Steady steps versus sudden shifts:

Cooperation in (a)symmetric continuous and step-level social dilemmas

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MSc Thesis

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Supervision: Michel Handgraaf (WUR) and David Hardisty (UBC)

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Abstract

Are groups of people better able to minimize a collective loss if there is a collective target that needs to be reached or if every small contribution helps? This paper explores ways to increase cooperation in social dilemmas: situations in which each individual is best off acting in his or her self-interest regardless of what the other persons do, but in doing so all individuals are worse off than if they had cooperated in the collective interest. In this paper we argue that cooperation in social dilemmas can be increased by framing the problem as a step-level social dilemma rather than a continuous social dilemma and by decreasing asymmetry between individuals. In a lab experiment, 120 participants played 20 to 40 rounds of one of four versions of a "public bads" game. We found that individuals defect less and are better able to minimize their personal costs in a step-level social dilemma than in a continuous social dilemma. Symmetry does not have an effect on defection in the first couple of blocks, but over time asymmetry in endowments between individuals removes the positive effect of the step-level game. These results imply that framing social dilemmas as step-level games and reducing asymmetry can help solving social dilemmas. Furthermore, this study contributes to the body of literature that studies social dilemmas by making a direct comparison of continuous and step-level game and its moderation by asymmetry.

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1. Introduction

Environmental problems often involve a social dilemma: a situation in which the (often short-term) individual and (often long-term) collective interest are in conflict (Van Lange, Joireman, Parks, & Van Dijk, 2013). In these dilemmas, each individual is best off acting in his or her self-interest regardless of what the other persons do, but in doing so all individuals are worse off than if they had cooperated in the collective interest (Sen, Gürhan-Canli, & Morwitz, 2001). A classic example is the Tragedy of the Commons (Hardin, 1968; Lloyd, 1980). In this dilemma individuals share a common resource, for example farmers that use the same pasture to graze their cows. For each farmer it is beneficial to have more cattle, because it means they can produce more milk and more meat. If all farmers act according to their self-interest, they should put as many cows as they can in the field, thereby severely damaging or even destroying the field and making it useless to all farmers. This damage would be shared by all farmers, but the benefits of the extra cows only go to their owner. Self-interest (having more cows) is at odds with the public interest (maximizing production while protecting the field) in this situation.

In social dilemmas, the pro-social behavior (with the lower private benefits, but higher benefits for society) is called *cooperation* or *contribution* and the anti-social behavior (with higher private benefits, but lower benefits for society) is called *defection* or *free-riding.*

1.1 Structures of social dilemmas

Social dilemmas can be divided in two classes: continuous and step-level social dilemmas (Abele, Stasser, & Chartier, 2010). Many efforts that aim to increase pro-social behaviors frame social problems as continuous and symmetric social dilemmas (e.g. Balliet, Li, Macfarlan, & Van Vugt, 2011). In these types of dilemmas, it is assumed that every extra person changing his or her behavior is equally effective in serving the common interest. For example, every extra cow that is added to the field damages the grass a little bit, causing severe damage if many cows are added. However, many social dilemmas have a different structure or can be framed in a different way, for example as step-level social dilemmas (Abele et al., 2010). These step-level problems involve sudden rather than gradual shifts. Once a certain threshold is reached, the burden on the environment is reduced, but if the threshold is not reached, no change happens. An example of a step-level environmental problem is overfishing: if a fish population is depleted below a critical threshold, the population does not have the capacity to reproduce itself anymore and even though not all fish of that population have been caught, the population will eventually be destroyed (Myers, Rosenberg, Mace, Barrowman, & Restrepo, 1994). This is not a gradual shift: before reaching that threshold, intensifying fishing is no real problem, because the fish population is capable of maintaining itself, but after the threshold is reached the fish population is quickly depleted.

Another example of a threshold environmental problem is the shutdown of the themohaline circulation (THC), the ocean currents that have a large impact on the climate of the Earth. This system is very complex, but one important driver of it is cooling of ocean water at high latitudes (Rahmstorf, 2006). Climate change is said to be affecting the THC: if the Earth heats up, the THC can be weakened, causing major changes in the climate on the Earth. This process is not continuous: there is a risk of triggering abrupt or irreversible changes if a certain threshold is reached (Stefan Rahmstorf, 2000).

A successful example of the implementation of step-level structures in real-life social dilemmas are crowd funding platforms like Kickstarter and One Planet Crowd. These platform give companies, projects, NGO’s and other organizations the opportunity to raise money from the crowd. Individuals and organizations that have an idea that requires money to be developed, can post their project on one of those platforms. They set a goal for the amount of money to be reached. Supporters of the project can make a 'pledge': if the goal is reached, the money will be invested in the project. If the goal is not reached, the supporters will get their money back and the project will be terminated, unless other sources of money are found. This is a clear example of a step-level approach to a social dilemma. The dilemma is in this case that many individuals might benefit from the execution of the project, but no one want to take the risk to invest in it. By setting a threshold and clearly communicating what the consequences are if that threshold is reached or not reached, that risk is reduced.

Extensive research on both continuous and step-level social dilemmas has been done, for example on the relationship with social value orientation (Balliet, Parks, & Joireman, 2009) and social identity (Simpson, 2006), the role of uncertainty (Biel & Gärling, 1995), membership fees (Bchir & Willinger, 2013) and the possibility to punish (Cooper & Stockman, 2002). However, we are not aware of any direct empirical comparisons of these two problem types.

Framing environmental problems as step-level rather than continuous social dilemmas may influence the way individuals and groups respond to those problems. Milinski, Sommerfeld, Krambeck, Reed, & Marotzke (2008) found that about half of the groups in their step-level game were successful in reaching a target to avoid a high associated risk. Bornstein (1992) did an experiment with two games that resemble a continuous and a step-level game and he found that cooperation was higher in the step-level-like game. These results indicate that groups may be effective in reaching a collective goal if there is a risk involved with not reaching the goal. However, none of the studies we found directly compares a step-level game with a threshold to a continuous game without a threshold. Abele et al. (2010) describe two important differences between the two types of social dilemmas, but have not empirically tested their hypotheses. The first difference has to do with the individual benefits of defecting. In a Nash-equilibrium, all actors in a problem make the best decision they can, taking into account the decisions of the other actors (Osborne & Rubinstein, 1994). In a Nash equilibrium no actor can benefit by changing his or her strategy while the other actors keep their strategy unchanged. For example, in the cattle example we discussed earlier, adding more cows to the field always yields an individual farmer more income, regardless of the decision of the other farmers.

Continuous social dilemmas have only one Nash equilibrium (Abele et al., 2010): regardless of the choice of the other players, defecting always yields superior outcomes for the self, because cooperation involves costs. Figure 1a shows the individual payoff functions of cooperators and defectors in a continuous social dilemma. The line for defectors always lies above the line of cooperators, so defecting always gives a higher personal benefit than cooperating. In contrast to continuous social dilemmas, step-level social dilemmas have more than one Nash equilibrium (Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010)(Abele et al., 2010): if none of the other actors cooperates, it is beneficial for the rational individual to defect as well, because the threshold will not be reached, no matter what action the individual takes. However, if the threshold is almost reached and the individual's contribution can be critical to reaching it, she should cooperate, because it will increase her private benefits. This is illustrated in figure 1b: the public good only is provided if five individuals or more cooperate. If an individual knows that two other individuals are cooperating, she should defect as well (point A), because cooperation is costly and we're not going to reach the threshold even if she cooperates (point B). However, if she knows that four other individuals are cooperating, she should cooperate as well, because then her cooperation is critical for reaching the threshold. If they reach the threshold her personal payoff is higher (point Q) than when she would defect and the threshold would not be reached (point P).

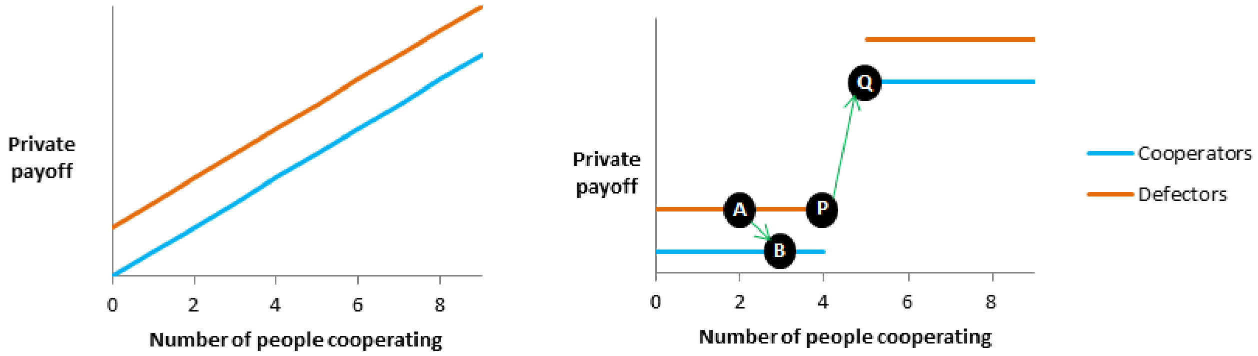


Figure 1: Payoff structures of a continuous versus a step-level social dilemma

The second difference between continuous social dilemmas and step-level social dilemmas has to do with Pareto efficiency. A solution is Pareto efficient if no other solutions exist that improves the outcome of at least one player, without negatively affecting the outcome of any other person. In continuous social dilemmas, the Nash equilibrium in which everyone defects is clearly not Pareto efficient: if everyone would have cooperated, everyone would have had a better outcome. 100% cooperation is a Pareto efficient solution, but this situation is no Nash equilibrium, because defecting is always tempting in continuous social dilemmas. As a consequence, the Pareto efficient solution in which everybody cooperates is unstable (Abele et al., 2010): it is always tempting for individuals to move towards defecting and thus move away from the optimal solution. In step-level social dilemmas self-interest does not necessarily lead to defection. When the threshold is exactly reached there is a Nash equilibrium that is also Pareto efficient. No one can move from cooperating to defecting without harming the others and themselves, because that would mean that the threshold is not reached anymore and both the personal and societal benefits are smaller than if that person would have cooperated.

