economic Journal* 100, 464-477.

Andreoni, James (1995a). “Warm-Glow versus Cold-Prickle: The Effects of Positive and Negative Framing on Cooperation in Experiments.” *Quarterly Journal of Economics* 110(1), 1-21.

Andreoni, James (1995b). “Cooperation in Public Goods Experiments: Kindness or Confusion?”. *American Economic Review* 85(4), 891-904.

Becker, Gary and Kevin Murphy (2000). *Social Economics. Market Behavior in a Social Environment.* Cambridge: The Belknap Press of Harvard University Press.

Bertrand, Marianne, Erzo Luttmer and Sendhil Mullainathan (2000). “Network Effects and Welfare Cultures.” *Quarterly Journal of Economics* 115(3), 1019-1055.

Bolton, Gary and Axel Ockenfels (2000). “A Theory of Equity, Reciprocity and Competition”. *American Economic Review* 90(1), 166-194.

Carpenter, Jeffrey, Peter Matthews and Okomboli Ong’Ong’a (2001). “Social Reciprocity”. Mimeo. Middlebury College.

Case, Anne and Lawrence Katz (1991). “The Company You Keep: The Effects of Family and Neighborhood on Disadvantaged Youths.” NBER Working Paper No. 3705.

Charness Gary and Matthew Rabin (2002). “Some Simple Tests of Social Preferences and a New Model.” *Quarterly Journal of Economics* , forthcoming.

Croson, Rachel (1998). “Theories of Commitment, Altruism and Reciprocity: Evidence from Linear Public Goods Games”. OPIM Working Paper, Wharton School of the University of Pennsylvania.

Durlauf, Steven and Peyton Young, eds. (2001). *Social Dynamics.* Cambridge: The MIT Press.

Dufwenberg, Martin and Georg Kirchsteiger (1998). “A Theory of Sequential Reciprocity.” Mimeo, CentER Tilburg.

Falk, Armin and Urs Fischbacher (1999). “A Theory of Reciprocity.” Working Paper No. 6, Institute for Empirical Research in Economics, University of Zurich.

Fehr, Ernst and Klaus Schmidt (1999). “A Theory of Fairness, Competition and Cooperation.” *Quarterly Journal of Economics* 114(3), 817-851.

Fischbacher, Urs (1999). “z-Tree. Zurich Toolbox of Readymade Economic Experiments.” *Working Paper* Institute for Empirical Research in Economics, University of Zurich, No. 21.

Fischbacher, Urs, Simon Gächter and Ernst Fehr (2001). “Are people conditionally cooperative? Evidence from a public goods experiment.” *Economics Letters* 71, 397-404.

Glaeser, Edward and José Scheinkman (2001). "Measuring Social Interactions." In: Steven Durlauf and Peyton Young (eds.): *Social Dynamics.* Cambridge: The MIT Press.

Glaeser, Edward, Bruce Sacerdote and José Scheinkman (1996). "Crime and Social Interactions." *Quarterly Journal of Economics* 111, 507-548.

Ichino, Andrea and Giovanni Maggi (2000). "Work Environment and Individual Background: Explaining Regional Shirking Differentials in a large Italian Bank." *Quarterly Journal of Economics* 115(3), 1057-1090.

Katz, Lawrence, Jeffrey Kling and Jeffrey Liebman (2001). "Moving to Opportunity in Boston: Early Results of a Randomized Mobility Experiment." *Quarterly Journal of Economics* 116(2), 607-654.

Keser, Claudia and Frans van Winden (2000). "Conditional Cooperation and Voluntary Contributions to Public Goods." *Scandinavian Journal of Economics* 102(1), 23-39.

Ledyard, John (1995). "Public Goods: A Survey of Experimental Research", in: John Kagel and Alvin Roth: *Handbook of Experimental Economics.* Princeton: Princeton University Press.

Ludwig, Jens, Gregg Duncan and Paul Hirschfield (2001). "Urban Poverty and Juvenile Crime: Evidence from a Randomized Housing-Mobility Experiment." *Quarterly Journal of Economics* 116(2), 655-679.

Manski, Charles (1993). "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies* 60, 531-542.

Manski, Charles (2000). "Economic Analysis of Social Interactions." *Journal of Economic Perspectives* 14(3), 115-136.

Palfrey, Thomas and Jeffrey Prisbrey (1997). "Anomalous Behavior in Public Goods Experiments: How Much and Why?" *American Economic Review* 87(5), 829-846.

Rabin, Matthew (1993). "Incorporating Fairness into Game Theory and Economics." *American Economic Review* 83(5), 1281-1302.

Sacerdote, Bruce (2001). "Peer Effects with Random Assignment: Results for Dartmouth Roommates." *Quarterly Journal of Economics* 116(2), 681-704.

Sonnemans, Joep, Arthur Schram and Theo Offerman (1999). "Strategic Behavior in Public Goods Games: When Partners Drift Apart." *Economics Letters* 62, 35-41.

