Supplementary materials for: Steady Steps versus Sudden Shifts: Cooperation in (A)symmetric Linear and Step-level Social Dilemmas

This document contains the instructions for the participants and the results from a number of exploratory analyses that are not a test of the hypotheses, but that may nonetheless be interesting.

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Instructions for participants

There are six different versions of the instructions for the participants (one for each condition). Instructions that are the same for all conditions are aligned to the left and condition-specific instructions have an indent and a coloured heading with the condition name.

Welcome to this study! Please read the instructions carefully. Communication with other participants is strictly forbidden throughout the study. In this study you are going to play a game in which your decisions have consequences for the amount of money you receive for participating in the study. If you have any questions, please raise your hand. After reading the instructions you will be tested to make sure you understand the rules of the game.

This study involves multiple participants. Each participant is presented with the same series of choices. Your payment this study is dependent on the decisions you make as well as the decisions of the other participants.

You will be assigned into groups of three people. The other two people are playing the game at the same time as you in this room, but you will not be told who the other two people in your group are and they will not know who you are. You will play multiple rounds with the same two people.

For this game, imagine you are running a business and that your company is located next to two other businesses at the shore of a lake. The three businesses are together responsible for the maintenance of the lake.

Symmetric conditions

Your business and the other businesses are each producing 30 units of waste every period.

Asymmetric conditions

One business is producing 20 units of waste, one business is producing 30 units of waste and the third business is producing 40 units of waste every period.

There is a waste disposal service that you can use to get rid of your waste, but this costs money: $1 million per unit. To reduce these costs, you can dump your waste in the lake instead.

Dumping your waste creates costs for the three companies together, because the lake needs to be cleaned at the end of each period to return it to its original state.

Continuous condition

Cleaning the lake costs $2 million per unit of waste and these costs will be equally divided among the three businesses (including you). The more pollution there is, the more everyone has to pay.

Step-level condition

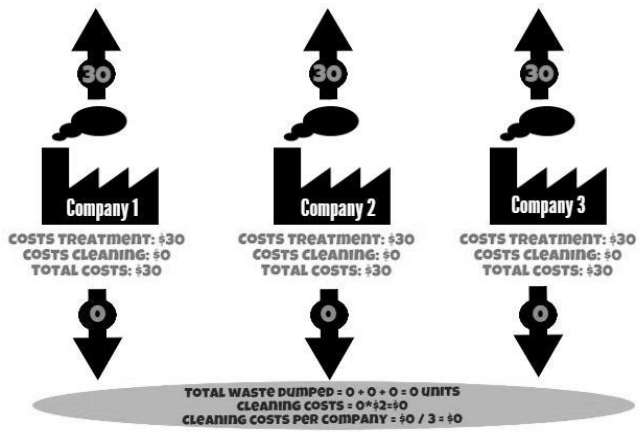
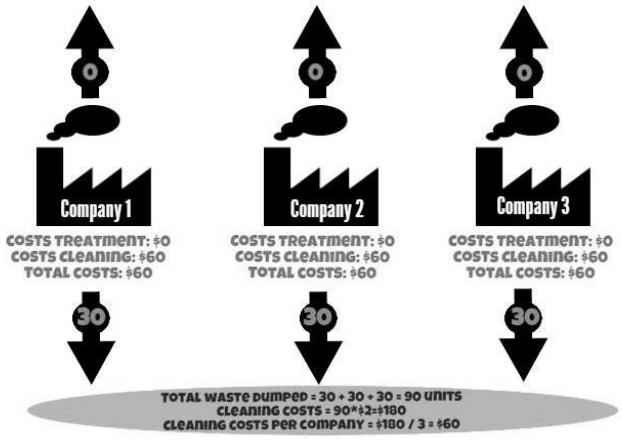
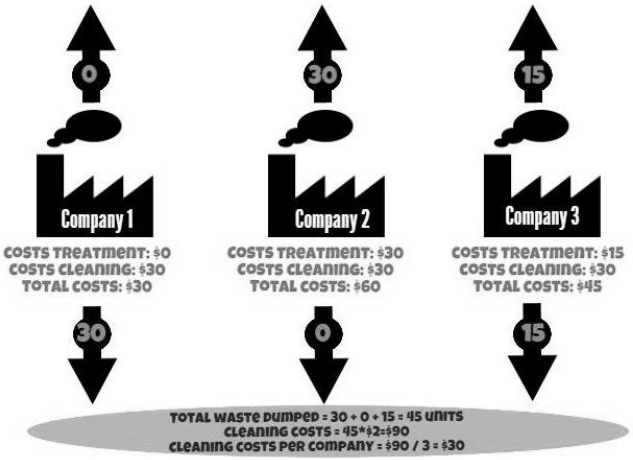
If 44 (treatment: threshold is 43) /46 (treatment: threshold if 45) or more units of waste are dumped in the lake, the lake needs to be cleaned. The costs of cleaning are $180 million and these costs will be equally divided among the three businesses (including you). If 43/45 or less units of waste are dumped cleaning is not needed, so there will be no cleaning costs for the businesses.