The third difference is a more intuitive one that only applies to social dilemmas in which cooperation and defection are gradual (someone can e.g. cooperate for 75% and defect for 25%) rather than a dichotomous choice. Different individuals have different perceptions of what an acceptable amount to contribute is (e.g. Buchan, Croson, & Johnson, 2004; Van Dijk & Wilke, 1993). In continuous social dilemmas those individual differences will translate into different cooperation rates by different persons, but step-level social dilemmas have no room for this variety (van Dijk, de Kwaadsteniet, & De Cremer, 2009). The threshold indicates what the right amount to contribute is. If the threshold is 45 and there are three persons in a group, the fair amount to contribute is 15 for every player, so in step-level social dilemmas it is easier for individuals to decide how much they should contribute than in a continuous social dilemmas that lack this reference point. If the threshold is higher than the average cooperation rate in continuous social dilemmas and if individuals try to reach that threshold, cooperation will be higher in step-level social dilemmas (Croson & Marks, 2000; Suleiman & Rapoport, 1992).

Based on these three differences, we hypothesize that there is a main effect of game type on cooperation in social dilemmas:

H1: Individuals cooperate more in step-level social dilemmas than in continuous social dilemmas.

1.2 (A)symmetry between actors

In the context of solving environmental problems it is important to consider that not all actors involved have the same amount of resources, time, power, or ability to combat these problems (Van Lange et al., 2013). Furthermore, not everyone has an equal influence on the environment: some individuals, businesses or countries pollute more than others and not everyone has the same interest in solving them. There have been a few studies that looked at asymmetry between actors in resources in social dilemma games and varying interest in the outcome. Cooperation has been found to be lower with asymmetric endowments in both step-level games and continuous social dilemmas (Rapoport, 1988; Tavoni, Dannenberg, Kallis, & Löschel, 2011).

Van Dijk & Wilke (1993, 1995) distinguish three rules that individuals use to decide how much they will contribute when the amount of resources is not equal between actors.

- Equal contribution rule: all actors contribute the same amount, regardless of their possessions.
- Proportional contribution rule: all actors contribute the same proportion of what they have.
- Minimize differences in final outcomes rule: actors with more resources contribute a larger percentage of their endowments than actors with fewer resources in order to minimize the difference between them.

Individuals use different rules in different situations. In public goods games, where individuals choose to contribute to a public good or not, individuals mostly use the proportional contribution rule. In resource dilemmas, in which individuals choose how much to take from a shared pool, individuals tried to minimize the differences in outcomes between them (Van Dijk & Wilke, 1995; Van Lange et al., 2013). In a step-level public goods game, players consider it to be fair that players with more endowments should contribute more, but in reality this does not happen (Van Dijk & Grodzka, 1992). Because asymmetry between individuals can have an effect on how they act in social dilemmas, the second question in this research focuses on the influence of asymmetry between actors in social dilemmas.

Beliefs about fairness influence individuals' decisions, but only if it is in their own self-interest (Buchan et al., 2004; Tavoni et al., 2011; Wade-Benzoni, Tenbrunsel, & Bazerman, 1996). Based on this finding we expect that individuals will adopt the proportional contribution rule and minimize differences in outcome rules when they have relatively few endowments, because these rules imply that individuals who possess fewer endowments should contribute more than individuals with few endowments. The individuals with more endowments want to avoid contributing more, because it is costly, so they will stick to the equal contribution rule more often. In sum this means that individuals who have fewer endowments contribute less, but individuals who possess more, do not necessarily contribute more, so in total cooperation will be lower when there is asymmetry between individuals. In the cow example this means that not all farmers can afford the same amount of cows. Most farmers will agree that the best solution would be to limit the number of cows in the field. However, the farmers that can only afford a few cows will not limit that amount, because they think it is unfair and because they believe that the rich farmers should limit their amount of cows. Rich farmers might agree on that, but since acting according to those beliefs is not in their self-interest, they will still increase the number of cows. Each farmer puts more cows in the field, because it increases their revenue, but at the same time they know it would be better if none of the farmers increases the number of cows. This leads us to the following hypothesis:

H2: Asymmetry between actors leads to lower cooperation.

1.3 Interaction between game structure and (a)symmetry of actors

We expect the effect of asymmetry to be stronger in continuous social dilemmas than in step-level social dilemmas, because it is not unambiguous if cooperation or defection are in a person's self-interest in the latter, whereas defection is always better for the individual in the continuous dilemma. If a person's contribution is critical for reaching the threshold in the step-level situation, he or she should cooperate to maximize both his or her own benefit and the societal benefit. In this case, cooperating overlaps with self-interest and therefore individuals who possess more endowments in step-level social dilemmas are likely to act according to their fairness beliefs. This means that individuals who have fewer endowments will still contribute less, but individuals who possess more endowments will also increase their cooperation more in step-level social dilemmas than in continuous social dilemmas when there is asymmetry.

H3: Asymmetry decreases cooperation rates more in continuous social dilemmas than in step-level social dilemmas.

1.4 The current research

Social dilemma problems have extensively been studied using decision making games: in experiments that resemble simplified social dilemma situations individuals are asked to make a choice between their self-interest and the group's interest. The main paradigm that is used to study social dilemmas are public goods games (in which players can cooperate by contributing to a public good) and resource dilemma games (in which players cooperate by not taking from a common resource pool; Van Dijk & Wilke, 2000). However, many environmental problems are not public goods games or resource dilemmas, but 'public bads'-games: the more CO_2 is emitted, the worse it is for the climate; the more people litter, the worse for the environment etc. The defecting behavior is here to litter or to emit CO^2 and the cooperative behavior is *not* to perform those harmful behaviors. Because many environmental problems entail public bads rather than public goods or common resources, the current study explores the research questions in a public bads game (e.g. Moxnes & Van der Heijden, 2003; Sonnemans, Schram, & Offerman, 1998).

In particular, we look at behavior in a public bads game that is framed as in an environmental setting. Besides testing our hypotheses by manipulating symmetry and continuous versus step level and measuring cooperation levels and public bad size, we also explanatively study changes in cooperation over the number of repetitions. We want to find out if the effects we find overall are always valid, or only before or after a number of repetitions. We do not only look at cooperation levels and public bad size. A very important indicator of a group's ability to cooperate, is the size of their personal costs or benefits. In a public bads game the goal is to minimize costs. The smaller the costs are, the better groups are in cooperating to keep the public bad small. We also explore the effect of previous decisions of other individuals in the group on an individual's cooperation level and the effect of rearranging groups. Furthermore, we explore what the effects of various demographics and individual differences are on cooperation levels and we have a look at the effect of endowment amount on cooperation levels: do rich individuals cooperate more than poor individuals? We distinguish between the number of individuals that cooperate and the size of their contributions to the public bad. These exploratory analyses will help us understand why the effect we find are occurring and they will spark interesting ideas for future research.

1. Methods

2.1 Participants and design

A laboratory experiment with a 2 (game type: continuous vs. step-level) x 2 (symmetry: symmetric vs. asymmetric actors) between-subjects design was conducted at a large North-American university. 120 individuals (70% female; average age *M* = 24.3, *SD* = 7.8) participated in the study across 16 sessions, each of which lasted for approximately one hour. The participants were recruited via posters in university buildings and messages on Facebook and most of them were students. Participants' compensation for participating in the study was incentive compatible – they received $11.45 on average.

2.2 Materials

The ability for the participants to reach an optimal solution is tested in a 'public bads' game. In this game the participants were asked to imagine that they were the owner of a company that was located at the shore of a lake, along two other businesses. The three businesses are together responsible for the maintenance of the lake. Groups of two to six individuals are commonly used in social dilemma games (Balliet, 2010; Sally, 1995; Zelmer, 2003) and three-person groups are practical while still allowing for group dynamics that characterize real-world problems.

In each period, the businesses produce a certain amount of waste that they can either transport to a waste treatment plan or dump in the lake. Bringing the waste to the treatment involves costs to a person's own business: $1 million per unit of waste. Dumping the waste in the lake is less costly for the responsible business, but more costly for the three businesses together.

The rules of the game were explained to the participants in written instructions (Appendix A). The instructions were phrased in neutral language with no mention of either cooperation and defection or competition. At the end of the instructions the participants were provided with an example of three companies and their decisions and they were asked to calculate the costs for one of these companies to ensure comprehension.

We used the software Z-tree for playing the social dilemma games (Fischbacher, 2007). A screenshot of the participants' interface can be found in appendix B.

2.2.1. Independent variables

The first independent variable is game type: we compare continuous and step-level social dilemmas. In the continuous condition the three businesses together have to pay $2 million per unit of waste that is dumped for cleaning the lake, regardless of who the dumper is. In the step-level condition the companies only pay if 46 units of waste or more are dumped in total. If that threshold is exceeded, each company pays $60 million for cleaning the lake, but if the threshold is not reached, the companies pay nothing for cleaning the lake. A threshold of 50% of total possible cooperation/defection and a multiplier (Marginal Per Capita Return (MPCR) in continuous social dilemmas and Step-return (SR) in step-level dilemmas) of 2 are commonly used in social dilemma experiments (Croson & Marks, 2000). These numbers indicates the benefits a player gets relatively to the contribution he or she has to put in the common pool to get benefits. For example, in a three-person game in which each player possesses 30 units of something, and for each unit that is dumped in a common pool they have to pay $2, the MPCR is 2. In case of a step-level game the players can together dump 90 units maximum. With a threshold of 50%, they will have to pay if 45 units of more are dumped. If the SR is 2, they will have to pay $180 (90*$2) if the threshold of 45 units dumped is exceeded. With these parameters the expected payoff of the continuous game and the step-level game are equal and two pilot studies showed that these values lead to sufficient variance in cooperation rates. The cost structures of the games are illustrated in figure 2.

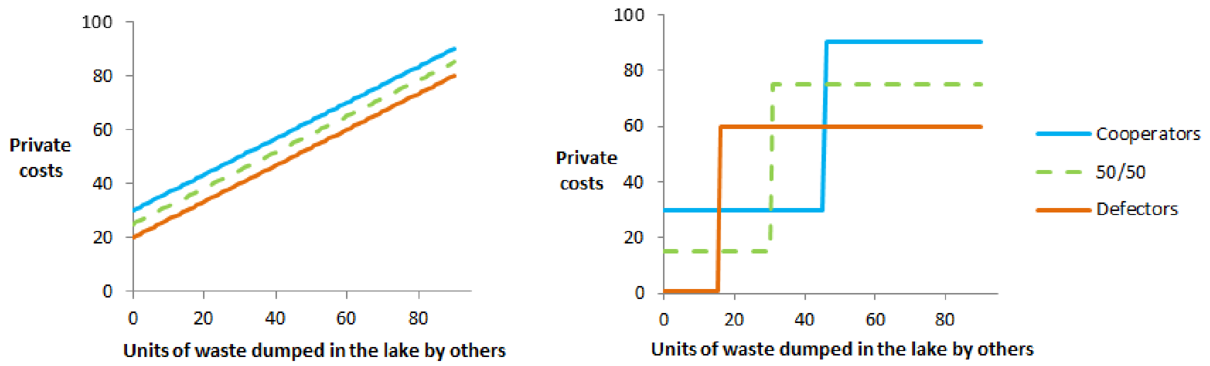


Figure 2: Structures of the continuous and step-level social dilemma game in this study

The second independent variable is endowment (a)symmetry. In the symmetric condition each company produces 30 units of waste per period. In the asymmetric condition one company produces 20 units of waste, one company produces 30 units of waste and one company produces 40 units of waste. A ratio of approximately 2 between the individuals that possess the most and the individual that has the fewest endowments is commonly used (Rapoport & Suleiman, 1993; Van Dijk & Grodzka, 1992; Van Dijk & Wilke, 1995).

