Abstract

Field behaviour suggests that entire sets of subjects perform less effectively than when subjects are split according to their willingness to contribute to a public good (e.g. climate negotiations which take place every year compared to single sub-negotiations, where only the EU is present). In this paper we design and conduct a laboratory experiment in order to test the hypothesis whether grouping subjects according to their willingness can be beneficial in multiple-period threshold public goods games. The empirical analysis shows that there is no significant effect of the policy proposal on the total contributions. However, only non-willing subjects increase their contributions when they play in subsets. Furthermore, the assignment procedure of subjects into subgroups has not proved to be significant.

♠ We would like to thank Dr. Florian Zimmermann for his extremely useful comments and inspiring discussions in helping to develop the set up of our experimental design. We are further grateful to Dr. Elisabeth Gsottbauer and Dr. Markus Ohndorf for other useful suggestions.

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1 Introduction

Climate change is stated to be the most complicated environmental problem society has ever faced [e.g. Dryzek et al., 2011]. The associated complexity of the problem is due to the large asymmetry between countries in terms of economic development and historical emissions. Moreover, future damages of a warmer planet can not well be predicted since the global carbon cycle, future emissions, or technology improvement are highly uncertain.

Climate negotiations, organised by the United Nations Framework Convention on Climate Change (UNFCCC), have so far not achieved much with respect to tackling climate change, the latest UNFCCC meeting having taken place in Warsaw in November 2013,[1] and "pretty speeches can only bring you so far" [Stiglitz, 2010]. As countries exhibit different levels of willingness to abate global warming, which in turn is part of their position standing,[2] there has recently been progress by opening up new negotiation tables, which involve countries with a more similar standing of abating global warming.[3]

Political commitment, i.e. major greenhouse gas abatement effort, is especially seen for some countries belonging to the European Union (EU) such as Germany and the United Kingdom [Wurzel and Connelly, 2011]. The EU in this regard takes a leadership role [Wurzel and Connelly, 2011]. E.g. Germany is investing massively into renewable energy alternatives.[4] It furthermore adopted an emission target of -40% by the year 2020 (relative to emission levels in 1990), and is the only actor with an *unconditional* target, which the Intergovernmental Panel on Climate Change (IPCC) recommends, i.e. a national emission reduction lying in the interval of 25-40% [IPCC, 2007]. These circumstances suggest that Germany's behaviour is not, at least not entirely, dependent on the behaviour of other countries, indicating it not being a *conditional cooperator* [Fischbacher et. al, 2001], either.[5] The UK, Switzerland, and some other countries participating in the commitment period of the UNFCCC Kyoto Protocol exhibit similar determined behaviour [e.g. KP, 2012].[6]

Leaning on such observations the idea for the following paper is to test effectiveness in realising a critical level of a public good for *willing* and *non-willling* subjects in an economic experiment.[7] The experimental game is very similar to the one used in Milinski et al. [2008] who were the first to present and experimentally test the *collective-risk social dilemma*. In their game investments into the public good (i.e. avoidance of abrupt climate change) are lost, meaning the marginal per capita return on collective investments is set zero. Above that the entire money is at risk if a critical threshold of the sum of the collective investments is not achieved. Economically speaking the probability of losing all money is equivalent to death in the collective-risk social dilemma game caused by a climate catastrophe [Milinski et al., 2008]. Since very few groups in Milinski et al. [2008] achieve the threshold (e.g. only 50% for a probability of 90% under which disastrous climate change happens), the research question is stated as follows: Will the separation of the whole set of agents into willing and non-willing subsets make it more likely to achieve a threshold of a

[1] See $< https://unfccc.int/meetings/warsaw\_nov\_2013/meeting/7649.php >$.

[2] For party groupings refer to $< https://unfccc.int/parties\_and\_observers/parties/negotiating\_groups/items/2714.php >$.

[3] These new, smaller negotiation strands can be imagined as subsets of the annual meetings of all parties (such as the meeting in Warsaw, 2013, representing an entire set (of all Kyoto parties)). See also $< http://unfccc.int/key\_documents/bali\_road\_map/items/6447.php >$.

[4] See $< http://www.businessweek.com/articles/2013-11-14/2014-outlook-germanys-green-energy-switch >$.

[5] *Conditional* pledges, on the other hand, are contingent on the behaviour of others. E.g. the conditional pledge of the EU, thanks to its climate and energy package ($< http://ec.europa.eu/clima/policies/package/index\_en.htm >$), implies a reduction of 30% by 2020 if the US and other developed countries agree on a similar target [UNEP, 2012: 15]. Contrary to this, the *unconditional* target is fixed at -20%.

[6] For possible political reasons of such determined behaviour refer to Christoff and Eckersley [2011].

[7] The adjective "willing" (or "determined") in this regard means whether an individual is willing to achieve the public threshold beforehand.

public goods investment?[8] If subsets prove to perform better than the whole set, this finding would have a big impact on climate-related negotiations for example, meaning that it is worthwhile to establish smaller negotiation tables consisting of like-minded countries only.

The experimental design consists of three stages. The first stage tries to extract the degree of "willingness" of every subject,[9] In the second and third stage subjects play a multiple-period threshold public goods game, where the second stage is played in subsets and the third stage is played by the whole set. The subgroup assignment is according to the individual willingness in the test treatment and is random in the control treatment.