During a period you and the other two businesses will be given the choice of how many, if any, units of waste you want to put in the lake. After each period, (1) the lake is cleaned (*Step-level condition:* if needed), and (2) the waste that was not dumped will be picked up by the waste treatment company, at the associated costs.

Your costs per period will equal the money you pay to the waste treatment company ($1 million per unit) plus the costs from cleaning the lake (Linear game: the costs of $2 million per unit are divided over the three companies. Step-level game: if 44/46 or more units of waste are dumped, the cleaning costs of $180 million will be shared by the three companies).

On the next page are three examples of the game with a step-by-step explanation of how the costs are calculated.

Examples continuous symmetric condition

Example 1	**Example 2**	**Example 3**
1. In this example all three companies brought all their waste to the treatment plant, so the total amount of waste dumped in the lake is 0 units. 2. The cleaning costs are 0*$2 = $0, which is $0 per company. 3. Each company pays $1 million per unit of waste that is brought to the treatment plant. 4. The total costs (treatment + cleaning of the lake) are $30 million for each company.	1. In this example all three companies dumped all their waste in the lake, so the total amount of waste dumped in the lake is 90 units. 2. The cleaning costs are 90*$2 million= $180 million, which is $60 million per company. 3. No waste is brought to the treatment plant, so the companies do not have to pay for that. 4. The total costs (treatment + cleaning of the lake) are $60 million for each company	1. In this example company 1 dumped all its waste in the lake, company 2 brought all its waste to the treatment plant and company 3 brought half of its waste to the treatment plant and dumped the other half in the lake. The total amount of waste dumped into the lake is 45 units. 2. The cleaning costs are 45*$2 million= $90 million, which is $30 million per company. 3. Each company pays $1 per unit of waste that is brought to the treatment plant. This means company 1 pays $0, company 2 pays $30 million and 3 pays $15 million to the treatment plant. 4. The total costs (treatment + cleaning of the lake) are $30 million for company 1, $60 million for company 2 and $45 million for company 3.
		

So to calculate your costs for a round you:

1) Decide how much of your waste you are bringing to the treatment plant and how much you are dumping in the lake. These amounts should sum up to the amount of waste you have produced.
2) Sum the amounts of waste that are dumped by your company and the two other companies.

Continuous conditions

3) Multiply this sum by $2 million.

Step-level conditions

3) If the three companies together dumped 43/45 or less units of waste, the costs for cleaning the lake are $0. If the three companies together dumped 44/46 or more units of waste, the costs for cleaning the lake are $180.
4) Divide those costs by 3 (because they are equally shared by the three companies). These are your costs for cleaning the lake.
5) Add $1 million for every unit of waste that you are bringing to the treatment company.

You will repeat this game several times.

Symmetric conditions

You are going to play the game on your computer: in every period you produce 30 units of waste.

Asymmetric conditions

You are going to play the game on your computer: in the first period you either produced 20, 30 or 40 units of waste and that amount will be the same in all periods.

You must fill in the number of units you want to dump in the lake. After all people in your group have made their decision, you will see how many units of waste the other people in your group dumped in the lake, how much waste in total is dumped and how high your costs and the costs of the others are. Then you proceed to the next period.

Each new period will proceed in the same way.

Symmetric conditions

After each period the lake is cleaned and you and the other two businesses will start each new period with 30 units of waste.