2.2.2 Dependent variables

The decisions in the repeated public bads game result in multiple dependent variables that are all related. First we looked at absolute defection: how many units of waste did a participant dump in the lake in a certain round? Second, we analyzed percentage defection: the amount of waste each participant dumped in the lake in a certain round as a percentage of a person's endowments.

The next dependent variable is the size of the personal costs in a certain round. The personal costs are composed of the costs of bringing waste to the treatment plant ($1 per unit) and the costs of cleaning the lake that are shared with the group. This variable is a good indicator of a person's and group's ability to reach the optimal solution: the lower the personal costs are (on average); the better a group is at managing the public bad.

The fourth variable 'cooperators' constitutes part of the previous three variables. This variable looks at the number of individuals that cooperate more than 0, which in this specific game means participants who do not dump everything they have in the lake. Every person that keeps at least one unit of waste for the treatment plan in that specific round is coded as a cooperator (Bchir & Willinger, 2013).

In addition to the number or percentage of cooperators, we also looked at the level of dumping of these cooperators. This is virtually the same variable as percentage defection, but the participants who fully defect are excluded.

The final two dependent variables can only be analyzed in the step-level conditions. We measure whether the groups managed to stay under the threshold or not and whether groups exactly hit the threshold. The first variable, staying under the threshold, indicates whether or not groups defect less than the threshold (absolute group defection is 45 or lower). The latter is a dichotomous variable that describes if a group exactly hits the threshold (which means the absolute defection per group is 45). This is a good indication of a group's ability to manage the public bad, because hitting the threshold requires coordination and entails the optimal solution, because both the treatment and cleaning costs are minimalized.

All independent and dependent variable and their definitions can be found in table 1.

Table 1: Overview of independent and dependent variables

Independent variables	
Game type	Continuous versus step-level social dilemma
Symmetry	Symmetric endowments within a group (each person has 30 units of waste) versus asymmetric endowments (group members have respectively 20, 30 or 40 units of waste).
Endowment level	Amount of waste assigned to a subject (small: 20, medium: 30, large: 40)
Dependent variables	
Absolute defection	Number of units of waste dumped in the lake in a round by a particular subject
Percentage defection	Amount of waste dumped in the lake by a certain player in a round/ endowments of that subject* 100
Absolute defection per group	Sum of absolute defection of a group in a round
Personal costs	Costs of bringing waste to the treatment plant + 1/3 of the group costs of cleaning the lake in a certain round
Cooperators	Participants who bring at least one of their units of waste to the treatment plant in a certain round.
Defection of cooperators	Percentage defection of cooperators in a certain round
Threshold hit	Groups that exactly hit the threshold of 45 in a certain round
Staying under the threshold	Groups that do not exceed the threshold of 45 in a certain round

2.2.3 Demographics and individual differences

After playing the game, the participants answered five demographic questions (gender, age, level and field of education and nationality) and a number of questions on numeracy, environmental attitude, social value orientation, consideration of future consequences and temporal discounting. The whole questionnaire can be found in Appendix C.

Numeracy was tested using a three-item scale (Schwartz, Woloshin, Black, & Welch, 1997). The participants were asked to give the right answer to questions like 'Imagine that we flip a coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?' The number of correct answers is included in the analysis.

Pro-environmental orientation was tested with the revised New Environmental Paradigm scale (Dunlap, Van Liere, Mertig, & Jones, 2000). The participants answered 15 items on a five-point Likert scale from 'strongly disagree' to 'strongly agree'. Examples of items are 'Humans have the right to modify the natural environment to suit their needs' and 'Humans are severely abusing the environment.' The scale had a Cronbach's alpha of 0.77, which indicates that the scale is reliable.

Social Value Orientation was tested with the SVO-slider measure (Murphy, Ackermann, & Handgraaf, 2011). On six items the participants indicated chose their preferred distribution of resources between themselves and another person. For example, they had to choose between ten options ranging from 100 for themselves and 50 for another person to 85 for both of them. From the choices of the participants the SVO angle is calculated. Low scores indicate that subjects are competitive or individualistic, high scores indicate that subjects are prosocial or altruistic.

The participants were asked twelve questions about their consideration of future consequences (Strathman, Gleicher, Boninger, & Edwards, 1994). They answered on a seven-point Likert scale whether or not a statement was a characteristic of them or not. An example statement is 'I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time.' Cronbach's alpha is 0.85, so the scale was reliable.

The last construct that was tested was temporal discounting. The participants were presented 9 choices between a small reward today and a larger reward in the future (Kirby, Petry, & Bickel, 1999). For example, they chose between receiving $25 today and $60 in 14 days. The scores are converted to discount rates: a higher number means a person is relatively impatient.

At the end of the questionnaire the participants were asked to guess the purpose of the experiment. None of them guessed the true hypotheses of the study.

2.3 Procedure

Each one-hour session consisted of 6 or 9 participants. If the number of participants that showed up was not a multiple of three, the remaining participants were assigned to another, unrelated task. Each session was randomly assigned to one of the four conditions.

The participants were seated in a private cubicle with a computer, from where they could not see the other participants. At the start of the experiment the experimenter read instructions out loud that informed the participants about the duration and procedure of the study (Appendix D). The participants were told that communication and the use of mobile phones were not permitted during the study and they were encouraged to read the instructions for the study carefully, because their payment depended on the decisions they were making in the study.

After that, the experimenter turned on the computers and the participants read the instructions for the game from their screen. After reading the instructions, the participants answered two questions to test their comprehension of the game instructions and when they finished they raised their hand. If they gave the correct answer to the question they just waited for the others to finish. If they gave the wrong answer to the question, they were instructed to go back to the instructions and try answering the questions again. If they failed to give the right answer the second time, the experimenter verbally explained the steps they needed to take to calculate the costs. After that, all participants gave the right answer to the questions. The participants were informed that the decisions they were making were private and that for each $50 million increase in costs in the game, their actual payment for the experiment would be reduced by $0.10. This means their payment varied between $8 and $15, depending on the decisions they and the others made.

Before the game started, the experimenter showed an example of the interface of Z-tree on the big screen in front of the room, to make sure all the participants understood what they had to do. Then all the participants were directed to the starting screen of Z-tree. A main server randomly assigned the participants to three-person groups. These group compositions were kept constant during the rounds of one block, but after every block of ten rounds the participants were assigned to a new group. The participants did not know who was in their group.

The participants then played two to four blocks of ten rounds of the public bads game, depending on the amount of time available. In some groups reading the instructions and answering the comprehension questions took longer than in other groups. Because the session time was limited to one hour, not every group played the same number of rounds. Table 2 shows the number of participants per condition in each block. The participants did not know how many blocks they were going to play and of how many rounds one block consisted (although they could guess after the first block that the subsequent blocks would also have 10 rounds). The fourth block is excluded from further analysis, because the number of participants is too low to base conclusions on.

Table 2: Number of subjects in each block per condition

	Block 1 (round 1-10)	Block 2 (round 11-20)	Block 3 (round 21-25)	Block 3 (round 26-30)	Block 4 (round 31-40)
Continuous					
Symmetric	30	30	30	30	21
Asymmetric	27	27	21	12	6
Step-level					
Symmetric	33	33	33	33	33
Asymmetric	30	30	21	21	15

At the beginning of a round, each participant was told how much waste he or she had produced. This number was constant during all rounds within a block. In the asymmetric conditions the three players in one group had a different endowment level. This distribution of endowments was the same throughout the block, but after the block the allocation was done again (randomly). The participants made a decision about how much waste they wanted to dump in the lake and they entered the desired amount in Z-tree. Once all the participants had made their decisions, the main server pooled all the decisions and provided each participant with feedback. The participants saw how much each of the players in their group had dumped and how much the costs were for each of them. In the results screen, they always viewed themselves as ‘You’ and the other players as ‘player 2’ and ‘player 3’. The participants could view the results as long as they wanted and as soon as they were all done with the results, they proceeded to the next round.

After completing the game, the participants proceeded to the questionnaire and if there was still time remaining they continued with some unrelated studies.

2. Results

Unless otherwise stated we use a 2 (Game type: continuous versus step-level) x 2 (Symmetry: symmetric versus asymmetric) mixed model analysis of variance with percentage or absolute defection as dependent variables in which we only included the first three blocks (periods 1-30). Game type and symmetry were entered as fixed factors, and individuals nested in groups were entered as a random factor. If the mixed model analysis yielded a significant interaction effect between game type and symmetry, we ran separate analyses in which we compared the scores of two conditions a time to find out in which conditions the dependent variables differ significantly from each other. With a 2x2 design this gives six analyses: CS and CA; CS and SLA; CS and SLS; CA and SLS; CA and SLA; SLS and SLA (C=continuous, SL=step-level, S=symmetric, A=asymmetric, always noted in the order game type followed by symmetry)

This standard analysis yielded a main effect on percentage defection for game type ($F(1, 3401) = 52.87$, $p < .001$). This main effect indicated that participants in the step-level game defected less than participants in the continuous game, both absolutely and relative to the amount of waste assigned to them. Overall, symmetry has no significant influence on percentage and absolute defection ($F(1, 3401) = 0.63$, $p = .43$) and there is no interaction effect between game type and symmetry ($F(1, 3401) = 1.63$, $p = .20$). The means and standard deviations per condition can be found in table 3.