Our empirical findings show that there is no significant effect of the policy, although there is a slight increase in the contribution levels. However, it causes the total contributions of the non-willing subjects only to raise when they play in subsets. The assignment procedure do not matter for the total contributions per subject.

The paper is structured as follows. Section 2 summarizes the related literature w.r.t. the collective-risk social game. Section 3 is devoted to the experimental design. Hypotheses and predictions are presented in section 4. Section 5 reports the results from the empirical analysis. Section 6 summarizes the findings and contains a discussion of weaknesses of the experiment and further research topics.

2 Related Literature

Out experimental design on the climate change game is closely related to the one used in Milinski et al. [2008]. The special feature of their dilemma game is that all investments into the public good (a "climate / group account") are lost. Furthermore, it differs from the commonly used pay-off function in the prisoner's dilemma where the pay-off P_i [10] is stated as $P_i(x_i, x_j) = e_i - x_i + a\sum_{j=1}^{N} x_j$ subject to $a > 0$, where e_i indicates i's initial endowment and a is the refunding factor with $a > 1 > \frac{1}{N}$ (e.g. Sturm and Weimann [2001]). This assumption states that all individuals would be better off if they contributed to the public good (which is not a dominant strategy), and thus the socially better outcome could be realised. Milinski et al. [2008] assume $a = 0$. The risk component in Milinski et al. [2008] is defined such that the value on the private account is at risk if a critical threshold $\bar{X}$ (a tipping point) is not achieved, thus $P_i(x_i, \bar{X})$ Discontinuous and irreversible climate change such as the collapse of the thermohaline circulation and an accelerated melt-down of polar ice caps [Lenton et al., 2008] occurs if the tipping point is exceeded.

Milinski et al. [2008] played the game in groups of 6 people over 10 periods and with initial individual endowments of €40. Every player could contribute €0 (free-riding strategy), 2 (fair strategy), or 4 (altruistic strategy) to the group account. If at round 10 the threshold of €120 $= \bar{X}$ was not achieved (i.e. if everybody played the fair strategy on average), then $P_i = 0$ with a certain probability. The tipping point was assigned with different probabilities varying from 0.1, 0.5, to 0.9, that account for the uncertainty of the occurrence of the environmental disaster. Investments into the climate account happened anonymously, and after each round the strategies of all subjects were communicated. Expected pay-off of an individual

[8] This research question is similar to the question of which incentives could be established to achieve a public goods contribution level, which is closer to the social optimum.

[9] We perform a one-shot linear public goods game for this, contrary to e.g. tests such as social valuation orientation tests from Murphy et al. [2011].

[10] P_i is dependent on i's contribution to the public good $x_i \in [0, e_i]$ and the sum in the group account determined by $\sum_{j=1}^{N} x_j = x_1 + ... + x_i + ... + x_N$

is given as follows (1-2):

$$E(P_i(x_{it})) = \begin{cases} (1-\pi)(40 - \sum_{t=1}^{10} x_{it}) + \pi * 0 & if\ \bar{X} < 120 \\ 40 - \sum_{t=1}^{10} x_{it} & if\ \bar{X} \geq 120 \end{cases} \quad (1)$$

$$s.t.\ x_{it} \in \{0, 2, 4\},\ \pi \in \{0.1, 0.5, 0.9\},\ \bar{X} = \sum_{t=1}^{10} \sum_{j=1}^{6} x_{jt} \quad (2)$$

For $\pi = 0.9$ only 50% of all groups achieved the threshold, whereas for π=0.5 only 10% groups achieved $\bar{X}$, and for π=0.1 none. Milinski et al. [2008] conclude that if individuals are sufficiently informed about the catastrophic probability π and its impacts [11] (i) and if these impacts are sufficiently known (if π is known) (ii) then $\bar{X}$ is more likely to be achieved.

Variations of the Milinski et al.'s [2008] experiment include the analysis of the effect on achieving a sufficient amount in the climate account if not only the probability distribution π is known, but $\bar{X}$ is common knowledge too [Danneberg et al., 2011]. This modification adds very high ambiguity to the climate change game. Dannenberg et al. [2011] find that the uncertainty about $\bar{X}$ has a significant negative effect on preventing a collective damage, whilst unknown probability distributions yield mixed results.[12] Tavoni et al. [2011] analyse heterogeneity and communication with π=0.5 and conclude that inequality in initial individual endowments e_i has negative influence on reaching the threshold. Communication on the other hand yields very desirable results. Burton-Chellew and May' s [2013] model considers both inequality in e_i and different risks of climate vulnerability. They conclude that rich subjects invest less into the avoidance of a climate catastrophe since they are less exposed to abrupt (and even gradual) climate change.

3 Experimental design

The experiment consists of three stages. The first stage aims to give an inside whether a subjects is willing to contribute to a public good. Second and third stages are conceptualized as multiple-period threshold public goods games. The third stage is designed such that the results from Milinski et. al' s experiment [2008] could be replicated and compared to our policy proposal. For this reason, stage 3 is played in the whole set, and stage 2 is played in subsets. Each session was conducted with 6 subjects. In the following, the game set-up is discussed in greater detail.