Asymmetric conditions

After each period the lake is cleaned and one business starts with 20 units of waste, one business starts with 30 units of waste and the last business starts with 40 units of waste.

At the end of the study your total costs from all periods will be summed up. The height of the payment you receive for participating in this study is determined by the amount of your costs in the study: the higher your costs in the study, the lower your actual pay at the end of the study. For every $50 million increase in costs in the game, you receive $0.10 less for participating in the study, up to the minimum of $8. This means that your payment will be between $8 and $15, depending on the decisions you make.

This is the end of the instructions. If you have any question now, please raise your hand.

We will now ask you some questions to make sure the rules of the game are clear. Please answer these questions on the separate piece of lined paper you received. If you want, you can use the calculator that is open on your computer. Assume you are company 1 in all questions.

Exporatory analyses

First experiment

Linear versus step-level and symmetric versus asymmetric

Table 1a: Percentage of tokens kept (cooperation) and percentage of contributors

Condition	Mean percentage of tokens kept	Mean percentage of contributors	Mean percentage of tokens kept by contributors
Linear Symmetric	11.9 (27.1)	26.2 (44.0)	45.2 (36.1)
Linear Asymmetric	17.6 (33.3)	26.7 (44.3)	66.0 (30.9)
Step-level symmetric	35.1 (29.8)	63.4 (48.2)	55.4 (16.5)
Step-level asymmetric	29.1 (31.9)	51.4 (50.0)	56.7 (20.3)

- A T-test at the group level shows that subjects keep more tokens in the step-level conditions than in the linear conditions ($t(138) = 5.967$, $p < 0.001$).
- The difference is mostly caused by a difference in the percentage of contributors ($t(138) = 6.087$, $p < 0.001$) and not by the number of tokens kept by contributors ($t(128) = 1.294$, $p = 0.198$).

Second experiment

Symmetric versus asymmetric and threshold of 45 (multiple of number of players) versus threshold of 47 (not a multiple of the number of players)

Table 1b: Percentage of tokens kept (cooperation) and percentage of contributors

Condition	Mean percentage of tokens kept	Mean percentage of contributors	Mean percentage of tokens kept by contributors
Symmetric threshold 47	38.3 (25.5)	74.8 (43.4)	51.1 (14.6)
Asymmetric threshold 47	39.5 (25.2)	84.8 (38.6)	48.3 (18.8)
Symmetric threshold 45	36.3 (25.8)	70.2 (45.8)	51.7 (12.1)
Asymmetric threshold 45	37.3 (29.6)	69.5 (46.0)	53.6 (19.5)

- There are no differences in the number of tokens kept between the conditions (Chi-square = 0.806, $p = 0.848$) and small differences between the contributions of contributors (Chi-square = 17.529, $p < 0.001$) and the number of cooperators (Chi-square = 8.205, $p = 0.042$).

First experiment

Table 2a: Mean costs per person per round

Condition	Mean costs per person (SD)
Linear Symmetric	56.4 (8.1)
Linear Asymmetric	54.8 (10.1)
Step-level symmetric	38.9 (25.6)
Step-level asymmetric	49.4 (24.0)

- Reflecting the different defection rates, the costs are higher in the linear conditions than in the step-level conditions (t(138) = 4.968, p , 0.001).

Second experiment

Table 2b: Mean costs per person.

Condition	Mean costs per person (SD)
Symmetric threshold 47	41.9 (26.8)
Asymmetric threshold 47	35.4 (26.8)
Symmetric threshold 45	43.3 (26.5)
Asymmetric threshold 45	46.2 (27.0)

- The costs are lower in the asymmetric threshold 47 condition than in the two threshold 45 conditions (t(124) = 2.800, p = 0.006).

First experiment

Table 4a: Additional analyses step-level conditions

Condition	% groups that stays under threshold	Mean number of tokens with which defection threshold is exceeded	% of groups that exactly meet the threshold
Linear Symmetric	n/a	n/a	n/a
Linear Asymmetric	n/a	n/a	n/a
Symmetric threshold 45	52.7 (49.9)	30.3 (12.1)	44.3 (49.7)
Asymmetric threshold 45	32.5 (46.9)	30.3 (16.9)	10.0 (30.0)

- More groups manage to stay under the threshold in the symmetric condition ($t(74) = 2.167$, $p = 0.033$) and more groups manage to exactly meet the threshold ($t(74) = 4.346$, $p < 0.001$).
- Groups that fail to stay under the threshold exceed that threshold with about the same number of tokens across the conditions ($t(58) = 0.274$, $p = 0.7852$).

