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Article

Reciprocity in Locating Contributions: Experiments on the Neighborhood Public Good Game

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Abstract: In repeated public good experiments, reciprocity helps to sustain high levels of cooperation. Can this be achieved by location choices in addition to making contributions? It is more realistic to rely on an intuitive neighborhood model for community members who interact repeatedly. In our experiments, participants can locate their contribution, yielding a small benefit for the participant, who receives the contribution and a small disadvantage for the participant, at the opposite location. This mechanism of individually targeted sanctions helps to foster initial cooperation. It decreases over time, however. Location choices are used to reciprocate, but may not suffice to stabilize voluntary cooperation as an effect observed in the field.

Keywords: public good game; neighborhood; cooperation; experimental analysis

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1. Introduction

In linear public good games, benefits from the common pool are smaller than the benefit of keeping everything for oneself, but investments in the common pool imply efficiency gains for the whole population. In experimental studies of repeated voluntary public goods provision (see, e.g., [1] for an early investigation or [2] for a recent review), participants initially contribute to the common pool. However, cooperation decreases with the length of the experiment and the growing number of participants [3].

Allowing participants to repeatedly interact in the same group, *i.e.*, by implementing a partner design, also allows for conditional cooperation [4]. Participants who cooperate conditionally adjust their contributions toward the average contribution of the whole group. This "reciprocal" adjustment is not perfect, but typically favors the adjusting participant, leading to a decline in contributions over time [5]. Several studies (e.g., [5,6]) report that the majority of participants resort to conditional cooperation, while a large fraction of participants free ride and a smaller fraction of them show unconditional cooperation.

A mechanism ensuring cooperation over time is sanctioning [7,8], where, after each period, participants are informed of the contributions of all other participants and can impose a fine on those who did not fulfill the former's expectations.[1] However, punishment has several drawbacks in addition to its potential demand effect: (1) It is costly for both, the punishing and the punished participant (see, e.g., [10]). (2) Some participants punish antisocial [11] participants who contributed more than they did. (3) Punishment is affected by an imposed and usually rather extreme relationship between the costs for the punisher and the fine imposed [12,13]. (4) The technology of such mandatory sanctions has no analogue in the field,[2] or more specifically, individual targeted mandatory sanctions by private agents may be useful for disentangling motives, but are rather unrealistic.

These drawbacks do not apply to rewarding. Allowing to reward may also invoke a demand effect [14,15], where participants can transfer part of their earnings to other participants without loss of efficiency and, thereby, ensure cooperation over time. The advantages of both, punishment and rewarding, are combined in institutions in which participants can both punish and reward [14,15].

Rand *et al.* [15] conclude that "it is not costly punishment that is essential for maintaining cooperation in the repeated public goods game but instead the possibility of targeted interactions more generally." In particular, they show that both punishment and rewarding with monetary transfers, *i.e.*, investing part of one's income to reduce or increase the income of another participant increases cooperation. In view of this, we modify the public good game by allowing for additional targeting of contributions. Our Neighborhood Public Good Game is played by four players located at the four corners of a square. Thus, each player has two direct neighbors (at adjacent corners) and one distant neighbor. Players do not only choose their contribution, but also the location (corner) of their contribution. What a player gains from a contribution depends on her distance to the location of the contribution. It is maximal (minimal) when the contribution is located at the (opposite) position of the player. Similar to monetary transfers (as used by Rand *et al.*), location choices are neutral with respect to efficiency—measured by the sum of contributions—and allow for both rewarding and punishment. For rewarding, a player locates his contribution at the position of the targeted player, while he chooses the opposite position when punishing.

[1] One wonders somewhat why this technology of monetary sanctioning is widely applied and apparently accepted in experimental economics, since modern democracies normally rely on democratically controlled sanctioning by the state (see [9] for an experimental comparison of decentralized and centralized sanctioning).

[2] In our view and in line with our experience, there seems to be no questioning of assumptions of former studies, even when they are outrageously unrealistic, what may be explained by habit information in science.

Having to locate one's contributions in one's neighborhood is quite natural. One example is locating facilities with positive or negative external effects for one's neighbors.[3] Furthermore, the act of locating is neither an obvious device for sanctioning or rewarding with a self-serving location, *i.e.*, locating one's contribution at one's location, as the obvious default. Will this allow voluntary cooperation by improved coordination? Since locating contributions for the whole group is efficiency neutral, this offers an intriguingly new aspect of repeated contributions in public goods experiments.

To better disentangle whether being able to locate one's contribution fosters voluntary cooperation, we first ran treatments with endogenous location choices and then treatments in which the same location choices are exogenously imposed. Thus, any difference in behavior in the main treatments and the control treatments can be unambiguously attributed to the discretion in locating one's contribution.

Only 16% of the participants always chose a self-serving location, confirming that they relied on location choices in spite of the self-serving location being the obvious default. Moreover, without the location option, there is less cooperation. Thus, assuming realistically that individual contributions are not just added in, but have to be located, captures a coordination device without any formal institution. In contrast to the literature on sanctioning with its demand effect [12,13], showing that punishment is more effective when the cost/fine ratio of punishment is low, we find the opposite effect, warning us against reaching general conclusions from strategies that employ highly unrealistic sanctioning schemes.

In Section 2, we introduce the voluntary contribution game with its simple neighborhood structure and present our experimental design. The experimental data, comprising individual contributions and location choices, are analyzed in Section 3. Section 4 discusses our results.

2. Experimental Design

In this section, we first introduce the model of our Neighborhood Public Good Game and then describe our treatments and the experimental procedure.

2.1. Model

The Neighborhood Public Good Game is repeated T times. Four players ($I = \{1, 2, 3, 4\}$) interact, and each player, $i \in I$, is assigned to a different corner of a square. The two players occupying adjacent corners of the square are the direct neighbors of player, i, the other player is i's distant neighbor.

In each period, $t \in \{1, ..., T\}$, each player, i, receives the same integer endowment, $e > 0$. Player i then chooses the size of the contribution, $c_t(i)$, with $1 \leq c_t(i) \leq e$ and its location, $l_t(i) \in I$. Each player can locate $c_t(i)$ at the position of a neighbor or his own position and keeps the difference, $e - c_t(i)$, for himself. The location of contribution, $l_t(i)$, can be any corner of the square, *i.e.*, the position of one of the four players. In the following, we also refer to $l_t(i)$ as the player located at corner, $l_t(i)$. Contributions have to be positive ($c_t(i) \geq 1$ for all i) to make their location always payoff relevantly. Further, the contribution, $c_t(i)$, can be located at one location, $l_t(i)$, only. By allowing only positive contributions at exactly one location, we intend to understand the motivation behind the contributions. If a player

[3]For instance, locating a chimney as far as possible from one's neighbor would favor this neighbor, but harm the neighbor at the opposite end. Similarly, industrial production sites and emissions can be located with different effects for the neighboring firms.

could contribute nothing to the public good, his location choice would be meaningless, which we want to avoid.