One-shot game (First stage)

Similar to Gächter and Thöni [2005], we include a one-shot public goods game in order to determine the individual contribution types. The reason behind this stage is to have information on individuals' willingness to contribute to the public good. This information is used in Stage 2 to assign subjects into subgroups. As the game is framed as an environmental problem, it is supposed to credibly uncover true preferences about the subjective willingness to avoid a climate catastrophe. In this stage, each player has the possibility to contribute any positive natural number of his initial endowment of 10 monetary units to the group account. The pay-off consists of subject's amount of the individual account and half of the total amount on the group account.[13]

Second and Third Stage

[11] This remark suggests that provision of information (i.e. "informing people" [Milinski et al., 2011: 2294]) is crucial.

[12] Lenton et al. [2008] however state that tipping points are unknown, implying their probability distributions to be even more unknown. According to Weitzman [2011] tipping points have a great impact if they happen, but occur with very low probability

[13] More detailed information can be found in the instructions in the Appendix.

In the second and third stage subjects play a threshold public goods game over 5 periods. At the beginning each individual is endowed with 20 monetary units on his/her private account. In every period each player makes an allocation decision between the individual and the group account. The individual contributions per period are restricted to 0, 2, or 4 monetary units as in Milinski et el. [2008]. There is a predefined threshold level for the total contributions on the group account that is set to 60 monetary units. The threshold is set such that it will be reached if each subjects contributes 2 monetary units per period. The investments on the group account are lost after the firth period.

The public goods game is framed as an environmental dilemma of irreversible and discontinuous climate change [Lenton et al., 2008]. After the fifth period an abrupt climate change happens with 90% probability if the threshold is not achieved. If the climate change does not occur with the remaining 10% probability or if the threshold is achieved, subjects' pay-off is determined according to the amount on their individual account. The expected pay-off function is thus similar to the one in Milinski et al.'s experiment [2008].

To simplify the payment procedure, we defined a ranking function for the second and third stage. Subjects were ranked according to the amount on their individual account after the fifth period. The highest rank was assigned to the amount of 25 CHF and the payments decrease in 5 CHF steps. All participants received a show-up fee. At the end of the experiment a random stage and subject were chosen for an additional monetary payment.

In the second stage subjects are assigned into one of two subgroups that are build according to subjects' contributions in Stage 1. They are informed about the effort of the 2 other members of their subgroup from the one-shot game. In addition, subjects receive feedback on the contribution only for the members of the subgroup. The underlying argument is that subjects' behaviour should be influenced only by his/her subgroup. Subjects are informed that their subgroup has to reach the threshold together with the other subgroup. In stage 3 all six individuals play the game as one group and receive complete information on other subjects' contributions in each period.

The reason behind the within subjects design is to examine the behaviour of the same individuals over the second and the third stage. Since the willingness is a subjective individual characteristics it is not easily comparable between individuals. By having the same participants in both treatments, we are allowed to isolate the effect of the policy proposal by holding the subjective willingness constant.

One drawback of the within subjects design is that individuals may experience learning effects across the two stages. In order to prevent this undesirable effect, we reverse the order of the second and the third stages in half of the experimental sessions.

The second stage was constructed according to two different treatments. The refer to the test treatment as the C-NC treatment ("Contributor - Non-Contributor"). In this treatment the three players with the highest contributions from the one-shot game are assigned to one subgroup (C-subset), and the remaining subjects constituted the NC-subset. Subjects were not explicitly made aware of the subgroup assignment in order to avoid conditional cooperation. However, they were informed about the contributions of the other members of the subgroup, so they could form a prior expectation of their contribution type.

In order to test the significance of the arrangement of the C-NC treatment we integrated a control treatment, where the subsets are composed randomly. We refer to the this treatment as the "R-R treatment". The experiment consists of four sessions, with one group of six individuals at a time. The following figure summarizes the number of sessions per treatment.
We applied between subjects design in the C-NC and R-R treatments. We seek to avoid possible experimenter demand effects, in case subjects understand the logic behind the subgroup assignment. Thus, our experimental design combines features of both design types.

In total 24 subjects participated in the experiment. All of them are students at ETH Zurich or University

Figure 1: Arrangements

	whole group	whole group
subset: C - NC	1	1
subset: R - R	1	1

of Zurich with different educational backgrounds. The four sessions took place at the University of Zurich in April and May 2014. The experiment was conducted using Google Drive forms.

4 Hypotheses and predictions

Our hypotheses and predictions are given as follows:

H_1: Subjects contribute more when they receive information about a three-person subgroup (C-NC and R-R treatment) rather than an entire six-person group. Hence, the threshold is more likely to be achieved in three-person subgroups.

Free-riding becomes more obvious in the subgroups than when it occurs in a larger group. Players might want to avoid having the reputation of a non-contributor and increase their effort. Furthermore, the uncertainty about the behaviour of the other subgroup might cause subjects to contribute more, in order to assure that the whole group will reach the threshold (assuming risk aversion).

H_2: Subjects are more likely to contribute more and to achieve the threshold in the C-NC treatment than in the six-person treatment.

We assume that the implicit willingness to contribute depends partly on the behaviours of others. So altruistic subjects will have an even higher motivation to contribute when they are in the same group with other high contributors. This effect is supposed to be strong enough to compensate for the low contribution levels of the non-willing subjects.