Second experiment

Table 4b: Additional analyses step-level conditions

Condition	% groups that stays under threshold (including groups that meet the threshold)	Mean number of tokens with which defection threshold is exceeded (groups that exceed threshold only)	% of groups that exactly meet the threshold
Symmetric threshold 47	49.3 (50.0)	20.5 (14.3)	12.0 (32.6)
Asymmetric threshold 47	61.6 (48.7)	20.3 (17.5)	31.6 (46.5)
Symmetric threshold 45	45.9 (49.9)	24.0 (15.8)	37.0 (48.3)
Asymmetric threshold 45	42.0 (49.4)	21.1 (14.4)	23.4 (42.3)

- More groups manage to stay under the threshold in the asymmetric 47 condition than in the asymmetric 45 condition ($t(80) = 2.567$, $p = 0.012$)
- For groups that fail to do so, the number of tokens with which the threshold is exceeded differs between groups in the symmetric 45 condition and the asymmetric 47 conditions ($t(66) = 2.308$, $p = 0.024$), but not between the other conditions..
- Groups in the symmetric 45 condition are better than groups in the other conditions at exactly meeting the threshold ($t(168) = 2.846$, $p = 0.005$). Groups in the symmetric 47 condition are worst at meeting the threshold ($t(168) = 3.538$, $p < 0.005$).