The position of the player in relation to contribution, $l_t(i)$, determines its constant marginal productivity $\alpha(k, l_t(i))$. For any player, k, the marginal productivity of an individual contribution, $c_t(i)$, is:

$$\alpha(k, l_t(i)) = \begin{cases} \overline{\alpha} & \text{for } l_t(i) = k \\ \alpha & \text{if } k \text{ and } l_t(i) \text{ are direct neighbors} \\ \underline{\alpha} & \text{if } k \text{ and } l_t(i) \text{ are distant neighbors} \end{cases}$$

where $1 > \overline{\alpha} > \alpha > \underline{\alpha} > 0$ and $\overline{\alpha} + 2\alpha + \underline{\alpha} > 1$. The payoffs are given by:

$$u_t(k) = e - c_t(k) + \sum_i \alpha(k, l_t(i))c_t(i)$$

for all players, $k \in I$, and all periods, $t = 1, \dots, T$ with $1 \leq c_t(i) \leq e$ for all i and t. Although the location of contribution, $l_t(i)$, affects the individual gains from $c_t(i)$, it does not influence the aggregated payoff of all players, $\sum_i u_t(k)$, as the aggregated marginal benefit of a contribution is $\overline{\alpha} + 2\alpha + \underline{\alpha}$ always.

Note that locating one's contribution does not only target just one community member, but favors the one whose location is chosen and harms another who is at the opposite corner. In our view, this captures a usual aspect of most sanctioning devices in the field and questions individual targeting in sanctioning without external effects on others.

2.2. Treatment Design

We conducted experiments to investigate the impact of location choices. In particular, we introduced treatments varying the values, $\underline{\alpha}$, α and $\overline{\alpha}$, without changing the sum, $\underline{\alpha} + 2\alpha + \overline{\alpha}$. Larger differences can, for instance, allow one to seriously harm the distant contact. Since we expected an increase in cooperation when participants have more discrimination power, we conducted two versions of the Neighborhood Public Good Game, Treatments, $\overline{M}$ and $\underline{M}$, using different values for $\underline{\alpha}$, α, $\overline{\alpha}$:

$$\overline{M} : \underline{\alpha} = 0.3, \alpha = 0.5, \overline{\alpha} = 0.7 \text{ and}$$
$$\underline{M} : \underline{\alpha} = 0.4, \alpha = 0.5, \overline{\alpha} = 0.6$$

In addition, we performed control Treatments, $\overline{C}$ and $\underline{C}$, of the Neighborhood Public Good Treatments, $\overline{M}$ and $\underline{M}$, where the location choices of participants are exogenously imposed, *i.e.* location choices were drawn from a uniform distribution. We did not inform participants of the control sessions how locations were determined—all the $\overline{C}$- and $\underline{C}$- instructions say is "Locations are predetermined and independent of your behavior."

Table 1 summarizes all four treatments.

2.3. Procedure

We recruited participants using ORSEE [16] for our computerized (using z-Tree, [17]) experiment. At the beginning of a session, participants were randomly seated in the laboratory. We handed out

Table 1. Distinction of treatments.

		Intensity of punishment/rewarding	
		low ($\overline{\alpha} = .6; \alpha = .5; \underline{\alpha} = .4$)	high ($\overline{\alpha} = .7; \alpha = .5; \underline{\alpha} = .3$)
Location	by participant	$\underline{M}$	$\overline{M}$
choice	by random draw	$\underline{C}$	$\overline{C}$

written instructions (see Appendix A for an English translation), which were also read aloud to make them common knowledge. After privately answering questions concerning the instructions, we checked the understanding of the instructions by a control questionnaire. Participants who were not able to answer these questions were replaced (altogether, 15 participants).

The participants played the four treatments of the Neighborhood Public Good Game for ($T =$) 20 periods.[4] In the beginning of the first period, we assigned each participant to a group and a location, which did not change throughout all 20 periods. In each period, t, participants received an endowment of ($e =$) 10 tokens. Each participant, i, decided how many tokens to contribute to the public good ($c_t(i)$). In the M Treatments, each participant also had to specify where to locate it ($l_t(i)$), while participants in the C Treatments were shown a location drawn from a uniform distribution where they could contribute. Each token was worth 10 points. Hence participants earned an integer number of points in each period, given the parameters in Table 1. At the end of each period, we informed the participants of their payoff, the contributions, $c_t(j)$, and the location choices, $l_t(j)$, of all participants in the current period. No additional information concerning other participants was given.

Table 2. Overview of treatments conducted.

Treatment	Sessions		Independent	No. of
	No.	groups per session	observations	participants
$\underline{M}$	3	8 (Sessions 1 and 2), 7 (Session 3)	23	92
$\overline{M}$	3	8 (all sessions)	24	96
$\underline{C}$	3	8 (all sessions)	24	96
$\overline{C}$	3	8 (all sessions)	24	96
Sum	12	95	95	380

A session lasted 60 to 90 minutes, including 25 minutes for reading and understanding the instructions. We paid participants privately at the end of each session. They earned points as payoffs (100 points = 0.20 euro). The average payoff was 14.02 euro. A participant who was replaced after not understanding the instructions received 2.50 euro in addition to the show-up fee of 2.50 euro.

Three hundred and eighty students from various fields of study participated in the experiment at the laboratory of the Max Planck Institute of Economics in Jena. We conducted three sessions with 32 participants for each of the four Treatments ($\underline{M}$, $\overline{M}$, $\underline{C}$, $\overline{C}$) with eight groups and one session of Treatment $\underline{M}$ with 28 participants in 7seven groups (see Table 2). Hence, we generated 24, respectively 23, independent observations per treatment. The reduction to 23 independent observations in Treatment $\underline{M}$ resulted from a hardware failure.

[4] After the 20 periods, we repeated the identical treatment with different groups. This repetition did not yield any additional insights. In this paper, we therefore focus on the results of the first repetition in this paper.

2.4. Hypotheses

Clearly, the solution behavior (from backward induction, e.g. in the sense of repeated elimination of weakly dominated strategies or subgame perfect equilibria) for all four players, i, is $c_t^*(i) = 1$ and $l_t^*(i) = i$ in all periods, t. For an efficient outcome, all participants must choose $c_t^+(i) = e$ and can make any location choice, $l_t(i)$, in all periods, t.