H_3: Subjects achieve higher contribution levels in the C-NC treatment than in the R-R treatment, so subgroup assignment matters.

We expect similar contribution levels of subjects in the R-R and the six-person treatment, since the subgroups are representative for the whole group of six-people. The beneficial effects of the subgroup building apply only to the C-NC treatment.

5 Results

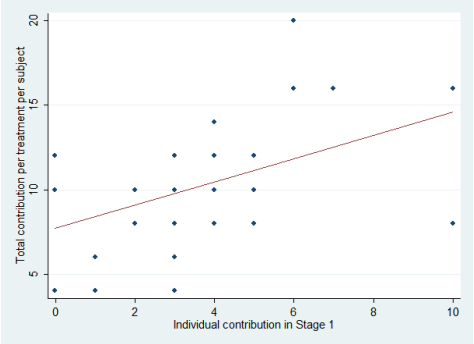
This section is devoted to the results of the empirical analysis. First, we verify the accuracy of the experimental procedure. We then present summary statistics on the outcomes in the control and test treatments and test the main hypothesises. All plots and outputs from the empirical analysis are generated with Stata 11.

Accuracy of the experimental procedure

In the following we test the accuracy of the information from the one-shot public goods game to assess subjects‘ willingness to contribute in the later stages. Afterwards we analyse empirically the importance of the order of the second and third treatments for subjects‘ behaviour.

As already discussed in Section 3, we assign the individuals into the sub-groups of contributors and non-contributors in Stage 2 based on their effort in the first stage. Hence, it is important to verify that the observed contribution level in the one-shot game is a sufficient estimate for individuals‘ subjective willingness to contribute. The results of a linear regression confirm that the contribution in the first stage has a positive and significant effect on the same subject‘s total contribution in the following two stages (p-value < 0.000)[14]. The positive relationship is evident from Figure 2.

Figure 2: Correlation between subjects‘ contributions in the one-shot game and the threshold public goods game



Nevertheless, a more detailed analysis of the contributions in the first stage reveals that there are considerable differences in the contribution pattern across sessions. Figure 3 summarizes the mean contribution level, standard deviation, as well as maximum and minimum value per session.

Figure 3: Summary statistics on contributions in the first stage

	Mean	St. deviation	Min	Max
Session 1	4.33	3.14	1	10
Session 2	3.67	1.97	0	5
Session 3	3.33	2.42	0	7
Session 4	3.17	2.64	0	6

The low amplitude of the contributions may harm the comparability across the C-NC and R-R treatments. For example, an individual that contributed 4 monetary units will be assigned to the contributor‘s group in session 2, whereas another individual with the same contribution will be assigned probably to the non-contributor‘s group in session 1. In order to justify the group assignment, we perform a regression of the group assignment on the contribution in the first period. We use a probit regression, since the dependent variable is binary. The results are summarized in figure 4.

The results show that the contributions in the first stage have a significant effect on the group assignment in the C-NC treatment. On the other hand, the assignment in the R-R treatment cannot be explained with the individual willingness.

In conclusion, we find an evidence that despite some variance between sessions, subjects were correctly assigned into the groups in the second stage, and that the results from the first treatment give precise information on one‘s subjective willingness.

The second aim of this subsection is to analyse the impact of the order of stage 2 and 3 to the final outcome of the stage. The reason is that possible learning effects across treatments will hinder the comparability

[14] The data and the complete Stata code are available upon request.

Figure 4: Verify the group assignment on the basis of the contributions in the first stage

	C-NC	R-R
Coef.	1.09	0.07
Std. Error	0.44	0.12
z-statistics	2.46	0.57
$P > \|z\|$	0.014	0.567
Log-Likelihood	-6.73	-16.47
Obs.	24	24

of the data from different stages. We test the hypothesis that the order of stage 2 and 3 do not matter for the outcomes using a Mann-Whithney rank-sum test, since different subjects participated in each session. Comparing the contribution levels from both stages between sessions 1-2 and 3-4 reveals that the order of the stages does not have a significant effect (p-values for stage 2 and stage 3 are equal to 0.6430 and 0.5936 respectively). Hence, the results from the sessions are comparable.

Whole set vs. subset

In three of the four sessions subjects managed to reach the threshold in both treatments and in one session they reached it in stage 2 only. For the purpose of the paper, it is appropriate to include the achievement of the threshold as a dependent variable in the empirical analysis. However, because of its low variance, we will abstain from that. In the following subsections we analyse the contribution pattern in greater detail.

In the current subsection we test the effect of playing the threshold public goods game in a group of six and three people. In the following, we use only non-parametric tests because of the limited sample size. The dependent variable equals the total contributions per subject for all periods in each treatment. Since the same subjects participated in the second and the third stage, we apply a Wilcoxon sign-rank test. The results are summarized in the Figure 5.

Figure 5: Difference between contribution levels in Stage 2 and 3

	obs	sum ranks	expected
positive	11	164	139.5
negative	7	115	139.5
zero	6	21	21
all	24	300	300
z-statistics	0.718		
$P > \|z\|$	0.4729		

The contributions in the second stage are higher than in the third stage for the same individual. Thus, there is a positive effect of receiving information only about a subset rather than the whole group, which supports our prior conjecture. However, we cannot reject the null-hypothesis that there is no difference in the total contributions per subject across treatments.