First experiment

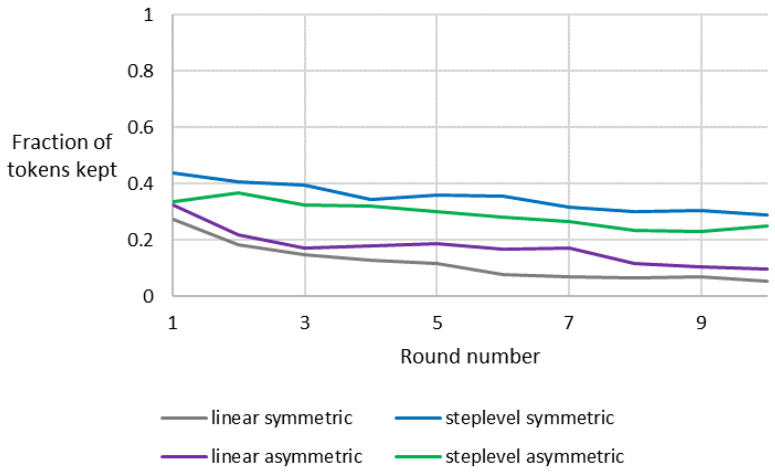


Figure 2a: fraction of tokens kept

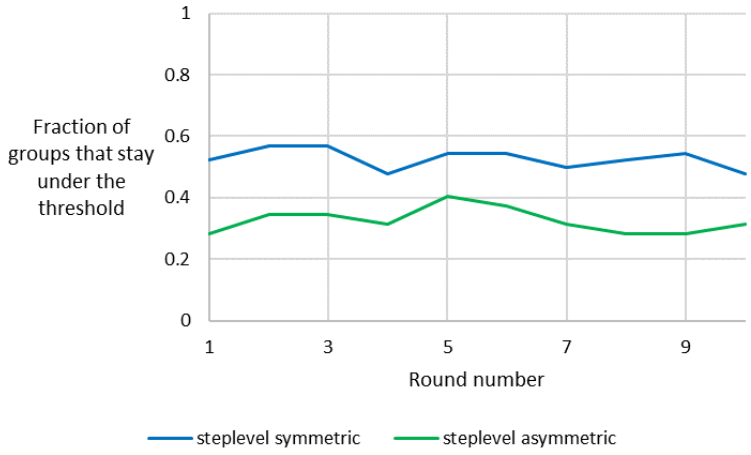


Figure 3a: Fraction of groups staying under the threshold

Second experiment

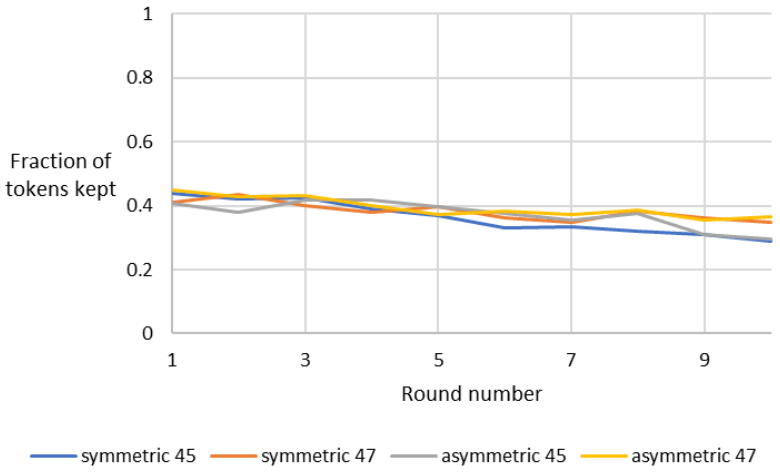


Figure 2b: Fraction of tokens kept

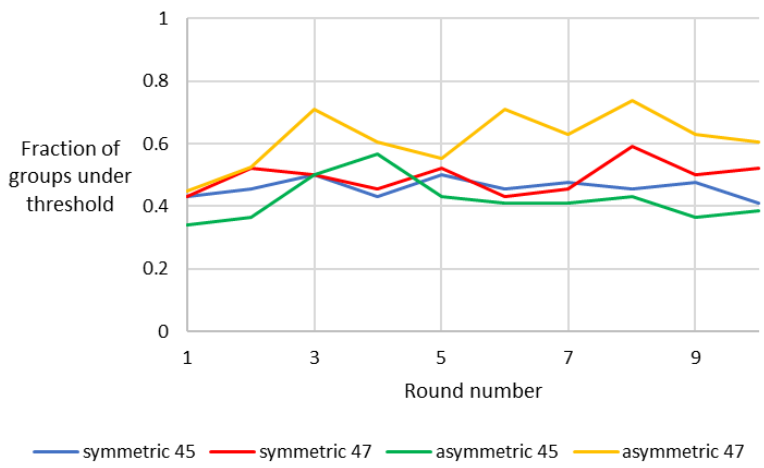


Figure 3b: Fraction of groups staying under the threshold

First experiment

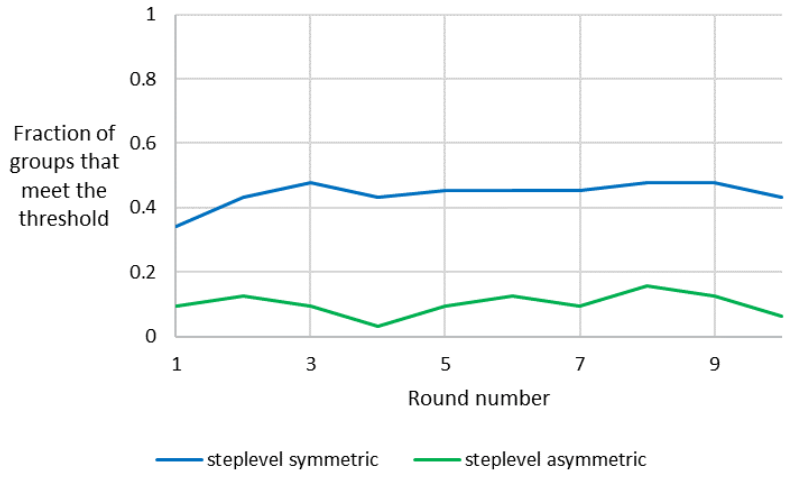


Figure 4a: Fraction of groups meeting the threshold.

- Although the fraction of tokens kept decreases over the rounds, the fraction of groups staying under or meeting the threshold does not seem to change.
- That means that groups are getting more efficient at coordinating their contributions.