However, results from experimental investigations show deviating behavior: in the Neighborhood Public Good Game, participants interact in a partners design. Previous studies (e.g., [18]) have shown that participants engage in initial cooperation, but reveal a downward sloping development of contributions with a further decline of cooperation in the terminal period. We expect qualitatively similar attempts for $c_t(i)$ in the Neighborhood Public Good Game, where our participants can additionally make self-serving location choices, $l_t(i) = i$, but much less reliability of such attempts. In our view, this is mainly due to the unrealistic technology of individually targeted and highly detrimental monetary sanctions.

Hypothesis 1 *Cooperation decreases after the first period with:*

(a) *contributions $c_t(i)$ decreasing rapidly over time and*

(b) *an increasing number of self-serving location choices $l_t(i) = i$ in later periods.*

The higher variance between $\underline{\alpha}$, α and $\overline{\alpha}$ in the $\overline{M}$ treatment than in the $\underline{M}$ treatment allows for higher discrimination power regarding location choices. In particular, the positive behavior of others can be more highly rewarded in the $\overline{M}$ treatment. As we expect reciprocity to be the driving force behind behavior, we also expect more cooperation in the $\overline{M}$ than in $\underline{M}$ treatment.

Hypothesis 2 *Participants contribute more in the $\overline{M}$ treatment than in the $\underline{M}$ treatment.*

Finally, only in M treatments can participants reciprocate the behavior of others, while in C treatments, the location choices are randomly determined. Hence, we derive the following hypothesis.

Hypothesis 3 *Participants contribute more in the M than in the C treatments.*

3. Results

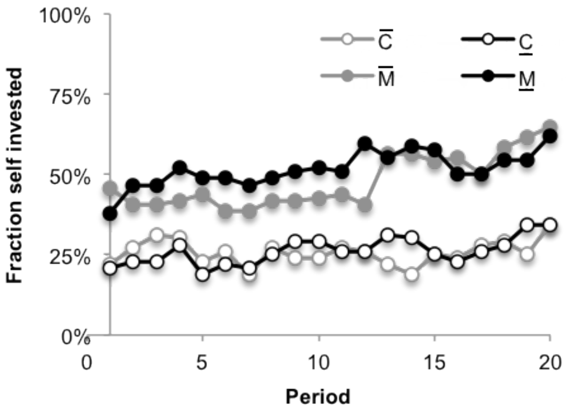
3.1. The Benefit of Location Choices

The overall contributions (see Figure 1 (b))[5] in the first period are 5.73 (in $\underline{M}$) and 5.72 (in $\overline{M}$) and are significantly higher than the contributions of 4.30 (in $\underline{C}$) and 4.27 (in $\overline{C}$) without location choices ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.016 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.003). Although contributions in treatments with

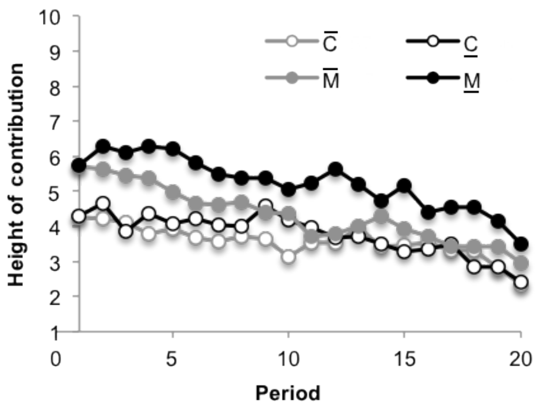
[5] If not specified separately, all test results in this section are one-sided, with 23 (for Treatment $\underline{M}$) or 24 (for Treatments $\overline{M}$, $\underline{C}$ and $\overline{C}$) independent observations. We use MW as abbreviation for Mann-Whitney U Tests and WX as abbreviation for Wilcoxon Signed Rank tests.

location choices remain higher than contributions in treatments without location choices, they decrease at least for the first 10 periods ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.007 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.016) until they approximate each other in the last period, clearly confirming Hypothesis 1 (a) ($\underline{M}$: 3.50, $\overline{M}$: 2.95, $\underline{C}$: 2.41, $\overline{C}$: 2.35). Compared to period 19, the last period only shows a weak endgame effect (in $\overline{C}$) if any ($\underline{M}$ (WX): p=0.062 / $\overline{M}$ (WX): p=0.070 / $\underline{C}$ (WX): p=0.061 / $\overline{C}$ (WX): p=0.046).

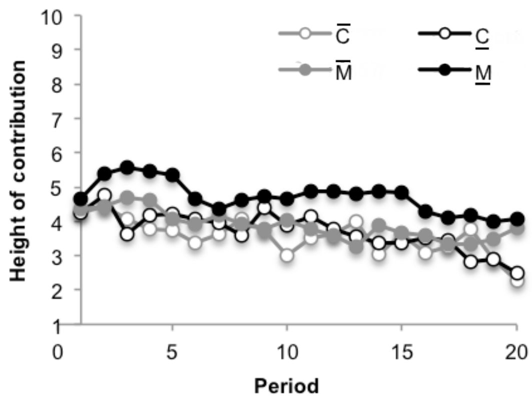
Figure 1. Development of contributions per treatment



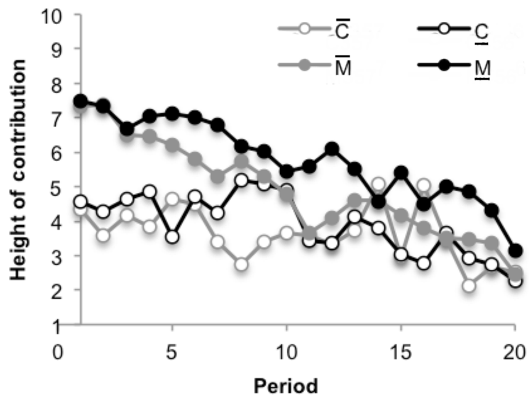
(a) Fraction of self-serving location choices



(b) Height of average contrib.



(c) Height of adjacent/distant contrib.



(d) Height of self-serving contrib.