One possible explanation for this observation is that subjects had to reach the threshold level as one group. This specification of the experimental design might have caused subjects to believe that it is sufficient if their group contributes half of the total required contributions to reach the threshold. Since the incentive to reach the threshold in both treatments is very high, subjects eventually converge to the same behaviour.

C-NC treatment vs. Six-person treatment

In this subsection we test the key underlying hypothesis of this paper: whether subjects in the C-NC treatment submitted higher contributions than in the six-person treatment. Since the comparison is *within* subjects in different treatments, we use a Wilcoxon sing-rank test. The results are presented in the following figure (6):

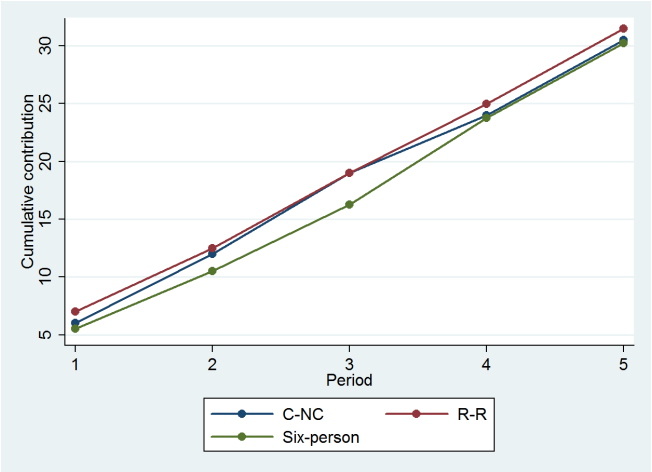
Figure 6: Difference between contribution levels in C-NC and six-person treatments

	obs	sum ranks	expected
positive	7	47	37.5
negative	3	28	37.5
zero	2	3	3
all	12	78	78
z-statistics	0.765		
$P > \|z\|$	0.4443		

The test shows that identical subjects contributed more in the C-NC rather than in six-person treatment, which is in line with the hypothesis. Repeating the test for the R-R treatments does not confirm the pattern. In the random assignment treatment there are an equal number of observations for all categories (positive, negative and zero) and an even lower p-value. Nevertheless, the null-hypothesis of the test cannot be rejected.

In order to understand the underlying contribution pattern, we analyse the dynamics of contribution. Figure 7 depicts the average cumulative contribution for all sessions over the five periods.

Figure 7: Mean cumulative contribution level of all sessions per period



It is evident from the plot that there are no significant differences in the absolute contribution across treatments. However, there are some differences in the dynamics before and after period 3. The shape of the six-person treatment curve is slightly convex. This pattern was observed in Milinski et al. [2008, p. 2293] for the case where the environmental disaster occurs with 90% probability. Thus, this result is replicated in our experiment.

The dynamics in Stage 2 is yet different: the contributions increase linearly in the R-R treatment, whereas the slope of the C-NC curve is the highest until period 3 and the lowest afterwards, so there is a kink at period 3. One possible way to explain this behaviour is that willing subjects lose their incentive

to contribute when they have achieved a high enough level and start free-riding on the other strong contributors in their group. On the other hand, subjects in the R-R treatment are not exposed to these incentives and sustain the same contribution level per period on average.

In order to examine the change in the behaviour of willing and non-willing subjects across treatments, we run again a Wilcoxon sing-rank test. We separate all subjects that participated in the experiment into two groups according to their contributions in the first period. We consider subjects as "willing" if they submitted more or equal to 5, and as "non-willing" if the contribution was less or equal to 4 monetary units (the median contribution in the first treatment is equal to 4). We then test whether there is a difference between subjects' behaviour in the second and third stage. The results are listed in figure 8.

Figure 8: Difference between contribution levels in Stages 2 and 3 of willing and non-willing subjects

	willing			non-willing		
	obs	sum ranks	expected	obs	sum ranks	expected
positive	1	8	24.5	10	91	49.5
negative	6	41	24.5	1	8	49.5
zero	3	6	6	3	6	6
all	10	55	55	14	105	105
z-statistics		-1.723			2.706	
$P > \|z\|$		0.0850			0.0068	

We can reject the null-hypothesis both for the willing and non-willing subset of subjects. The results are quite puzzling: the 10 willing subjects contributed significantly more in the six-person treatment, whereas the 14 non-willing subjects contributed more in Stage 2.

This observation can be explained by the fact that willing subjects might start to free-ride when they are in a contributor group. On the other hand, in their attempt to reach at least 50% of the threshold level, non-willing subjects might increase their individual contribution, when they observe only that other's in their group contribute low. This explanation is yet only valid in the C-NC treatment, and the table above includes results from R-R treatment as well. Therefore, the next subsection is devoted to isolating the effect of C-NC treatment from R-R.

C-NC treatment vs. Six-person treatment

Lastly, we analyse effect of group assignment in Stage 2. We applied between subjects design for this part. The test that we use to distinguish the effect of C-NC and R-R treatment is the Mann-Whithney test. The results are reported in the figure below (fig. 9).