Table 3: Mean percentage defection (standard deviation in parentheses) in the different game types (continuous versus step-level) and (a)symmetry (symmetric versus asymmetric)

	M (SD)
Continuous	
Symmetric	87.3^{a} (27.9)
Asymmetric	82.8^{a} (32.9)
Step-level	
Symmetric	65.6^{b} (30.7)
Asymmetric	67.0^{b} (32.1)

DV: percentage defection
Note. Means in the same column with different superscript differ significantly (Mixed model analysis, p < .05)

3.1 Defection over time

We ran the standard analysis as described in the first paragraph of this section and we included each of the 30 rounds separately in the analytics. Percentage defection significantly increased over the rounds in all four conditions ($F(1, 3397) = 170.26$, $p < .001$). Figure 3 shows defection per condition over time.

The upward slope of the graphs of both continuous conditions and the step-level symmetric condition are similar, but the increase in defection is significantly stronger in the step-level asymmetric condition than in the continuous symmetric condition ($F(1, 1896) = 6.90$, $p = .05$). The slope of the step-level symmetric condition is not significantly flatter than the slopes of the two continuous conditions.

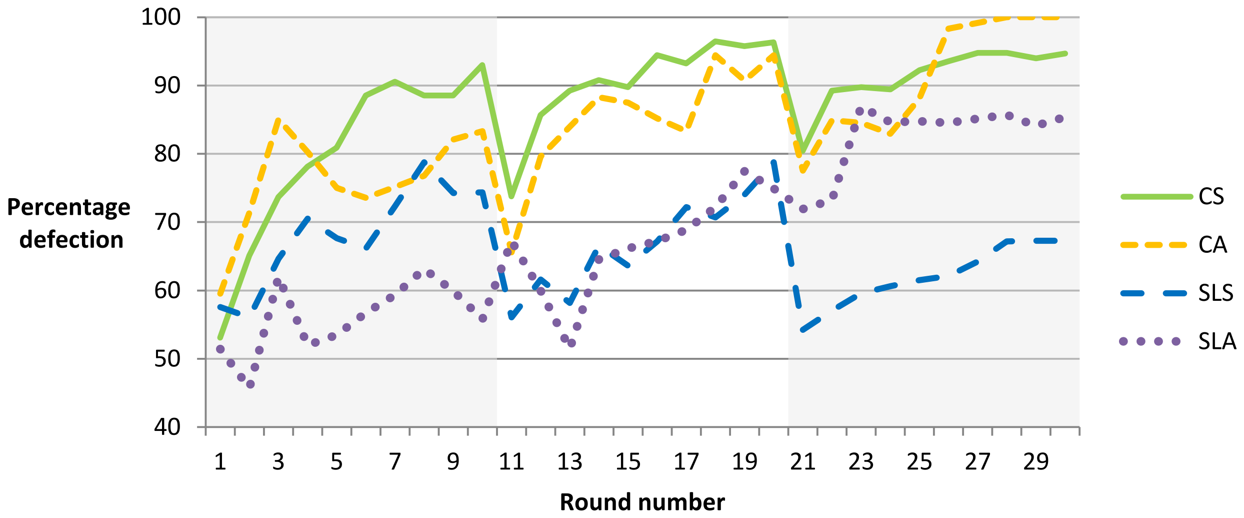


Figure 3: Average percentage defection over the rounds per condition

We repeated the standard analysis for each of the three blocks separately and for the first and the last round of the games. In the first two blocks (round 1 to 10 and round 11 to 20) there is a main effect of game type ($F(1, 2396) = 41.64$, $p < .001$), a marginally significant effect of symmetry ($F(1, 2396) = 3.42$, $p = .07$) and no interaction effect between game type and symmetry ($F(1, 2396) = 0.08$, $p = .78$). Table 4 contains the mean percentage defection and standard deviations per block. Percentage defection is higher in the continuous and symmetric conditions than in the step-level and asymmetric conditions in the first two blocks. In block 3 (round 21 to 30) there is, in addition to the main effect of game type ($F(1, 1001) = 10.52$, $p < .001$), an interaction effect of game type and symmetry ($F(1, 1001) = 7.36$, $p = .01$). Defection is significantly lower in the step-level symmetric condition than in each of the other three conditions in that block (all $p < .01$)

Table 4: Mean percentage defection per condition (standard deviation in parentheses)

	Block 1	Block 2	Block 3
Continuous			
Symmetric	80.0 (32.2)^{a}	90.5 (25.2)^{a}	91.3 (24.2)^{a}
Asymmetric	76.2 (36.2)^{ab}	85.3 (31.0)^{a}	89.4 (28.3)^{a}
Step-level			
Symmetric	68.2 (31.7)^{b}	66.9 (30.6)^{b}	62.1 (29.5)^{b}
Asymmetric	56.0 (32.3)^{c}	67.0 (31.5)^{b}	82.6 (25.6)^{a}

DV: percentage defection
Note. Means in the same column with different superscript differ significantly (Mixed model analysis, $p < .05$)

In the very first round of the game there are no main and interaction effects of game type and symmetry ($F(1, 116) = 0.09$, $p = .76$ and $F(1, 116) < 0.001$, $p = .98$). In the last round (30) there was a main effect of game type ($F(1, 92) = 15.66$, $p < 0.001$) and a main effect of symmetry ($F(1, 92) = 4.86$, $p = .03$). Percentage defection is lower in the step-level symmetric game than in all the other conditions in that round (all $p < .05$).

The means and standard deviations for percentage defection in the first and the last round can be found in table 5.

In the last round, there is no difference in percentage defection between the two continuous conditions ($F(1, 40) = 0.92$, $p = .34$), but defection is significantly lower in the step-level asymmetric condition than in the continuous asymmetric condition ($F(1, 31) = 4.43$, $p = .04$).

Table 5: Mean percentage defection in the first and last round of the game (standard deviation in parentheses)

	Round 1	Round 30
Continuous		
Symmetric	53.1 (38.0)^{a}	94.7^{ac} (19.2)
Asymmetric	59.5 (38.7)^{a}	100.0^{a} (0.0)
Step-level		
Symmetric	57.6 (26.1)^{a}	67.3^{b} (31.3)
Asymmetric	51.4 (29.5)^{a}	85.4^{c} (23.9)

DV: percentage defection

Note. Means in the same column with different superscript differ significantly (Mixed model analysis, $p < .05$)

3.1.1 'New group'-effect

When looking at figure 3 and table 6 with percentage defection in the first and last rounds of the blocks, defection seems to go down at the beginning of each new block. If this is the case, participants behave more prosocially when joining a new group. With a 2x2 standard mixed model analysis in which we included round (last of block or first of block) as a covariate, we tested if this observation is true. Only period 10, 11, 20 and 21 are included in the analysis, which means we were comparing the last period of a block with the first period of the next block. Overall percentage defection decreases when moving to the next block ($F(1, 46) = 24.3$, $p < .001$), but when looking at the conditions separately we find that in the step-level asymmetric condition there is no 'new group'-effect ($F(1, 109) = 0.16$, $p = .70$).

Table 6: Mean percentage defection per condition in the last and first round of a block (standard deviation in parentheses)

	Round 10 (last of block)	Round 11 (first of block)	Round 20 (last of block)	Round 21 (first of block)
Continuous				
Symmetric	93.0 (20.4)	73.8 (38.0)	96.3 (18.2)	80.4 (36.0)
Asymmetric	83.3 (35.2)	65.6 (43.9)	94.4 (21.2)	77.5 (39.8)
Step-level				
Symmetric	74.3 (33.1)	56.1 (30.0)	78.8 (28.0)	54.2 (29.1)
Asymmetric	55.8 (34.9)	67.2 (31.1)	74.9 (27.3)	71.9 (29.3)

DV: percentage defection

2.2 Hitting and staying under the threshold

The participants in the step-level conditions can limit their costs from the public bad by staying under the threshold or by exactly hitting it. By exactly hitting the threshold they can reach the optimal solution: if they together exactly dump 45 units of waste they avoid the cleaning costs, while still benefitting from dumping some of their waste, and thus not paying the treatment costs. We did two separate mixed model analysis with symmetry (symmetric versus asymmetric endowments) as a fixed factor and with respectively hitting the threshold and staying under threshold as dependent variables.

The groups in the symmetric condition managed more often than the groups in the asymmetric conditions to exactly hit the threshold ($F(1, 1798) = 30.37$, $p < .001$). There is no significant difference between the frequency of staying under the threshold between the conditions ($F(1, 598) = 1.46$, $p = .23$). In neither of the step-level conditions the groups got better or worse at staying under ($F(1, 596) = 1.09$, $p = .30$) or hitting ($F(1, 596) = 0.48$, $p = .49$) the threshold over time. The means and standard deviations of hitting and staying under the threshold can be found in table 7.

Table 7: Hitting an exceeding the threshold in the symmetric and asymmetric step-level social dilemma (standard deviation in parentheses)

	Mean percentage hitting the threshold	Mean percentage staying under the threshold
Step-level		
Symmetric	40.9^{a} (49.2)	59.7^{c} (50.1)
Asymmetric	10.4^{b} (30.5)	37.0^{c} (48.4)

Note. Means in the same column with different superscript differ significantly (Mixed model analysis, $p < .05$)

3.3 Influence of previous round

The participants within one group are not independent of each other: they respond to each other's decisions and they may try to influence each other. To capture some of the group dynamics we have had a look at the influence of defection of a subject's group members in the previous round on a person's defection in the current round. We did the standard mixed model analysis with the sum of the units of waste dumped by the other group members in the previous round as a covariate. We find a positive effect of defection in the previous round on defection in the current round($F(1, 3277) = 129.80$, $p < .001$): the more defection there was in the previous round, the more individuals will defect in the next round and the bigger the chance that they will exceed the threshold. When looking at the effect of whether or not a group exceeded the threshold in the previous period we find an interesting interaction effect. If the threshold has not been exceeded in the previous round, the chances that a group will exceed it in the current round is higher in the asymmetric condition than in the symmetric condition ($F(1, 575) = 8.72$, $p = .02$). This interaction is visualized in figure 4.