Second experiment

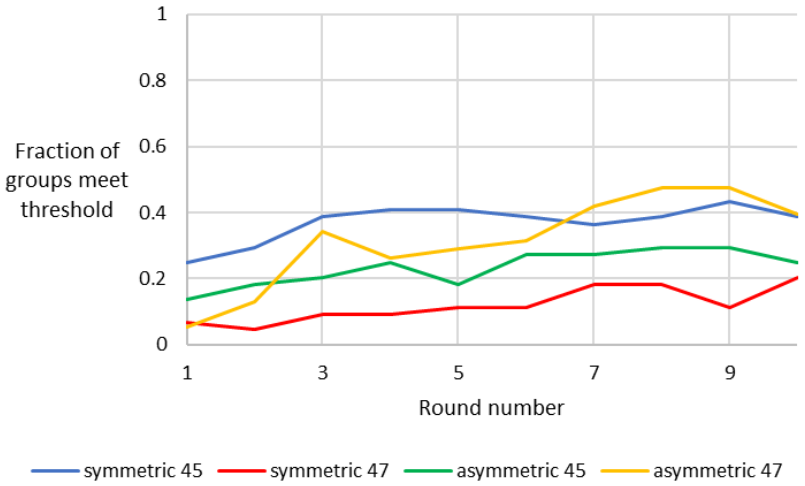


Figure 4b: Fraction of groups meeting the threshold.

- In the second experiment the groups got better at meeting and staying under the threshold, while their contributions increased.
- Like in the first experiment, they are becoming more efficient.

First experiment

Table 5a: Correlation between a subject's previous and current decision

Condition	Block 1	Block 2	Block 3	Block 4
Linear symmetric	0.428	0.570	0.545	0.695
Linear asymmetric	0.177	0.313	0.285	0.248
Steplevel symmetric	0.527	0.372	0.440	0.497
Steplevel asymmetric	0.106	0.193	0.289	0.249

Table 5a: Regression: relation between a subject's previous and current decision (DV = fraction of tokens kept)

Independent variables	All blocks	Block 1	Block 2	Block 3	Block 4
Constant	0.047	0.120	0.016	0.023	0.017
	(0.009)	(0.120)	(0.018)	(0.016)	(0.017)
Main effects					
Step-level (ref = linear)	0.138***	-0.017	0.167***	0.199***	0.206***
	(0.015)	(0.034)	(0.030)	(0.026)	(0.026)
Asymmetric (ref = symmetric)	0.072***	0.067	0.062*	0.026	0.162***
	(0.015)	(0.030)	(0.026)	(0.027)	(0.037)
Fraction of tokens kept in previous round (FpR)	0.509***	0.536***	0.490***	0.471***	0.584***
	(0.034)	(0.077)	(0.062)	(0.056)	(0.060)
Two-way Interactions					
Step-level * Asymmetric	-0.020	0.235***	0.026	-0.159***	-0.345***
	(0.023)	(0.047)	(0.042)	(0.042)	(0.048)
Step-level * FpR	-0.054	0.052	-0.107	-0.035	-0.156*
	(0.043)	(0.099)	(0.081)	(0.072)	(0.073)
Asymmetric * FpR	-0.275***	-0.335**	-0.224**	-0.240*	-0.290*
	(0.047)	(0.099)	(0.080)	(0.083)	(0.115)
Three-way interaction					
Step-level * Asymmetric * FpR	-0.009	-0.139	0.034	0.011	0.029
	(0.061)	(0.132)	(0.109)	(0.107)	(0.138)
N	3735	1080	1080	900	675

The results do not change when controlling for block and period, or when including random intercepts for subjects and groups.

Second experiment

Table 5b: Correlation between a subject's previous and current decision

Condition	Block 1	Block 2	Block 3	Block 4
Symmetric threshold 47	0.514	0.499	0.538	0.561
Asymmetric threshold 47	0.758	0.770	0.736	0.492
Symmetric threshold 45	0.349	0.445	0.557	0.682
Asymmetric threshold 45	0.488	0.520	0.477	0.501

Table 5b: Regression: relation between a subject's previous and current decision (DV = fraction of tokens kept)