Result 1 *Being able to freely locate one's contribution fosters initial cooperation, but cannot prevent its erosion over time.*

We attribute the decrease in contributions (mainly) to the increase in self-serving location choices. Both with high and low intensity of punishment or rewarding, significantly more (about 50%, see Table 4) participants invest in their own location than in experiments with random location choices ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.001 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.026) and the fraction of investments in self-serving locations slightly increases over time, confirming Hypothesis 1 (b) (see Figure 1 (a)). An analysis of contributions at adjacent/distant locations (see Figure 1 (c)) and contributions at self-serving locations (see Figure 1 (d)) in isolation confirms this. Contributions are significantly higher in treatments with location choices, both for self-serving ($l(i) = i$; $\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.001 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.000) and other contributions ($\underline{M}$ *vs.* $\underline{C}$

(MW): p=0.045 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.013). The effect even persists during the first 10 periods for contributions in self-serving ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.001 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.003) and other locations ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.029 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p=0.033).

Table 3. Comparison of first period contributions based on location choices.

Treatment	Other locations		Own location	
	Mean	SD	Mean	SD
$\underline{M}$	4.65	3.52	7.49	3.80
$\overline{M}$	4.35	2.88	7.34	3.85
$\underline{C}$	4.24	3.48	4.55	3.89
$\overline{C}$	4.25	3.43	4.33	3.41

However, the effects are stronger for self-serving location choices (in *p*-values). The difference between contributions at self-serving and distant location choices is most obvious when contributions in the first period are analyzed (see Table 3). Here, contributions at other locations are, on average, around four for all four treatments. However, in treatments allowing participants to choose the location of their contribution, the average contribution at self-serving locations is about twice as high. In addition, we find no endgame effect for contributions at self-serving locations ($\underline{M}$ (WX): $p = 0.236$ / $\overline{M}$ (WX): $p = 0.091$ / $\underline{C}$ (WX): $p = 0.352$ / $\overline{C}$ (WX): $p = 0.415$). Nevertheless, there is an endgame effect for contributions at other locations for Treatment $\overline{M}$ and $\overline{C}$ ($\underline{M}$ (WX): p=0.063 / $\overline{M}$ (WX): $p = 0.095$ / $\underline{C}$ (WX): $p = 0.135$ / $\overline{C}$ (WX): $p = 0.018$).

To sum up, contributions differ between treatments with and without location choices. This effect can be mainly attributed to the role of self-serving location choices. Whenever participants have the possibility, contributions at self-serving locations are more frequent and corresponding contributions are (at least initially) higher than choices for other locations.

Result 2 *Contributions at self-serving locations compensate this effect by being larger than contributions at distant locations, suggesting one can substitute free riding by self-serving location choices.*

3.2. Impact of Costs for Rewarding and Punishment

How fast cooperation decreases depends on the reward and punishment effects by location. While more than 40% of location choices fall on adjacent locations, only 5% choose distant neighbors (see Table 4). In particular, while no significant difference between the random (Treatments C) and the target mechanism (Treatments M) exists for adjacent locations (MW: $p = 0.150$), self-serving contributions at (distant) locations are significantly higher (lower) when participants choose these themselves (self-serving (MW): $p = 0.000$ / distant (MW): p=0.000). Thus, they refrain from punishment and rewarding of distant neighbors and focus on adjacent neighbors. The difference in impacts between Treatments $\underline{M}$ and $\overline{M}$ leads to differences in the effectiveness of this mechanism.

While investments in the second half of the experiment are significantly higher in Treatment $\underline{M}$ than in Treatment $\underline{C}$ (MW: $p = 0.010$), no difference exists between Treatment $\overline{M}$ and Treatment $\overline{C}$ (MW: $p = 0.359$). Although the benefit of our punishment and rewarding mechanism decreases in

Table 4. Fraction and contributions of participants investing in location types per treatment.

Treatment	Adjacent				Distant				Self-serving			
	Fraction		Height		Fraction		Height		Fraction		Height	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
$\underline{M}$	43.9%	0.257	4.83	2.07	4.5%	0.054	3.42	2.74	51.7%	0.272	5.45	2.56
$\overline{M}$	47.7%	0.297	3.00	1.91	4.5%	0.047	4.03	2.35	47.8%	0.311	4.41	2.68
$\underline{C}$	49.7%	0.067	4.07	2.35	24.1%	0.060	3.29	2.41	26.2%	0.050	3.73	2.18
$\overline{C}$	49.5%	0.044	3.82	2.09	24.9%	0.053	2.92	2.09	25.6%	0.051	3.67	2.42

the $\underline{M}$ Treatment, it persists until the final period ($\underline{M}$ *vs.* $\underline{C}$ (MW): p = 0.013 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.220; U = 251.0).

An analysis of all 20 periods shows that allowing for location choices in Treatment $\underline{M}$ is strongly beneficial - here contributions are significantly higher in the M treatment than in the C treatment confirming Hypothesis 3 (MW: p=0.005), while it has no positive impact on contributions in Treatment $\overline{M}$ for the whole experiment contradicting Hypothesis 3 (MW: p=0.076). A side effect of this observation is that average contributions per group are significantly higher in Treatment $\underline{M}$ than in Treatment $\overline{M}$, obviously contradicting Hypothesis 2 (MW: p=0.046).

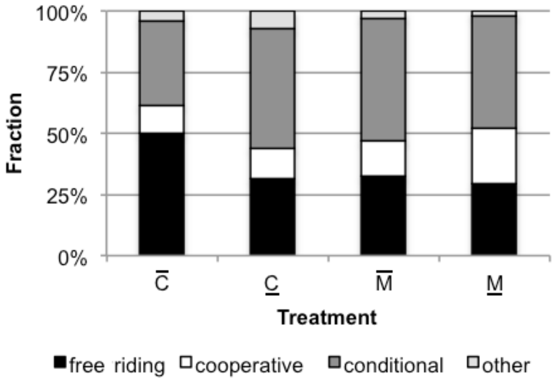
Clearly, the results in this subsection are surprising, especially the low contributions in Treatment $\overline{M}$. In the remainder of this section, we analyze this unexpected behavior from different angles.

3.3. (Un)conditional Cooperation and Free Riding

To classify cooperation behavior as conditional cooperation, unconditional cooperation and free riding, we resort to a notion introduced by [4] and formalized by [6]. In line with this approach, we plot the contributions of each participant against the average contribution of the remaining group in the previous period, *i.e.*, against observed behavior. We classify participants making contributions above (below) the $45°$ line as cooperators (free riders). If the contributions of a participant cluster around the $45°$ line, we classify him as a conditional cooperator. Formally, we perform an ordinary least-squares regression of the participant's contribution on the average contribution of the group. If the regression line is always above (below) 50% of all possible contributions, we classify the participant as an unconditional cooperator (free rider). If the regression line has a positive slope and lies both above and below 50% of all contributions, we classify the participant as a conditional cooperator. We classify all participants who do not fit any of the criteria as others. Although this approach may lead to misclassification (see [6]), we consider it to be accurate and not prone to tendentious classifications by visual inspection.