Appendix: Experimental Instructions

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

You are now taking part in an economics experiment which has been financed by various 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 all, the experiment consists of 20 periods. Every participant is always divided into **two groups** (one group 1 and one group 2). Both groups contain 3 participants, that means there are two more participants in each group besides you. Please notice that the two participants in group 1 are other participants than the two participants in group 2. **Therefore, there is no other person besides you also either in group 1 as well as in group 2.**

The composition of the groups will stay the same during the whole 20 periods. **Therefore you will be with the same participants for 20 periods in group 1 as well as 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 periodic income inside the 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 one 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 =

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:

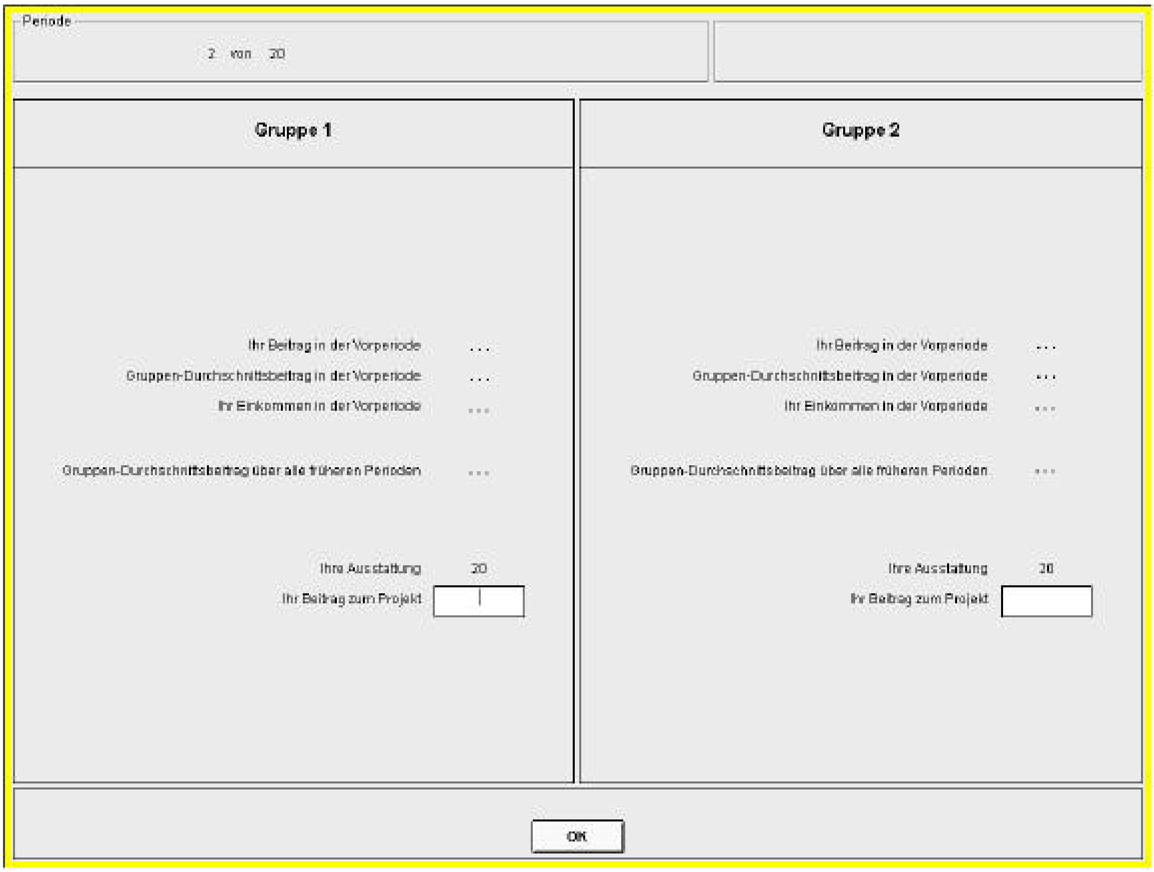
(20 - your contribution to the project) + 0.6*(total contributions to the project)

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 the contributions of all group members is 50 points. In this case each member of the group receives an income from the project of: 0.6*50=30 Guilders. If the total contribution to the project is 8 points, then each member of the group receives 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, then the total contribution to the project would rise by one point. Your income from the project would rise by 0.6*1=0.6 points. However, the income of the other group members 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 income is exactly the same in group 1 and group 2.

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



The number of the period appears in the top left corner of the screen. In the top right corner you can see how many more seconds remain for you to decide on the distribution of your points.

The screen is divided in two parts. On the left, you find the information concerning group 1, on the right the information for group 2. First you can see your contribution of the previous period. Below you find the average contribution of each group concerning the project of the previous period. If the contributions of the three group members have been 10, 15 and 20 respectively in the previous period, the number beside "Average-Group-Distribution in the previous period" will be 15. Your income of the previous period you will find below.

A bit further down you can see the "average group contribution of all previous periods". This number shows the average contribution of all group members in each group about all previous periods together. If for example the average contribution in period 1 was 3, in period 2 it was 2 and in period 3 for example 1, the number for the fourth period in this line would be 2. The "group average contribution over all previous periods" is therefore a short summary of the previous story in one group. The higher the average contribution in one 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 every of the two groups will be 20 points. You choose in every 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 for this period.

Please notice: **Group 1 and group 2 are two totally independent groups.** Therefore you can decide about your contribution in group 1 and group 2 absolutely independently, that means 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 one possibility to choose your contribution. In the first period there is no previous period and therefore the other information (like: "your contribution in the previous period") can not be shown.

After all group members have made their decision, one period is over. After that you get back your input monitor. On this monitor you can see the contributions of the previous period of both groups and how high your income in both groups is. You can also see the average contribution of both groups up to now. Afterwards you make your new contributions for 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!

1. 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? ...

2. 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? ...

3. 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? ...