Figure 9: Difference between contribution levels in R-R and C-NC treatments

	obs	rank sum	expected
R-R	12	156.5	150
C-NC	12	143.5	150
combined	24	300	300
z-statistics	0.402		
$P > \|z\|$	0.6879		

It is evident from figure 9 that there is no effect of composing the groups according to their willingness or to build them randomly. Thus, further research is needed to explain the diminishing willingness of the contributors in Stage 2 and increasing contribution is Stage 3 of the non-willing subjects.

6 Discussion and conclusion

It has been observed in the field as well as in the laboratory that a set of players does not perform sufficiently well in achieving a predefined threshold in multiple-period public goods games. The key idea of this paper is that this observation is due to the heterogeneity of the players with respect to their cooperativeness. As a consequence, cooperative individuals might resign in playing fair or altruistic strategies because of the free-riding strategy of non-cooperative players. Splitting the players into groups according to their willingness to contribute and restricting their information only to the performance of their group should reduce the problem.

We designed and conducted a laboratory experiment in order to test this hypothesis. The main results are that there is some positive effect of the policy proposal, but the effect is not significant. The subgroup assignment does not influence the contributions per individual. Only non-willing subjects contributed significantly more in the subgroup-treatments.

Our experiment supports weakly the policy proposal. Because of some limitations of the validity of the experiment, further research in this field is needed. One reason for the unsatisfactory results might be the quality of the data. Since 24 subjects participated in the experiment, the sample size might be too small. Moreover the participants in our experiment are only students. As Cappelen et al. [2011] show, students perform in some aspects significantly different than the representative population. Hence, it is recommended to repeat the experiment with a larger and more representative sample.

There are several specifications of the experimental design that should also be reconsidered. First, the group size of 6 subjects per session might be too small. A larger group will possibly exacerbate the coordination among players and will lead to more variation in the data. Second, in reality the UNFCCC negotiations players are not anonymous players. Finally, contributions to a public good in real circumstances do not happen in discrete amounts, and continuous contributions might yield better results [e.g. Cadsby and Maynes, 1999].

Further research should consider including communication in the subgroup treatment. This modification is assumed to increase the efficiency [e.g. Tavoni et al., 2011]. Moreover, it would be better to depict the current situation in the field (i.e. the negotiations among the players). One further research proposal consistent with the results of our experiment is to include a treatment, where willing subjects receive full information about other players‘ behaviour. On the other hand, non-willing subjects are informed only about the actions of the other non-contributor. Based on our results, such treatment should deliver the highest contributions.

A crucial point for further research is to define the threshold separately for every subgroup. This would be consistent with the introductory story-line. This means to decouple the achievement of the threshold from the other (e.g. non-willing) subgroup. If a subset (e.g. the willing subgroup) managed to successfully achieve a critical level of the public good, in contrast to an entire group, then such a finding would be most interesting. For this, however, one would have to balance out effects of group size, meaning that a smaller subset would have to create more of the public good on average per capita than the whole set. This stands in support to define more than one threshold, or rather a relative and an absolute threshold for every subset.

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Appendix

Attached to the appendix are the instructions.

Instructions

You are now taking part in an economic experiment. It is expected to last about 30 minutes. Thank you for your participation. In order to understand the rules and to increase your chance of achieving a higher payoff from the experiment, it is important that you study the instructions very carefully.

You will need an electronic device with an internet access. Please ask the experimenters to provide you with one, if you do not have any available. During the experiment conversation is not allowed. If you have questions, please raise your hand and one of the experimenters will answer your question personally.

You are not allowed to reveal your identity to the other participants. You will receive an ID number from 1 to 6 on a separate sheet. This ID number will remain the same during the whole experiment. Violation of the rules about communication and anonymity will lead to exclusion from the experiment and all payments.

All participants will receive a Kinder surprise egg as a reward for their participation. At the end of the experiment one randomly chosen participant will receive an additional monetary payment according to his/her performance. We will determine the payment as follows:

- The experiment consists of 3 stages. We will roll a dice to determine the stage that will be paid. If the outcome is 1 or 2, stage 1 is chosen; if the outcome is 3 or 4, stage 2 is chosen; if the outcome is 5 or 6, stage 3 is chosen.
- We will toss the die again to determine the participant that will be paid. The outcome corresponds to the assigned person`s ID number.
- In stage 1 you will be paid out according to your payoff at the end of the game. One monetary unit in the game corresponds to one Swiss franc.
- In stage 2 and 3 you will be ranked according to your performance in each part of the experiment. The person that achieves the highest payoff is ranked as 1, the second highest is ranked as 2, etc. The table summarizes the payoffs in Swiss francs according to the rank:

Rank	1	2	3	4	5	6
Payment	25	20	15	10	5	0

In case of a tie, the minimal amount will be paid. The table below shows the payment when the rank for the 3rd, 4th and 5th position is the same.

Rank	1	2	3	4	5	6
Payment	25	20	5	5	5	0

In the following, the stages of the experiment are explained in detail.