On average, the distribution of strategies is similar to other studies on public good games. The majority of all participants (about 45%) resort to conditional cooperation. The second largest group are free riders (about 36%), the smallest group any unconditional cooperators (about 15%). Only 4% of all participants do not fall into either of these groups. When the treatments are investigated in isolation, only Treatment $\overline{C}$ is different (see Figure 2). Here, with about 50% of all participants, significantly more participants free ride compared to about 30% in all other treatments ($\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.016 / $\underline{C}$ *vs.* $\overline{C}$ (MW): p = 0.011). This effect comes at the expense of the frequency of conditional cooperators. In Treatment $\overline{C}$, only 35% of all participants resort to conditional cooperation—significantly less than the about 48% in the other treatments ($\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.013 / $\underline{C}$ *vs.* $\overline{C}$ (MW): p = 0.017).

Figure 2. Fraction of contribution "strategies".



(a) Bar chart

	Free riding		Uncond. coop.	
	Mean	SD	Mean	SD
$\underline{M}$	29.4%	0.028	22.8%	0.301
$\overline{M}$	32.3%	0.239	14.6%	0.220
$\underline{C}$	31.3%	0.268	12.5%	0.221
$\overline{C}$	50.0%	0.276	11.5%	0.208

	Cond. coop.		Other	
	Mean	SD	Mean	SD
$\underline{M}$	45.7%	0.326	2.2%	0.104
$\overline{M}$	50.0%	0.233	3.1%	0.085
$\underline{C}$	49.0%	0.227	7.3%	0.173
$\overline{C}$	34.4%	0.206	4.2%	0.095

(b) Means and SDs

We now compare contributions between all three strategies by calculating the average contribution per group for each strategy, *i.e.*, free riding, conditional cooperation and unconditional cooperation. We then select only those groups in which participants show this behavioral pattern and compare the contributions between these groups. The analysis shows for all four treatments that free riders contribute significantly less ($\underline{M}$ (WX): obs. 12; p = 0.002 / $\overline{M}$ (WX): obs. 18; p = 0.000 / $\underline{C}$ (WX): obs. 17; p = 0.000 / $\overline{C}$ (WX): obs. 19; p = 0.000) and earn significantly more ($\underline{M}$ (WX): obs. 12; p = 0.002 / $\overline{M}$ (WX): obs. 18; p = 0.000 / $\underline{C}$ (WX): obs. 17; p = 0.000 / $\overline{C}$ (WX): obs. 19; p = 0.000) than conditional cooperators.

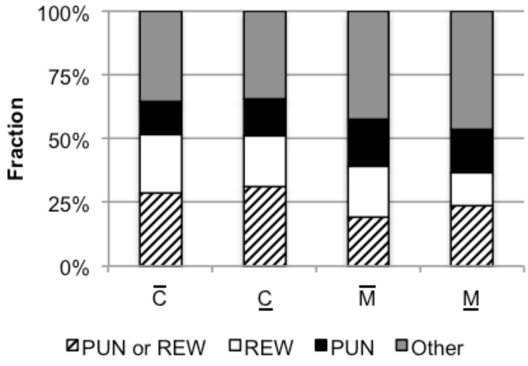
Result 3 *Conditional cooperators suffer from the existence of free riders, which explains the decline in cooperation over time.*

3.4. Punishment, Rewarding and Reciprocity

In this subsection, we analyze if location choices are used to punish or reward. To do so, we focus on all non-self-serving location choices (and classify them as punishment or rewarding for a previous act). We rank the highest contributions from the preceding period first and the lowest contributions last. If a participant chooses the participant ranked first in the preceding period as a target for his contribution, we classify this as rewarding and if she chooses the participant opposite to the participant ranked last as punishing. Notice that the first and last rank are opposite to each other, so that locating the contribution at the first rank might be both, punishment and rewarding. We capture this aspect in a third class, *i.e.*, "either punishment or rewarding." All location choices which do not fit any of these criteria are categorized as "other choices." Figure 3 captures the classification of all our treatments.

Punishment and rewarding differs between treatments without location choices (around 30%) and treatments with location choices (around 20%). However, this difference is not significant ($\underline{M}$ *vs.* $\underline{C}$ (MW): p = 0.182 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.061). In both M treatments, the fraction of rewarding location choices is about 5% lower than in the C Treatments. The effect is significant for a comparison of Treatments $\underline{M}$ and $\underline{C}$ ($\underline{M}$ *vs.* $\underline{C}$ (MW): p=0.016 / $\overline{M}$ vs. $\overline{C}$ (MW): p=0.106). The fraction of punishment choices is quite similar for all treatments (around 15%), although significantly higher

Figure 3. Fraction of location "strategies".



(a) Bar chart

	PUN or REW		REW	
	Mean	SD	Mean	SD
$\underline{M}$	23.7%	0.016	13.2%	0.113
$\overline{M}$	19.5%	0.112	19.8%	0.154
$\underline{C}$	31.3%	0.231	20.2%	0.095
$\overline{C}$	28.9%	0.206	22.9%	0.134

	PUN		Other	
	Mean	SD	Mean	SD
$\underline{M}$	16.5%	0.124	46.6%	0.191
$\overline{M}$	18.3%	0.130	42.5%	0.178
$\underline{C}$	14.4%	0.098	34.4%	0.149
$\overline{C}$	13.0%	0.148	35.5%	0.140

(b) Means and SDs

in Treatment $\overline{M}$ than $\overline{C}$ ($\underline{M}$ *vs.* $\underline{C}$ (MW): *p* = 0.351 / $\overline{M}$ *vs.* $\overline{C}$ (MW): *p* = 0.044). Hence, we believe that neither rewarding nor punishment is an important motive behind making location choices.

Result 4 *Contrary to our expectations, location is not used to punish, respectively, reward, past behavior.*

Table 5. Reciprocity and location choices.

Treatment	Pos. or neg.	Pos.	Neg.	No reciprocity
$\underline{M}$	13.3%	29.2%	14.9%	42.5%
$\overline{M}$	16.9%	25.6%	19.9%	37.6%
$\underline{C}$	6.8%	18.9%	17.3%	57.0%
$\overline{C}$	6.7%	19.3%	18.3%	55.7%

Do participants use the mechanism to simply reciprocate the location choice made by others? Let us classify a location choice as positively reciprocal if a participant, after being chosen as a target, chooses the giving participant as a target in the next period. As negatively reciprocal, we classify contributions if a participant invests in the distant location of another participant and the latter reciprocates in the next period by investing in the distant location of the former.