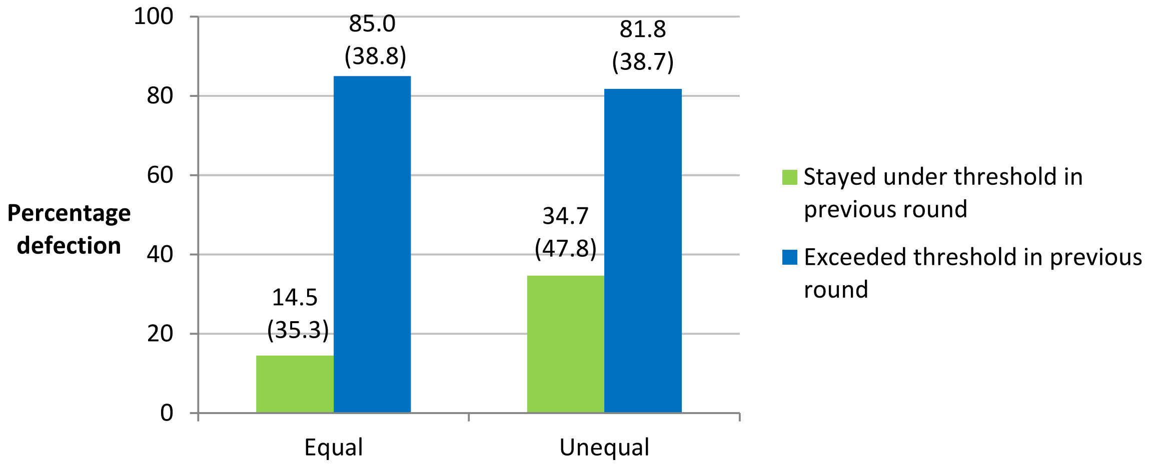


Figure 4: Influence of staying under/exceeding the threshold in the previous round on percentage defection in the symmetric and asymmetric step-level condition (standard deviation in parentheses)

3.4 Personal costs

Another measure of ability of groups of reaching the optimal solution in the different social dilemmas is the size of the costs per person in a specific round, which is the sum of the costs caused by defection paid by the group and the individual costs of cooperating. The lower the personal costs are, the better participants are in balancing their private and the group interest. Figure 5 shows the average costs per round for the different conditions. We did the standard analysis as described in the introduction of the results section, but now we used personal costs instead of percentage defection as the dependent variable.

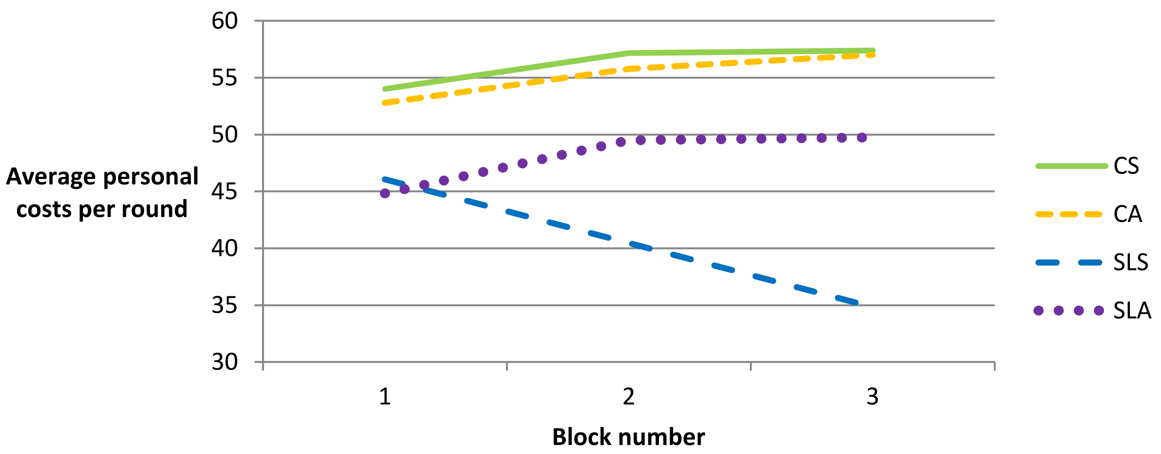


Figure 5: Average personal costs per block per condition

The costs are significantly higher in the continuous conditions than in the step-level conditions ($F(1, 3401) = 48.52$, $p < .001$). The influence of symmetry on costs is a trend ($F(1, 3401) = 3.32$, $p = .07$), and there is a significant interaction between game type and symmetry ($F(1, 3401) = 7.37$, $p = .01$). There is no significant difference between both continuous conditions ($F(1, 1603) = 1.92$. $p = .17$), but in block 2 and 3 the personal costs are higher in the step-level asymmetric condition than in the step-level symmetric condition ($F(1, 1798) = 6.22$, $p = .01$).

To further analyze the effects over time, we included the 30 rounds separately in the analysis. The personal costs increase over time in the continuous conditions (F(1, 1601) = 84.89, *p* < .001), but in the step-level conditions the change in personal costs is not significant, because there is a lot of variance in those conditions (*F*(1, 1796) = 1.57, p= .21).

3.5 Number of cooperators and contributions of cooperators

To better understand what is happening in the different conditions, we have had a look at the number of cooperators and at amount of waste dumped by them (see table 8). The lower defection rates in the step-level and symmetric conditions can be explained by a) the number of cooperators and/or b) the percentage defection of cooperators. Cooperators are defined as players who kept at least one of their units of waste. We did two versions of the standard analysis with respectively the number of cooperators and their percentage defection as dependent variables. We find that there are more cooperators in the step-level game than in the continuous game (*F*(1, 3401) = 70.31, *p* < .001), but percentage defection of those cooperators is not lower than in the continuous conditions (*F*(1, 1493) = 0.82, *p* = .37). Asymmetry does not have an effect on the number of cooperators (*F*(1, 3401) = 0.01, *p* = .94), but it does decrease percentage defection of cooperators in the continuous condition (*F*(1, 420) = 6.05, *p* = .01).

Table 8: Mean percentage and mean size of contributions by cooperators per condition (standard deviation in parentheses)

	Mean percentage of co-operators	Mean percentage defection by co-operators
Continuous		
Symmetric	26.2 (44.0)[a]	51.5 (35.1)[a]
Asymmetric	23.4 (44.1)[a]	34.7 (31.2)[b]
Step-level		
Symmetric	61.0 (48.8)[b]	43.9 (17.7)[b]
Asymmetric	58.2 (49.4)[b]	43.2 (20.6)[b]

Note. Means in the same column with different superscript differ significantly (Mixed model analysis, *p* < .05)

3.6 Endowment level

In the asymmetric conditions players within each group have different endowment levels (amounts of waste). To understand what is happening in the asymmetric conditions and to find out which participants are responsible for the higher defection rates than in the asymmetric condition, we did two 2 (Game type: continuous versus step-level) x 3 (Endowment amount: few, medium and many) mixed model analysis with absolute and percentage defection as dependent variables and individuals nested in groups as a random factor. The mean values and standard deviations can be found in table 9. We only included subjects that are assigned to the asymmetric condition in the analysis. Absolute defection is higher for participants with many endowments (*F*(1, 1511) = 113.66, *p* < .001), but having fewer or more endowments does not have an effect on percentage defection (as a percentage of endowments; *F*(1, 1511) = 0.07, *p* = .91) and there is no interaction effect with game type (F(1, 1511) = 0.01, p = .79). We calculated the amount of waste that was dumped by an individual as a percentage of the total amount of waste dumped by a group. After that we tested whether that percentage was similar to the percentage you would expect based on the proportional contribution rule (22% for individuals who produce little waste, 33% for individuals who are assigned a medium amount of waste and 44% for individuals that have a lot of waste. Table 9 and a t-test reveal that the values do not significantly differ from the expected values (t(504), all $p > .05$) of 22%, 33% and 44%, but they do significantly differ from the percentages you would expect based on the equal contributions rule and the minimize differences in outcome rule (t(504), all $p < 0.01$)

Table 9: Mean absolute and percentage defection and defection as a percentage of a group's absolute defection per game type and endowment level in the asymmetric conditions (standard deviation in parentheses)

	Mean absolute defection in units of waste	Mean percentage defection	Mean defection as a percentage of a group's absolute defection	N
Continuous				
Few endowments	16.4^{a} (6.7)	82.0^{a} (33.5)	22.7 (13.3)	9
Medium endowment	24.5^{b} (10.7)	81.6^{a} (35.7)	32.6 (17.4)	9
Many endowments	33.9^{c} (11.8)	84.7^{a} (29.4)	44.7 (17.0)	9
Step-level				
Few endowments	13.9^{a} (6.5)	69.6^{a} (32.5)	24.6 (14.1)	10
Medium endowment	19.8^{b} (9.4)	66.0^{a} (31.2)	33.3 (14.7)	10
Many endowments	26.1^{c} (13.0)	65.4^{a} (32.6)	42.1 (15.6)	10

Note. Means within the same game type condition with different superscript differ significantly (Mixed model analysis, $p < .05$)

3.7 Individual differences

The mean scores on the individual differences scales can be found in table 10. Fourteen participants entered an age that was lower than 18 years; these age data are excluded from the analysis that included age. Due to a lack of time, not all participants finished the survey.

The scores of NEP and consideration of future consequences differ significantly between the different conditions (table 11). The NEP scores are significantly higher in the step-level asymmetric conditions than in the other conditions ($F(1, 116) = 4.38$, $p = .04$).

The consideration of future consequences scores are significantly lower in the continuous symmetric condition than in the other three conditions ($F(1, 111) = 4.05$, $p = .05$). When including those individual characteristics in the analysis we would assume that the scores are similar across the different conditions. Since that is not the case, we cannot include NEP and consideration of future consequences as covariates in the analysis.

Table 10: Descriptives demographics and individual differences scores

	Mean SD)	Minimum	Maximum	N
Age	24.3 (7.8)	18	60	106
Numeracy[a]	2.5 (.8)	0	3	120
SVO[b]	25.6 (12.8)	-9.5	47.6	114
ConsFuture[c]	4.6 (.8)	3.3	7	115
Temporal discounting[d]	.002 (.054)	.000	.25	114
NEP[e]	3.67 (.5)	2.4	4.93	120

[a] Number of items answered correctly (maximum possible=3)
[b] SVO-angle
[c] 7-point Likert scale
[d] Discount factor: hyperbolic discount parameter at indifference between two rewards
[e] 5-point Likert scale

Table 11: Mean NEP and Consideration of Future Consequences scores per condition (standard deviations in parentheses)

	Mean NEP-score	Mean consideration of future consequences score
Continuous		
Symmetry	3.6[a] (0.5)	4.8[a] (1.0)
Asymmetry	4.9[a] (0.5)	4.3[b] (0.5)
Step-level		
Symmetry	3.6[a] (0.5)	4.6[a] (0.7)
Asymmetry	3.9[b] (0.4)	4.8[a] (0.8)

Note. Means within the same game type condition with different superscript differ significantly (Mixed model analysis, $p < .05$)

Gender, SVO, temporal discounting, numeracy and age do not differ across the different conditions *($p > .05$).* First we did five mixed model analyses with each time one of the covariates as a predictor and percentage defection as a dependent variable. None of the covariates has a significant effect on percentage defection (all $p > .10$). After that, we repeated the standard analysis as described in the introductory paragraph of the results five times. In each version we included one of the five individual differences in the model as a fixed factor, and we examined both the main effect and the interactions with game type and symmetry. The first four covariates have neither a direct nor a moderating effect on percentage defection (all $p > .05$), but adding age to the analysis removes the effect of game type ($F(1, 2977) = 0.26$, $p = .61$). Age on its own does not have an effect on percentage defection ($F(1, 2983) = 0.65$, $p = .42$).