Independent variables	All blocks	Block 1	Block 2	Block 3	Block 4
Constant	0.165	0.274	0.180	0.135	0.124
	(0.011)	(0.028)	(0.021)	(0.018)	(0.020)
Main effects					
Threshold = 47 (ref = 45)	0.013	-0.088*	0.008	0.048	0.027
	(0.015)	(0.036)	(0.030)	(0.029)	(0.029)
Asymmetric (ref = symmetric)	0.010	-0.039	-0.004	0.025	0.037
	(0.014)	(0.038)	(0.030)	(0.025)	(0.026)
Fraction of tokens kept in previous round (FpR)	0.533***	0.338***	0.461***	0.548***	0.680***
	(0.024)	(0.056)	(0.049)	(0.044)	(0.044)
Two-way Interactions					
Threshold 47 * Asymmetric	-0.083**	-0.080	-0.105*	-0.067	0.042
	(0.022)	(0.049)	(0.041)	(0.043)	(0.049)
Threshold47 * FpR	-0.007	0.181*	0.024	-0.013	-0.112
	(0.033)	(0.072)	(0.068)	(0.067)	(0.065)
Asymmetric * FpR	-0.020	0.140	0.071	-0.072	-0.184**
	(0.031)	(0.073)	(0.066)	(0.058)	(0.059)
Three-way interaction					
Threshold47 * Asymmetric * FpR	0.217***	0.076	0.217*	0.227***	0.114
	(0.047)	(0.098)	(0.092)	(0.095)	(0.105)
N	4971	1161	1290	1290	1230

The results do not change when controlling for block and period, or when including random intercepts for subjects and groups.

First experiment

- The variable positive relation between the fraction of tokens kept in the previous round (FpR) and the fraction of tokens kept in the current round indicates that subjects who were more likely to keep more tokens in the previous round are also more likely to keep more tokens in the current round.
- The significant and negative interaction between asymmetry and FpR indicates that subjects in both asymmetric conditions showed less consistent behavior than subjects in both symmetric conditions.

- In all conditions the effect of FpR on the fraction of tokens kept is more of less stable across the conditions. An extra regression with the the fraction of tokens kept as the dependent variable and condition variables, FpR and block and all interactions (up to the 4-way interaction) as independent variables confirms that there is no change in the effect over the blocks.

Second experiment

- The variable positive relation between the fraction of tokens kept in the previous round (FpR) and the fraction of tokens kept in the current round indicates that subjects who were more likely to keep more tokens in the previous round are also more likely to keep more tokens in the current round.
- The significant and positive three-way interaction indicates that subjects in the asymmetric game with threshold=47 show more consistent behavior than the subjects in the other three conditions.
- In the symmetric 45 condition, the effect of FpR of the fraction of tokens kept increases over the blocks.
- In the symmetric 47 condition, the effect of FpR on the fraction of tokens kept is in the first block larger than in the symmetric 45 condition, but after that the effect of FpR is similar as in the symmetric 45 condition. That means that overall the increase of the effect of FpR over the blocks is smaller in the symmetric 47 condition than in the symmetric 45 condition.
- In the asymmetric 45 condition, the trends are similar as in the symmetric 45 condition, except that the effect of FpR is smaller in the last block in the former. Overall, the increase of the effect of FpR is thus smaller in the asymmetric 45 condition.
- In the asymmetric 47 condition, the effect of FpR on the fraction of tokens kept is similar to the other condition in the first and the last block, but the relation is stronger in the middle two blocks. The overall difference in consistency between earlier and later decisions between the asymmetric 47 condition and the other condition (model ‘all blocks’ in Table 5b) is thus caused by the middle two blocks.

First experiment

Second experiment

- We ran an extra analysis with the the fraction of tokens kept as the dependent variable and condition variables, FpR and block and all interactions (up to the 4-way interaction) as independent variables to test the trends described above. The increase of the effect of FpR on the fraction of tokens kept is significantly larger in the symmetric 45 and asymmetric 47 conditions than in the other conditions.

First experiment – survey data

- At the end of the first experiment, we asked the subjects a number of demographic questions, as well as question on numeracy, environmental attitude, social value orientation, consideration of future consequences and temporal discounting.
- We ran a regression per condition with the average fraction of tokens kept per subject as the dependent variable. We included the five individual differences items as independent variables. The results of the regressions are in the table below. There are no strong relations between these individual differences and the decisions of the subjects in the experiment.