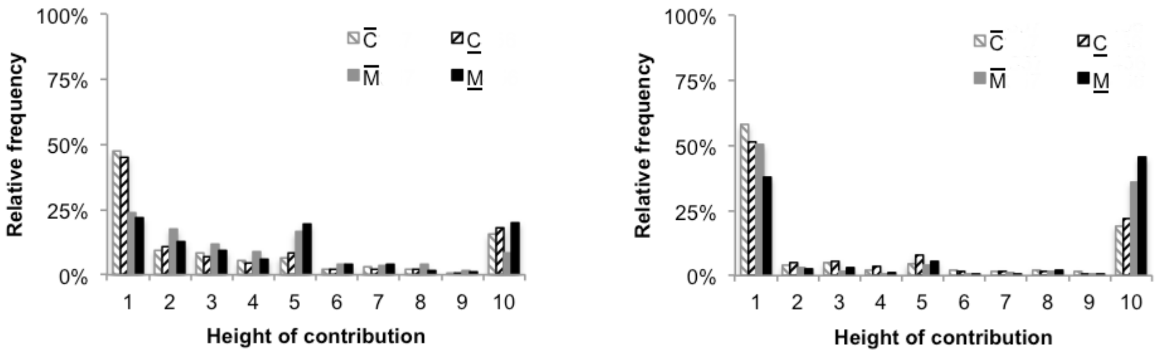
Example: In period 1, let the participant at location 1 locate her contribution at location 2. In period 2, the participant at location 2 can show positive reciprocity by investing in location 1, *i.e.*, the location of the initially giving participant, while the participant at location 4 can show negative reciprocity by investing in location 3, *i.e.*, the location opposite to location 1.

As both definitions, positive and negative reciprocity, do not exclude each other, some contributions might be positively and negatively reciprocal. Table 5 gathers the fraction of corresponding reciprocal acts for all four treatments (again, analyzing non-self-serving location choices only).

Notice that in both C treatments, reciprocity is not possible by intention, as all location choices are chosen from a uniform distribution instead of being specified by the participants. However, reciprocity (according to our definitions of positive and negative reciprocity) might occur even in these treatments. Hence, the comparison of C and M treatments is meaningful: only if reciprocity occurs more frequently in the M treatments than in the C treatments, can it be intended.

In Treatments $\underline{M}$ and $\overline{M}$, 57.5%, respectively, 62.4%, of all contributions not assigned to a self-serving location are positively or negatively reciprocal (compared to around 44% in the random treatments), indicating that it is reciprocity that drives location choices in the Neighborhood Public Good experiment. For both treatments, it triggers positive reciprocity more frequently than in a random location ($\underline{M}$ *vs.* $\underline{C}$ (MW): p = 0.016 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.043). While negative reciprocity occurs less frequently in Treatment $\underline{M}$ than in $\underline{C}$, no such effect occurs in Treatment $\overline{M}$ ($\underline{M}$ *vs.* $\underline{C}$ (MW): p = 0.008 / $\overline{M}$ *vs.* $\overline{C}$ (MW): p = 0.156).

Figure 4. Height of contributions



(a) Contrib. in adjacent/distant locations (b) Contrib. in own location

Result 5 *Participants of the* M *treatments reciprocate the location choice by positively (negatively) reacting to others who locate (distance) their contributions from their position.*

4. Discussion

We believe that in a real world, people implement different mechanisms to punish. Think of a firm, where managers can rely on the punishment mechanism often described in the economic literature (e.g., [7,12]), while ordinary employees cannot. Instead of cutting salaries or imposing fines, they reward and punish others by distributing or not distributing information. This approach typically incurs no cost on the punisher. However, this punishment mechanism involves a targeted effort. In this sense, we have proposed an unusual way of punishment: our subjects could punish others by locating their contributions in a specific way. We consider this approach to be realistic, not only for teams, but also for families or clubs in which an individual has only limited influence on the formation of the group. In our experimental design, by choosing whom to give new information, the participant controls who finally receives the information and at what precision—more distant participants will not get the information, while close ones will.

With our "Neighborhood Public Good Game", we have tried to capture such situations by an admittedly stylized paradigm. We expected some initial difficulties of participants in locating their contributions, e.g., in using this action as a means to sanction or reward specific others, but that they would subsequently try to establish high and only slowly decreasing levels of cooperation and an intensive use of rewarding. Since by rewarding one participant another participant is always punished (and *vice versa*), we did not expect the permanently high levels of cooperation as observed in other experiments with punishment [7] and rewarding [15]. However, the monetary sanctioning schemes in these studies rely on a dramatic inefficiency of sanctions, explaining why our findings are different. Other than in traditional Public Good games, participants in our experiments cannot only free-ride or cooperate; location choices provide them with a happy medium: they can invest in the group project and place their investment in a self-serving location. This is exactly how they use the mechanism. However, one would expect that in the $\overline{M}$ treatment this effect would be more obvious, as the loss between group investments in self-serving locations and keeping the money is smaller than in the $\underline{M}$ treatment. This is not the case, because only in the $\underline{M}$ treatment are contributions significantly higher than in the $\underline{C}$ treatment, indicating that being perceived as too selfish is not accepted by the participants. In addition, rather than using a location for punishment and rewarding, participants simply use the mechanism to reciprocate the location choices made by others. Nevertheless, we find that, initially, cooperation is higher in an experiment allowing for location choices than in an experiment without this option.

Table 6. Fraction of contribution compared to endowment.

	First period	Last period
Partner designs		
Keser and van Winden, 2000 [18]	57%	10%
Fehr and Gächter, 2000 [8]	56%	16%
Punishment		
Fehr and Gächter, 2000 [8]	62%	90%
Egas and Riedl, 2008 [12]	45%	25%-55%
Nikiforakis and Normann, 2008 [13]	43%-65%	4%-85%
Rewarding		
Sefton *et al.*, 2007 [14]	60%	20%
Rand *et al.*, 2009 [15]	75%	85%
Our treatments		
$\underline{M}$	57%	35%
$\overline{M}$	57%	30%
$\underline{C}$	43%	24%
$\overline{C}$	43%	24%

Compared to other mechanisms (see Table 6), allowing for location choices yields the same level of first period contributions as all other designs, namely partner designs and punishment and rewarding. However, the benefit of a mechanism can be observed only in the periods closer to the end of the game, where location choices clearly outperform the partner design with contributions being approximately twice as high in our treatments. Rewarding clearly outperforms location choices—here, cooperation in the terminal period lies above that in the first period.[6] The results concerning punishment are mixed. While the mechanism introduced by [8] clearly outperforms location choices, experiments with higher relative costs for punishment yield results similar to ours (see [12,13]).