3. Discussion and conclusions

In line with our hypothesis and the expectations of Abele et al. (2010), individuals and groups defect more in a continuous social dilemma than in a step-level social dilemma, which means our first hypothesis was confirmed. In the introduction we listed three potential reasons for defection to be lower in the step-level game: individuals have a target, and are therefore less dependent on personal ideas about fairness; contributing can be in a person's self-interest in the step-level dilemma if his or her contribution is critical for reaching the threshold, and the optimal solution is a Nash equilibrium in the step-level game, but not in the continuous game. We expect that the most important driver of the effect is that individuals can personally benefit from cooperation in the step-level game, since the key problem in social dilemmas is that individuals are driven by self-interest. We expect that having a clear target might be effective in increasing cooperation in a one-shot social dilemma game, but over time some individuals will move to defection anyway, because it is still in their own interest. The fact that the optimal strategy leads to a stable solution in step-level social dilemmas is important, but this reason is builds upon the fact that cooperation can yield a higher personal payoff in step-level social dilemmas. Without the latter, there would be no optimal, stable solution, so we hypothesize that the having personal benefits from cooperating is the most important driver in increasing cooperation in the step-level game. However, we did not ask the participants about their contribution motivations (or otherwise measure motivation), so we are not able to identify which of the three reasons mentioned above was dominant.

The problem at the core of social dilemmas is that defection is the dominant strategy, because it always yields a higher personal payoff than cooperating. By aligning personal interests with societal interests, you can get around this problem. An example of this theory are social enterprises: by selling a product that their customers value for their functionality or appearance, the enterprises make profit that they can use for fulfilling their (non-profit) mission. Personal interest of the customer (having a good product) is in line with the societal interest (raising money for making the world a better place to live).

The effect of symmetry in the first rounds and overall is not significant, but over time the effect increases. By the end of the game (round 30) percentage defection is higher when there is asymmetry than when there is symmetry. More specifically defection is lower in the step-level symmetric condition than in the other three conditions. Two previous studies (Van Dijk & Grodzka, 1992; Van Dijk & Wilke, 1995) show the negative effect of asymmetry in a one-shot social dilemma game. In the current study we did not find an effect of symmetry in the first round which may indicate that individuals behave differently in one-shot versus repeated games. Another study we found showed in a 7-round study that asymmetry increases defection (Tavoni et al., 2011), but unfortunately only the aggregated results for all rounds together are reported, so we are not able to compare our results of the first round with theirs.

A reason why asymmetry may not have an effect in the continuous conditions is that there might be a ceiling effect: defection is already close to 100% in the continuous symmetric game, so there might simply be not much more room for further increasing defection caused by asymmetry. This ceiling effect could potentially be reduced by framing the game differently: in our study we mainly used business students and gave a cover story of a company. We also used the word 'players' for the other participants. That may have triggered subjects to see their group members as competitors, rather than partners. This may be resolved by using more neutral terms and examples, for example by using a cover story of students sharing a house that they need to keep clean. Another option would be to change the Marginal Per Capita Return (MPCR) in the continuous games and the Step-return (SR) in the step-level game. If the MPCR/SR is higher, it is more interesting to cooperate, because it gives more benefits per unit invested.

Defection significantly increases in all conditions over time, but the defection slope is steeper in the continuous symmetric condition than in the step-level symmetric condition. From the third block onwards defection was significantly lower in the step-level symmetric condition than in the other three conditions. Apparently it is harder to coordinate contributions when there is asymmetry, or individuals are less willing to contribute when the benefits are not equally distributed. This is also illustrated by the results in table 7: in the step-level symmetric condition 41% of the groups managed to exactly hit the threshold, whereas only 10% of the groups in the step-level asymmetric condition hit the threshold. In that condition, 27% of the groups stays under the threshold without exactly hitting it, while this number is only 9% in the step-level symmetric condition. This larger number in the asymmetric condition indicates that more groups are willing to cooperate, but that they are not able to coordinate their contributions in the most efficient way and thus that they are wasting resources. Another confirmation of the idea that coordination between subjects is harder in the asymmetric conditions stems for the analysis of the influence of exceeding the threshold or not in the previous round: the chances that groups manage to stay under the threshold if they did not exceed in the previous round it is bigger in the symmetric condition. Once groups have exceeded the threshold, chances that they manage to get under it again are similar in the symmetric and asymmetric conditions.

In the asymmetric conditions participants with more waste defect more when looking at absolute defection, but not when looking at percentage defection. This means that in each condition and endowment level the subjects use the proportional contribution rule (Van Dijk & Wilke, 1993, 1995). The t-test with defection as a percentage of total defection in a group confirms this. This finding is in contrast with the theories of egocentric interpretations of fairness (Buchan et al., 2004; Tavoni et al., 2011; Van Dijk & Wilke, 1995; Wade-Benzoni et al., 1996): in our study participants did not adjust the fairness rule they used for deciding how much to contribute depending on the number of resources they had. This contrast with previous research can partly be explained by the way we operationalized the construct. In earlier public good experiments that studied symmetry, subjects either started the game with a few or many 'positive' resources and they could choose how much of what they possess they contributed to the public good (Tavoni et al., 2011; Van Dijk & Grodzka, 1992). In that case it is always beneficial to have more resources, because it gives both personal benefits and power. In the experiment we did, having more waste is not necessarily positive. It gives power, because individuals producing more waste have more influence on the size of the public bad, but it also gives more personal costs if a person decides to keep more. Therefore, the benefits of having more or less 'resources' are ambiguous and it is less clear which fairness role serves an individual best.

The results show no significant difference in slope between the symmetric and asymmetric continuous conditions. Looking closely to those results yields an interesting question. In the continuous symmetric condition, defection seems to increase strongly between block 1 and 2, but barely between block 2 and 3. In the continuous asymmetric condition, the increase in defection is more gradual. A reason why defection reaches its peak sooner in the symmetric condition might be that the groups have a harder time to coordinate defection and cooperation in the asymmetric condition. Since the dominant strategy in the continuous game is to defect, the groups in the symmetric conditions might be more effective in reaching that dominant Nash equilibrium than the groups in the asymmetric conditions.

Within each block defection increased over the rounds. Apparently individuals are willing to try again to keep the shared costs low when assigned to a new group, but then increase defection over the rounds. Individuals have a tendency to voluntarily cooperate, if treated fairly (Fehr, Fischbacher, & Gächter, 2002). Several studies show that 'tit for tat' is the best strategy to adopt in a social dilemma game (e.g. Axelrod & Hamilton, 1981) : if the other persons defect in a certain round, you should defect in the next round. If they cooperate in a certain round, you should cooperate in the next round. If everyone adopts this strategy, groups will either go to 100% cooperation, which minimizes group costs or maximizes group benefits, or groups go towards 100% defection, which limits personal costs involved with investing in the group's interest if no one else does it. Tit for tat explains why we find that some groups in the step-level conditions are continuously staying under the threshold and why other groups, that have once exceeded the threshold, have a hard time getting under it again after that. Individuals that are part of a 'cooperative' group should cooperate as well to maximize their benefits. Individuals that are part of a 'defective' group should defect as well, since cooperating does not make sense if the rest of the group defects.

The exception in this 'new group'-effect is the step-level asymmetric condition. In this condition there is no decrease of defection at the start of a new block and there even seems to be a reversed 'new group'-effect: defection increases at the beginning of a block. One explanation for this could be related to the difficulty of asymmetric groups to coordinate contributions that we just described: groups have a hard time coordinating their contributions if there is asymmetry, but they might learn how to do it over time. It might be that players in the asymmetric conditions, like the players in the other conditions, are willing to try to keep the shared costs low, but that it is difficult for them to do so. In the continuous conditions this effect was not visible: defection decreased at the beginning of each block. However, in the step-level asymmetric condition defection is lower than in the continuous conditions because groups are trying to stay under the threshold and the asymmetry might be a bigger issue there: who is paying more to stay under the threshold? In the first rounds of a block the uncertainty about what a fair distribution is may have a stronger effect than the urge to stay under the threshold, so in sum defection increases in the first rounds.

Boyd & Richerson (1988) have a theory that describes conditions in which reciprocity is likely to evolve in small to bigger groups. First, defectors should not be able to enjoy the benefit of long term cooperation of others. Secondly, cooperators must form a substantial fraction of the group. The first condition is not satisfied in the game we played: defectors do benefit from other's cooperation. However, defectors might not always benefit from their own defection in the step-level game (if the threshold is almost reached), which partly explains why defection is lower in that condition. The second condition might have been satisfied in part of the groups, but as cooperators find out that there are defectors in a group, they might lose their motivation to contribute and the fraction of cooperators may drop.

We further found that the effect of game type on defection does not occur in the very first round of the game and that defection goes down at the beginning of a block and increases throughout the block. The latter does not occur in the step-level asymmetric game, which might be one of the reasons for the strong increase in defection in that condition.

The next dependent variable we had a look at are personal costs. These costs are lower in the step-level games than in the continuous games, because defection is lower and therefore some groups managed to stay under the contribution threshold and therefore avoided the public costs. In the step-level symmetric game groups managed more often to keep the personal costs low than in the asymmetric game, which is consistent with the increase in defection in the step-level asymmetric condition. The personal costs increase in the continuous games, but not in the step-level games, even though percentage defection went up in all four conditions. In the step-level conditions, the subjects increased defection and thus reduced the costs of bringing waste to the treatment plant, but they avoided exceeding the threshold and thus high cleaning costs. In the continuous condition subjects reduced the private treatment costs, but at the cost of higher cleaning costs. The groups in the step-level condition are better able to manage the public bad, because a number of groups is approaching the optimal solution by (almost) hitting the threshold.