	Model 1: Linear Symmetric	Model 2: Linear Asymmetric	Model 3: Steplevel Symmetric	Model 4: Steplevel Asymmetric
Numeracy	0.058	0.140	0.048	-0.008
	(0.119)	(0.172)	(0.157)	(0.101)
NEP	0.043	0.010	-0.022	-0.183*
	(0.075)	(0.069)	(0.070)	(0.083)
Future consequences	-0.011	0.031	0.082	0.012
	(0.037)	(0.065)	(0.056)	(0.046)
Temporal discounting	0.015	0.017	0.012	-0.004
	(0.010)	(0.010)	(0.010)	(0.009)
SVO	0.002	-0.004	-0.005	0.000
	(0.003)	(0.003)	(0.003)	(0.003)
Constant	-0.154	-0.147	0.039	0.980*
	(0.263)	(0.417)	(0.313)	(0.352)
Observations	30	27	33	30
R-squared	0.152	0.205	0.273	0.182

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Second experiment – survey data

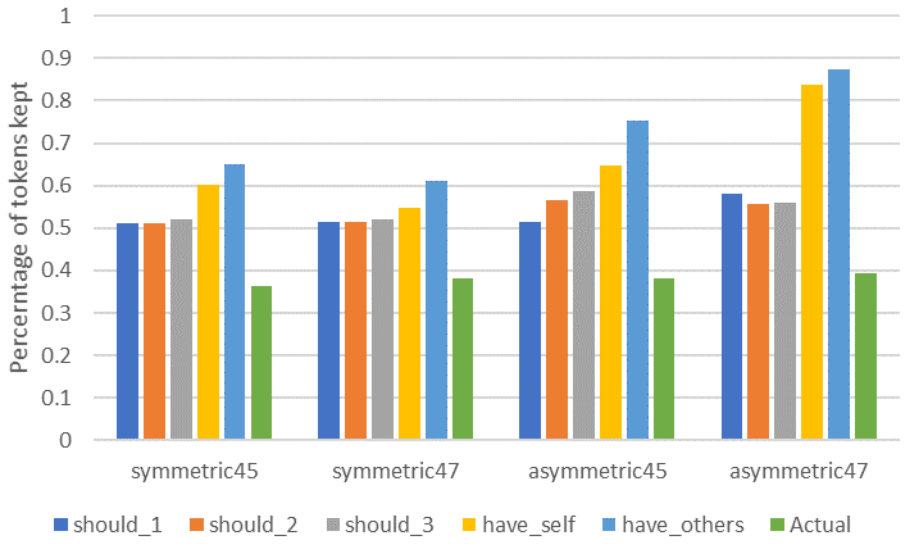
- At the end of the second experiment, we asked the subjects a number of demographic questions, as well as questions about their opinion on and perception of the contributions of the other players.

- The age, gender and status (student or not) of the subjects does not differ across conditions.

- Figure 5 summarizes the answers of the subjects in the different conditions to the following questions.
    - *should_1, should_2 and should_3:* How much waste should each of the three players in your group bring to the treatment plant (at the costs of $1 per unit)?
      In the asymmetric condition: player 1 had an endowment of 20 tokens, player 2 of 30 tokens and player 3 of 40 tokens.
    - *have_self:* How much waste do you think you have on average brought to the treatment plant (at the costs of $1 per unit) in all rounds of the game together?
    - *have_others:* How much waste do you think the other players together have on average brought to the treatment plant per player (at the costs of $1 per unit) in all rounds of the game together?

  We have converted their answers to the fraction of tokens they think players should keep / have kept.

  The bar 'Actual' indicates the actual fraction of tokens kept ('brought to the treatment plant') in the different conditions.



- In all conditions, the subjects indicate that the players should contribute proportional to their endowment.
- In all conditions, the subjects think the others contributed more than they did. The subjects also thought that on average the players kept a larger fraction of tokens than they should.
- The gap between what the subjects think about the average the fraction of tokens kept and the actual fraction of tokens kept is large in all conditions, but especially in the asymmetric conditions. Of course we only asked this question once at the end of the experiment, but this suggests that the subjects largely overestimate the contributions of their group members.