As usual, it is widespread conditional cooperation and the existence of free riding that leads to a fast and steady decrease in cooperation. The decrease is faster, the more drastic the payoff effects of location choices are.

[6] The 20% contribution in the terminal period of the experiments conducted by [14] results from a very strong end game effect not visible in any other experiment. Contributions are above 50% in all preceding periods.

Table 7. Distribution of strategies compared to literature.

	Free Rider	Cooperator	Cond. coop.	Others
Fischbacher *et al.*, 2001 [4]	30%	14%	50%	6%
Kurzban and Houser, 2005 [6]	20%	13%	53%	14%
Chaudhuri and Paichayontvijit, 2006 [19]	16%	16%	62%	4%
$\underline{M}$	29%	23%	46%	2%
$\overline{M}$	32%	15%	50%	3%
$\underline{C}$	31%	13%	49%	7%
$\overline{C}$	50%	12%	34%	4%

The strategies observed are similar to existing experiments on repeated Public Good Games using the partner design (see Table 7), both in the types observed and their frequency. Given our expectation that location choices should allow for punishment and rewarding, we would have expected an increase in the number of conditional cooperators compared to these designs. Only Treatment $\overline{C}$ is different: here, free riding (conditional cooperation) is more (less) frequent. This is a further indication that location choices have no positive impact on cooperation.

Punishment and rewarding using location choices cannot help to sustain cooperation. Although participants initially saw the potential of the mechanism, its benefit decreased after a few periods. In our opinion, this result implies that cooperation within groups can either be ensured by punishing uncooperative members by some form of manager. Sustaining cooperation in groups of equal members seems to be difficult to impossible. We have come to a more or less frustrating conclusion: hierarchic structures are one way to guarantee cooperative behavior, at least toward higher levels who are able to punish. On the team level, only positive behavior, namely rewarding, sustains cooperation.

Acknowledgments

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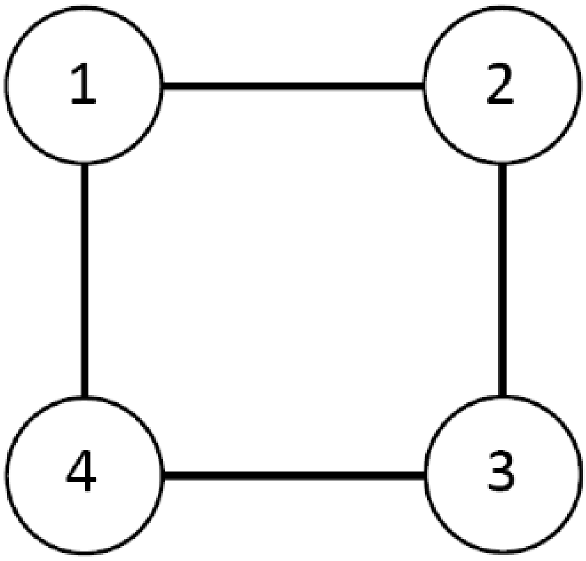
Appendix

A. Instructions

Welcome to this experiment and thank you very much for your participation. You will receive 2.50 euro for showing up in time. During the experiment, you will have the opportunity to earn additional money. Please stay quiet and switch off your mobile phone. Please read these instructions carefully, which are identical for all participants. Communication between the participants is not allowed. If you do not follow these rules, we have to exclude you from the experiment and, consequently, from any payment. To ensure that you understand the instructions, we ask you to answer several control questions before beginning the experiment. If you have any questions, please raise your hand. One of the experimenters will then come to you and answer your question in private. The endowment of 2.50 euro for showing up in time as well as any other amount of money you earn during the experiment will be paid to you in cash at the end of the experiment. We will pay you privately to ensure that no other participant becomes aware of the amount of your payment.

Figure 5. Placement of participants within one group.



Your payment depends on your own decisions as well as the decisions of other participants. The payoff in the experiment is measured in points. The points you earn during the experiment will be converted into euro at the end of the experiment and paid to you. You find the conversion rate at the end of this document. You and all other participants enter their decisions independently of other participants in individual computer terminals.

Course of the Experiment

At the beginning of the experiment, you are randomly assigned to three other participants, forming groups of four. Each member of your group will be randomly positioned in one corner of a square (see Figure 5). The two other participants, who share one line of the square with you, are your direct neighbors, the fourth is your distant neighbor. The participants in one group will not necessarily sit side by side. The composition of the group and the positioning remain unchanged. In the following, "partners" stands for the participants in your group. The participants of other groups are not considered in the remainder of these instructions.

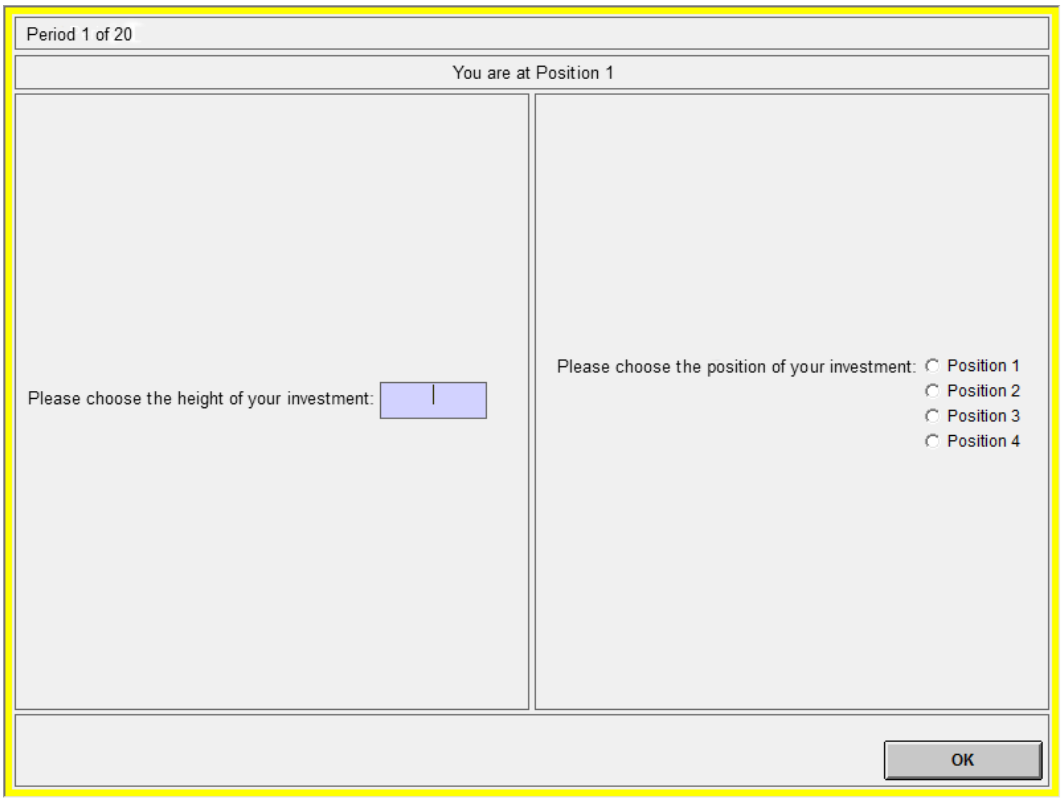
Figure 5 shows the arrangement of participants in one group. For example, the direct neighbors of the participant at position 1 are located at positions 2 and 4. The distant neighbor is located at position 3.