The analysis of the number of cooperators and the size of their contributions shows that there are more co-operators in the step-level game, but that they do not contribute more. The structure of the game gives an explanation for this: it is not necessary to contribute more than 50% if there are many cooperators in the step-level game, whereas it does help society or the public to contribute more in a continuous game, even if not everybody is contributing. From this can be concluded that it is useful to frame a problem as a step-level social dilemma if you want to increase the number of cooperators. If you want to increase the size of the contributions of existing cooperators it is not effective to frame a problem as a step-level social dilemma, but it is also not less effective than framing it as a continuous social dilemma. Reducing asymmetry can help increasing the size of the contributions in the continuous game, but not in the step-level game.

In the continuous conditions on average only one fourth of the participants made a contribution per round (i.e. did not dump everything), and on average they contributed more than half of what they had. This means that three quarters of the subjects dumped everything and one fourth of the participants kept defection from increasing 87% to 100%.Previous research already found that a small part of the population is altruistic (Andreoni & Miller, 1993) and not so much affected by manipulations. This may explain why some individuals are still contributing in a group full of defectors.

4.1 Discussion of the methods

In our study we made many choices with regard to the set-up of the experiment. We decided to use groups of three persons, but usually in real-life social dilemmas more individuals are involved. Group size may make a difference in a group's effectiveness in solving the social dilemma (Bonacich, Shure, Kahan, & Meeker, 1976; Brewer & Kramer, 1986; Isaac & Walker, 1988; Sally, 1995). Our experiment shows a strong effect of game type and symmetry in a small group social dilemma game. To increase the external validity, it would be useful to repeat the experiment with bigger groups (with e.g. 6 or 10 participants in one group). In bigger groups individuals have a smaller impact on the group result, so the differences between continuous and step-level games may change. On the one hand we can argue that defection will be more similar in the continuous and step-level game when using bigger groups, because individuals may have the feeling they have less control over whether the threshold is reached or not and take a safe choice which is to defect (e.g. Isaac & Walker, 1988). On the other hand group size may not make a difference as long as enough individuals are cooperative in the first rounds of the game. Individuals are shown to be voluntarily cooperative, as long as they are treated fairly (Fehr et al., 2002). If a group manages to stay under the threshold during the first couple of rounds, since cooperators have the feeling their efforts are worthwhile and they will keep on cooperating. In that case group size may not have a big effect.

Another choice we made was to use four blocks of ten rounds. Due to a lack of time in some conditions there were only a few observations in the fourth block, so we decided to exclude that block from the analysis. It would be interesting to see what happens after even more rounds: does the increase in defection stop at the level of defection in the continuous games, or does it increase even further? The latter would mean that the positive effect of a step-level game compared to a continuous one is eventually reversed if there is asymmetry between actors. An extended study with more rounds can provide an answer to this question.

In this experiment we gave the participants feedback about the choice and personal costs of the three players in their group after every round. Most social dilemma experiments use the same set-up with full feedback without revealing the identity of the players (Osbaldiston & Schott, 2012). However, one can imagine that in real-life social dilemmas there is not always transparency and not always feedback on how your behavior impacts the public good. A study by Erev & Rapoport (1990) demonstrates the positive effect of feedback on cooperation. In future studies this could be varied to see how it influences behavior in continuous versus step-level and symmetric versus asymmetric social dilemma games.

Communication is known to affect cooperation rates in social dilemmas (e.g. Sally, 1995). In our study we did not allow participants to communicate with each other by any means. In real-life there often is communication between actors in social dilemmas, especially nowadays with digital media that removes barriers of big groups and large distanced. A study of Bornstein (1992) shows that communication has a different effect in respectively continuous and step-level social dilemma games. If there is both a within-group and a between-group social dilemma (e.g. in cases where groups gain from winning a competition between groups, but individuals in those groups benefit equally regardless of the amount of effort they put in the group's success), communication between groups to solve the intergroup problem is more effective in the continuous dilemma. However, within-group communication is more effective in solving intragroup problems in the step-level game. This research suggests that communication has different effects in different game types, so it would be interesting to see how effective communication would be in only a within-group social dilemma, like the one we did. We expect that allowing communication will have a stronger effect in the step-level social dilemma, because it allows groups to coordinate their behavior in order to exactly hit the threshold. Defecting would not only harm the group, but also the individual defector in that case.

We chose the Marginal Per Capita Return (MPCR) and Step-return (SR) to be 2, because the pilot studies showed that there would be sufficient variation in defection with this number and because it is a value that is commonly used (Croson & Marks, 2000). The level of the threshold in the step-level game was set to 50% of the total endowments of a group. The threshold level influences the size of the contributions: a threshold that is set at a higher level leads to more cooperation in case of the possibility to contribute part of the endowments (Croson & Marks, 2000; Suleiman & Rapoport, 1992) . However, the threshold should not be set too high, because it may discourage players to try to reach it (Medina, Quesada, & Lozano, 2014). If the threshold is too low or too high for a specific situation, the positive effect of a step-level game in comparison to a continuous game may disappear. An experiment in which a continuous game and a step-level game with different threshold levels are compared, may identify a range of thresholds for which a step-level game leads to more cooperation than a continuous game. A critical remark here is that researchers should be cautious with varying the level of the threshold. A threshold of 50% allowed us to have equal expected summed payoffs in the two game types while using the same MPCR/SR. It is impossible to keep the MPCR equal to the SR if the threshold level is changed: a higher threshold has to be compensated with a SR that is higher than the MPCR in the continuous game. In that case the structures of the games differ in more than one aspect, so it will be difficult to say what variable causes possible differences between the two games: the game type (continuous versus step-level) or the difference in MPCR/SR. We recommend sticking to a threshold of 50% of endowments to avoid these problems.

The next choice we made was about the asymmetry of the endowments of the players. We chose to use a 2:3:4 ratio, but there are many more options. In the literature we found ratios between 1:2 and 1:7 (Rapoport & Suleiman, 1993; Rapoport, 1988; Van Dijk & Grodzka, 1992; Van Dijk & Wilke, 1995), so it would be interesting to study how different ratios affect cooperation and defection. The initial amount of endowments may also influence the size of the contributions. Having more endowments allows for a more precise contribution: if players have only 10 units, they need to decide which multiple of 10% of their endowments they are contributing. An endowment of 100 units allows players to decide up to 1% precise how much of their endowments they are contributing.

4.2 Limitations

Table 2 shows the numbers of participants in each condition over the rounds. In block 3 (round 21 to 30) the number of subjects is lower in the asymmetric conditions than in the symmetric conditions. This is no random variation: the participants in the symmetric conditions took more time for reading the instructions and answering the comprehension questions, probably because the asymmetric games are harder to understand. As described in the introduction, this is inherent to the difference between the symmetric and the asymmetric condition, so it does not make our results invalid, but it does cause a problem in the analysis of the last block, because the group sizes are quite small.

The effect of endowment level on percentage defection is not significant according to the analysis. However, the group sizes per endowment level are small (only 9 or 10 per endowment level), so this analysis does not have a lot of power. It would be good to repeat the experiment (possibly with only the asymmetric conditions) with more participants to figure out if endowment level really does not have an effect on percentage defection or if this results from a lack of power in the analysis. A solid conclusion would help us to understand what is happening in the asymmetric conditions and if the proportionally contribution rule is really the strategy that used in all conditions.

Thirdly, the individual differences were measured after the participants played the social dilemma games. We made that decision on purpose, because asking questions about environmental attitudes, social value orientation, temporal discounting and consideration of future consequences might prime certain thought in the subjects that can influence the way they play the game. We wanted the choices that are made in the game to the as little as possible to be influenced by the lab setting and therefore we chose to measure the individual differences after the social dilemma game. However, as the difference in the NEP and consideration of future consequences scores show, the individual differences are not fixed personal characteristics; they are influenced by the context in which they are measured. We are not sure if the scores on the individual differences measures are a product of the game the participants played or not, and we can therefore not use them as reliable covariates. To do that, they would have to be measured before playing the game. It would be interesting to see if the individual differences scores are correlated with the defection: do individuals who are more focused on equality, the future and the environment contribute more?

4.3 Future research

In the discussion of the results we identified a number of interesting questions for future research.

First of all, we did not ask the participants about their contribution motivations, so we are not able to identify which of the three differences between the continuous game and the step-level game was dominant in increasing cooperation in the step-level game. To find that out, future studies should include measures of motivation, such as questions about perceived fairness of different contribution levels (the target may help participants in the step-level conditions to have similar ideas about what a fair amount to contribute is, while we hypothesize that this is more dependent on personal ideas about fairness in the continuous conditions), perceived criticality, frustration, perceived benefits of contributing versus defecting, perceived influence on other players and whether the subjects experience the game as a lock-in. Another way to figure out why the participants defect more in the continuous game is to vary the setup of the game to find out which strategy the subjects in different conditions follow. This method can produce more reliable results because self-reports of participants about their motivations may be unreliable due to socially desirable answers and unawareness of important processes. An example of varying the setup of the game is doing a continuous dilemma game with a target without consequences if it is not reached, to test whether the mere existence of the threshold affects defection. Other examples are manipulating the other group member's contributions to vary the criticality of the subjects' contributions (criticality has been shown to have a positive effect on cooperation, Chen, Au, & Komorita, 1996), or introducing multiple thresholds to remove the stable situation in the step-level game. Technically the continuous social dilemma game that we used in this experiment could be characterized as a step-level game with 90 thresholds. For each threshold that is exceeded, the costs increase with 2. A future study could vary the number of thresholds to see when the effect of the threshold occurs: does every threshold that is removed decrease defection or does the positive effect on cooperation only occur if there are only a few or even one threshold? Normann & Rau (2014) show that adding a second threshold further increases contributions, but does not improve public-good provision or lower payoffs.

Motivational questions could also help us to understand other processes for which the data do not provide an answer. For example, why does the 'new group'-effect happen? Are participants driven by trust, hope for reciprocity or something else? Motivational questions may also clarify why defection increases more in the step-level asymmetric game than in any of the other conditions and why the 'new group'-effect does not occur in that condition. Another question that may be answered by asking the participants questions is whether members of groups with a high defection rate or a strong increase in defection over the rounds all blame each other or if they recognize the group dynamics in the process. It is important that those questions are being asked after the participants decide the size of their contributions, but before they get feedback about the behavior of the group.