Stage 1

Now you are faced with an environmental problem. All six participants take part simultaneously in this stage. There exist two types of accounts – individual accounts for each participant and one group account. The group account is an investment into avoiding climate change, for example investments into renewable energy to decrease CO_2 emissions. All participants are endowed with 10 monetary units on their individual accounts. The group account is empty. Each participant should decide how to split the endowment between his/her individual account and the group account. All participants submit their bids simultaneously.

Your payoff in this stage is equal to the sum of the amount on your individual account and ½ of all contributions to the group account. This means for each monetary unit, which you contribute, your individual payoff and the payoff of each group member will increase by ½ monetary units. So, the total income of the group rises by 6*½ = 3. Therefore the other group members profit from your payment to the group account, and likewise you profit from their contributions to the group account.

The tables below illustrate a possible allocation and the resulting outcomes of this stage.

ID	Indiv.	Group
1	10	0
2	10	0
3	10	0
4	10	0
5	10	0
6	10	0

⇨

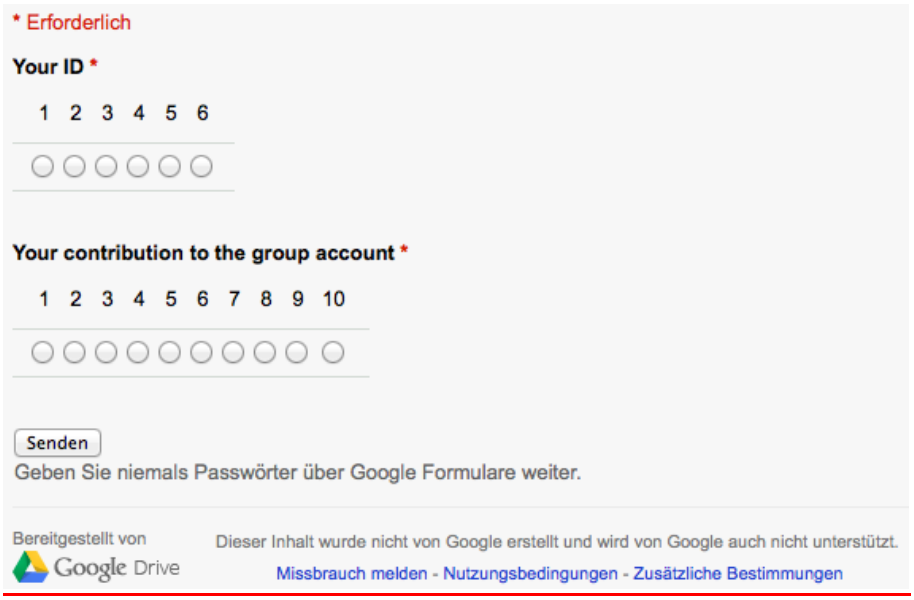
ID	Indiv.	Group
1	0	10
2	3	7
3	5	5
4	10	0
5	8	2
6	4	6

⇨

ID	Payoff	Rank
1	15	6
2	18	5
3	20	3
4	25	1
5	23	2
6	19	4

Your behavior in this stage of the game will affect the arrangement of the next stages. The ranks from this stage will remain secret unless this stage is chosen for payment.

If you have any questions, please ask them now. You can start the experiment by loading the webpage http://tinyurl.com/oocu2gm. Below you see a screenshot:



Please choose the current stage number and your ID from the list and your contribution. Click the button to submit your decision. On the next screen you will see a message that your response has been recorded.

Stage 2

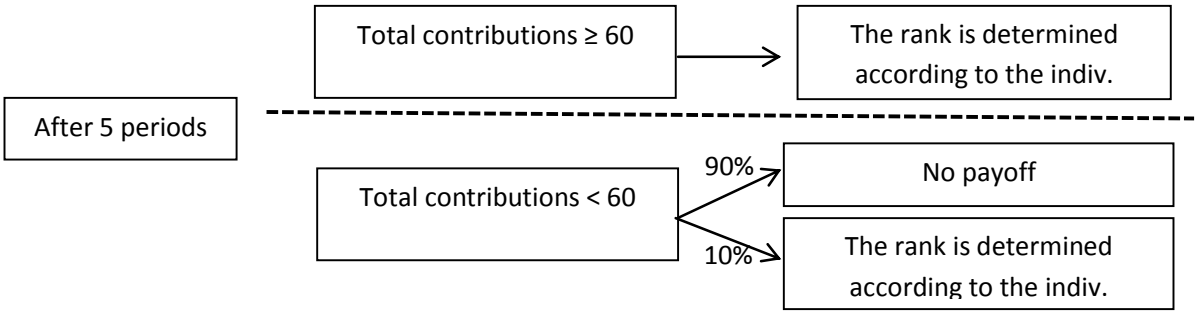
In this stage you will be placed in a group with 2 other participants. The groups are determined according to your performance in the 1st stage. You will receive your group number on a sheet of paper. Please do not reveal your group number to the other participants. You can now see the contributions from stage 1 of your group members on the link, which is on the separate paper.

There are again 2 types of accounts – individual accounts and a group account for all 6 participants. You will play the game for 5 periods. Each participant is endowed with 20 monetary units on the individual account at the beginning of the game. In each period you decide whether you want to donate 0, 2, or 4 monetary units to the group account. Please wait for the experimenter's announcement that the period is over before you submit your contribution for the next period. You will get anonymous information about each individual contribution level of all team members of your team after each period, but you will not be informed about the contributions of the other team. You will learn your payoff and your rank at the end of this stage.