This experiment consists of 20 periods. At the beginning of each period, you will receive 10 tokens. Subsequently, you have to make two decisions:

- on the amount of your investment, i.e., the number of tokens ranging from 1, 2, ..., 9, 10, and
- on where to place your investment, more precisely: in which partner, i.e., at your position, the position of a direct neighbor or a distant neighbor.

While making your decision, you will see the following display on your computer screen (see Figure 6). Your position is visualized in the upper area of the screen. On the left side you decide on the amount of your investment, and on the right side you choose the partner in whom you want to place your investment.

Figure 6. Decision screen.



Your Payoff

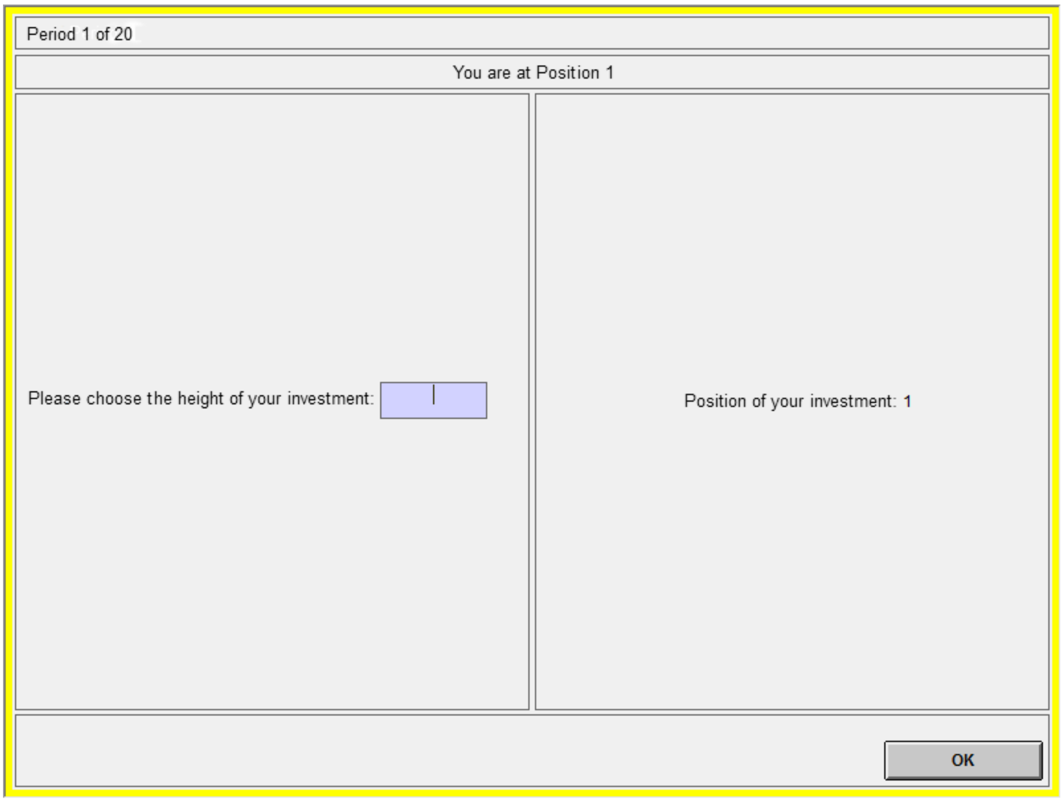
At the end of each period, your payoff is calculated, based on the decisions of all participants. The result of this calculation is shown on the computer screen.

The calculation of your payoff is as follows. For each token you have kept, you receive 10 points. You receive 7 points for every invested token assigned to you; for each token assigned to a direct neighbor you receive 5 points; and for every token assigned to the distant neighbor you receive 3 points. For the final payoff the points are added up over all periods. For 100 points you receive 0.20 euro. Payoff is rounded to the next higher amount divisible by 5 euro cent.

This is repeated twenty times. Hence all groups and the groups' assignment to positions in the square remain identical for all 20 periods. Please remain seated during all periods and only get up when asked.

After these 20 periods the experiment is continued, and you will receive separate instructions.

Figure 7. Decision screen.



A.1. Differences in instructions

1.1.1. Differences between C and M Treatments

During C Treatments, the three paragraphs between "This experiment consists of 20 periods. [..], in whom you want to place your investment." are replaced with the following text:

"This experiment consists of 20 periods. In the beginning of each period, you will receive 10 tokens. Subsequently, you have to make one decision: on the amount of your investment, i.e., the number of tokens ranging from 1, 2, ..., 9, 10.

In addition to the amount of the investment you specified yourself, the placement of your investment, i.e., in which partner, i.e., at your position, the position of a direct neighbor or the distant neighbor, is given by the computer terminal. The assignment is independent of your behavior.

While making your decision, you will see the following display on your computer screen (see Figure 7). Your position is visualized in the upper area of the screen. On the left side you decide on the amount of your investment. Additionally, you see the result of the placement of your investment in a partner made by the computer terminal."

No other changes were made in the instructions.

1.1.2. Differences between $\underline{M}$,$\underline{C}$ and $\overline{M}$,$\overline{C}$ Treatments

For the $\underline{M}$,$\underline{C}$ Treatments in the paragraph "The calculation of your payoff is as follows: [...] Payoff is rounded to the next higher amount divisible by 5 euro cent." the multiplier of tokens was changed to 4, 5, and 6, respectively.

No other changes were made in the instructions.