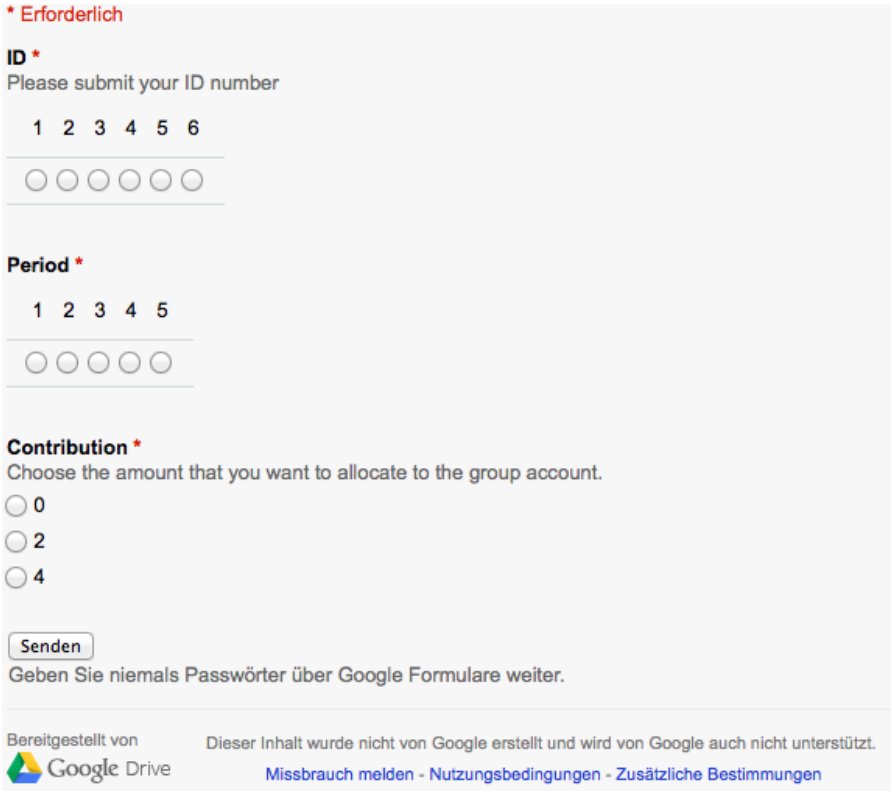
In this stage you are faced with an environmental problem. Your contributions to the group account are investments that are used to prevent a drastic climate change (for example: a collapse of the Gulf Stream or a melt-down of the polar ice caps).

If sum of the contributions from both groups after 5 periods is more or equal than 60, the ecological disaster will not occur. In this case your rank is determined according to the amount on your individual account. The person with the highest amount receives rank 1 and the person with the lowest – rank 6.

If the amount on the group account is less than 60, the climate change will occur with 90% chance. If it occurs, all money on your private account is lost. If the ecological disaster does not occur (10% probability), your payoff is determined as usual according to the amount on your individual account. We will use a random number generator to determine whether climate change occurs. The rules are illustrated schematically below:

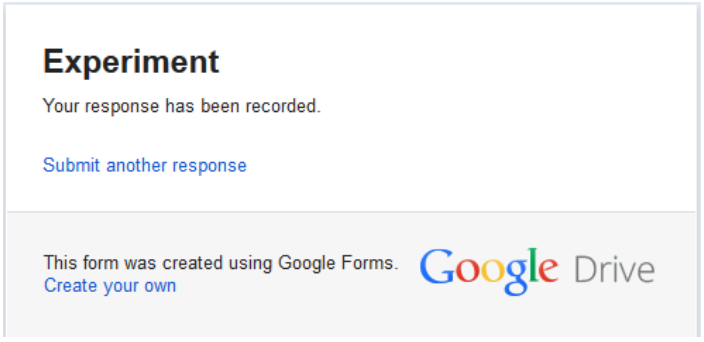


If you have any questions, please ask them now. To start the experiment, please load the webpage http://tinyurl.com/ky2h8tl.



After every period you will be able to view the contributions of your group members by loading a webpage that will be written on a separate sheet.

Please return to the first page by clicking on “Submit another response”.



Stage 3

The rules of this stage are the same as in the previous stage, but the participants are not split into groups any more. You are again faced with a climate change problem. All participants are endowed with 20 monetary units. The game is played for 5 periods. In each period you make a decision whether to place 0, 2, or 4 monetary units into the group account. At the end of the 5th period the sum of the contributions is compared to the threshold level of 60. If it is above or equal to the threshold, the ecological disaster does not occur, so that your rank will be determined according to the amount on your individual account, like in stage 2. If the total contribution is below 60, we will determine whether the climate change occurs or not. The probabilities and the outcomes in each scenario are identical to the ones in stage 2.

You will be informed about the contributions of each participant and about the total contribution verbally after each period.

If you have any questions, please ask them now. To start the experiment, please load the same webpage as in the previous stage (http://tinyurl.com/ky2h8tl). After every period you will see the contributions made in this period on the following website http://tinyurl.com/klpug5d.

Thank you for your participation in the experiment.