We showed that once groups have exceeded the threshold, the chances that they manage to get under it again are similar in the symmetric and asymmetric conditions. It would be interesting to know if a group's ability to accomplish a goal in general is reduced after they did not manage to stay under the threshold, or if it is only their ability or willingness to reach that specific goal that is diminished. To test that, the groups could perform a second, unrelated task after playing the game and see if the groups that did not accomplish the first goal are better or worse than groups that did accomplish the goal. They could for example try to solve a puzzle that requires cooperation of all or most of the group members. The intuitive hypothesis would be that groups that did not accomplish the first goal, will also be less successful in reaching the second goal, due to negative emotions, lack of trust and lack of motivation. However, the 'new group'-effect we found suggest that individuals can be motivated to do their best when they are assigned to a new group, even though they know that it is very probable that they are assigned to at least one of their previous group members. This effect might as well occur when assigning a new task to the same group: if they view it as a new, unrelated task, they might not be influenced that much by the first failure. People are known to be bad at estimating how good they are at a task and on estimating how much time it takes to accomplish them. One characteristic of this planning fallacy is that it diminishes the importance of previous experiences (Buehler, Griffin, & Ross, 1994). People are too optimistic about future events, but when they are stimulated to make the link between past and future events, the optimistic bias is reduced. It could be the case that individuals who are assigned to a new task after failing the first, attribute the loss to random factors rather than the group member's individual choices. They could be overly optimistic and therefore do not have a worse performance on the unrelated task.

Another approach for future research would be to focus on the two step-level conditions. In the first few rounds there is no difference between the symmetric and the asymmetric step-level condition, but over time defection is a lot higher in the asymmetric conditions. It would be interesting to repeat the experiment with more rounds and with more subjects that play the final rounds to be able to detect differences in the personal costs curve of the different conditions. In the current study we had between 15 and 33 participants per condition in the last block, and because of a large standard deviation we were not able to demonstrate that the personal costs decrease in the step-level symmetric condition and increase in the asymmetric condition, although figure 5 suggests that there is a trend.

4.4 Conclusions

Individuals defect less and are better able to minimize their personal costs in a step-level social dilemma than in a continuous social dilemma. Symmetry does not have an effect on defection in the first couple of blocks, but over time asymmetry removes the positive effect of the step-level game. Both the game type effect and symmetry effect are quite strong: in the continuous asymmetric condition defection went up to 100 per cent in the last round, whereas defection was only 67 per cent in the last round of the step-level symmetric game.

This knowledge may be applied to environmental and other societal social dilemmas. Rather than framing problems as continuous social dilemmas in which 'every little bit helps', a solution might be in setting a target and communicating what the consequences are if the target is not reached. An example of a situation in which step-level strategies are already used are crowdfunding platform like Kickstarter. In these platforms, individuals and organizations can make a donation to fund a project and only if enough money is collected the project will be executed. The threshold is set by the fundraiser and the consequence of not reaching the threshold is that the project cannot be continued. The platforms enable smaller and bigger supporters of the ideas to together contribute enough money to execute a project. The consequences are clear: if the threshold is reached, the project will be executed, if not, then not. This fundraising method is very successful: many start-ups and projects are able to be developed by relying on these sources of money. This is a real-life example of the promising results of this study that step-level approaches might help solving social dilemmas.

Another example of a potential application of the step-level dilemma is to implement variable gas or electricity prices in buildings where the costs of these resources are shared. If the households together succeed in staying under a certain amount of gas use, the prices will be low, but if they exceed the threshold prices per m^3 of gas or kWh will strongly increase.

Furthermore, asymmetry has again been shown to have a negative effect on solving repeated social dilemmas. In order to reach an optimal solution in a real-life repeated social dilemma, asymmetry between actors should be minimized. Depending on the scale of the environmental problem, the scale on which asymmetry should be reduced varies. Littering problems in neighbourhoods require smaller scale solutions than the world-wide climate problem. Depending on the scale of the social dilemma, asymmetry between households, neighbourhoods, cities and countries should be reduced.

References

Abele, S., Stasser, G., & Chartier, C. (2010). Conflict and coordination in the provision of public goods: A conceptual analysis of continuous and step-level games. *Personality and Social Psychology Review*, *14*(4), 385–401.

Andreoni, J., & Miller, J. H. (1993). Rational cooperation in the finitely repeated prisoner's dilemma: Experimental evidence. *The Economic Journal*, 570–585.

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science*, *211*(4489), 1390–1396.

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution*, *54*(1), 39–57.

Balliet, D., Li, N. P., Macfarlan, S. J., & Van Vugt, M. (2011). Sex differences in cooperation: a meta-analytic review of social dilemmas. *Psychological Bulletin*, *137*(6), 881.

Balliet, D., Parks, C., & Joireman, J. (2009). Social value orientation and cooperation in social dilemmas: A meta-analysis. *Group Processes & Intergroup Relations*, *12*(4), 533–547.

Bchir, M. A., & Willinger, M. (2013). Does a membership fee foster successful public good provision? An experimental investigation of the provision of a step-level collective good. *Public Choice*, *157*(1-2), 25–39.

Biel, A., & Gärling, T. (1995). The role of uncertainty in resource dilemmas. *Journal of Environmental Psychology*, *15*(3), 221–233.

Bonacich, P., Shure, G. H., Kahan, J. P., & Meeker, R. J. (1976). Cooperation and group size in the n-person prisoners' dilemma. *Journal of Conflict Resolution*, *20*(4), 687–706.

Bornstein, G. (1992). The free-rider problem in intergroup conflicts over step-level and continuous public goods. *Journal of Personality and Social Psychology*, *62*(4), 597.

Boyd, R., & Richerson, P. J. (1988). The evolution of reciprocity in sizable groups. *Journal of Theoretical Biology*, *132*(3), 337–356.

Brewer, M. B., & Kramer, R. M. (1986). Choice behavior in social dilemmas: Effects of social identity, group size, and decision framing. *Journal of Personality and Social Psychology*, *50*(3), 543.

Buchan, N. R., Croson, R. T. A., & Johnson, E. J. (2004). When do fair beliefs influence bargaining behavior? Experimental bargaining in Japan and the United States. *Journal of Consumer Research*, *31*(1), 181–190.

Buehler, R., Griffin, D., & Ross, M. (1994). Exploring the" planning fallacy": Why people underestimate their task completion times. *Journal of Personality and Social Psychology*, *67*(3), 366.

Chen, X.-P., Au, W. T., & Komorita, S. S. (1996). Sequential choice in a step-level public goods dilemma: The effects of criticality and uncertainty. *Organizational Behavior and Human Decision Processes*, *65*(1), 37–47.

Cooper, D. J., & Stockman, C. K. (2002). Learning to punish: experimental evidence from a sequential step-level public goods game. *Experimental Economics*, *5*(1), 39–51.

Croson, R. T. A., & Marks, M. B. (2000). Step returns in threshold public goods: A meta-and experimental analysis. *Experimental Economics*, *2*(3), 239–259.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of Social Issues*, *56*(3), 425–442.

Erev, I., & Rapoport, A. (1990). Provision of Step-Level Public Goods: The Sequential Contribution Mechanism. *Journal of Conflict Resolution*.

Fehr, E., Fischbacher, U., & Gächter, S. (2002). Strong reciprocity, human cooperation, and the enforcement of social norms. *Human Nature*, *13*(1), 1–25.

Fischbacher, U. (2007). No Title. *Experimental Economics*, *10*(2), 171–178.

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243–1248.

Isaac, R. M., & Walker, J. M. (1988). Group size effects in public goods provision: The voluntary contributions mechanism. *The Quarterly Journal of Economics*, 179–199.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using contro ls. *Journal of Experimental Psychology: General*, *128*(1), 78.

Lloyd], [William Foster. (1980). WF Lloyd on the Checks to Population. *Population and Development Review*, 473–496.

Medina, F. J. L., Quesada, F. J. M., & Lozano, V. A. (2014). The Production of Step-Level Public Goods in Structured Social Networks: An Agent-Based Simulation. *Journal of Artificial Societies and Social Simulation*, *17*(1), 4.

Milinski, M., Sommerfeld, R. D., Krambeck, H.-J., Reed, F. A., & Marotzke, J. (2008). The collective-risk social dilemma and the prevention of simulated dangerous climate change. *Proceedings of the National Academy of Sciences*, *105*(7), 2291–2294.

Moxnes, E., & Van der Heijden, E. (2003). The effect of leadership in a public bad experiment. *Journal of Conflict Resolution*, *47*(6), 773–795.

Murphy, R. O., Ackermann, K. A., & Handgraaf, M. (2011). Measuring social value orientation. *Judgment and Decision Making*, *6*(8), 771–781.

Myers, R. A., Rosenberg, A. A., Mace, P. M., Barrowman, N., & Restrepo, V. R. (1994). In search of thresholds for recruitment overfishing. *ICES Journal of Marine Science: Journal Du Conseil*, *51*(2), 191–205.

Normann, H.-T., & Rau, H. A. (2014). Simultaneous and Sequential Contributions to Step-level Public Goods One versus Two Provision Levels. *Journal of Conflict Resolution*, *59*(7), 1273–1300.

Osbaldiston, R., & Schott, J. P. (2012). Environmental sustainability and behavioral science: Meta-analysis of proenvironmental behavior experiments. *Environment and Behavior*, *44*(2), 257–299.

Osborne, M. J., & Rubinstein, A. (1994). *A course in game theory*. MIT press.

Rahmstorf, S. (2000). The thermohaline ocean circulation: A system with dangerous thresholds? *Climatic Change*, *46*(3), 247–256.

Rahmstorf, S. (2006). Thermohaline Ocean Circulation. In S. A. Elias (Ed.), *Encyclopedia of Quaternary Sciences*. Amsterdam: Elsevier. Retrieved from http://www.pik-potsdam.de/~stefan/Publications/Book_chapters/rahmstorf_eqs_2006.pdf

Rapoport, A. (1988). Provision of step-level public goods: Effects of inequality in resources. *Journal of Personality and Social Psychology*, *54*(3), 432.

Rapoport, A., & Suleiman, R. (1993). Incremental contribution in step-level public goods games with asymmetric players. *Organizational Behavior and Human Decision Processes*, *55*(2), 171–194.

Sally, D. (1995). Conversation and Cooperation in Social Dilemmas A Meta-Analysis of Experiments from 1958 to 1992. *Rationality and Society*, *7*(1), 58–92.

Schwartz, L. M., Woloshin, S., Black, W. C., & Welch, H. G. (1997). The role of numeracy in understanding the benefit of screening mammography. *Annals of Internal Medicine*, *127*(11), 966–972.

Sen, S., Gürhan-Canli, Z., & Morwitz, V. (2001). Withholding Consumption: A Social Dilemma Perspective on Consumer Boycotts. *Journal of Consumer Research*, *28*(3), 399–417. http://doi.org/10.1086/323729

Simpson, B. (2006). Social identity and cooperation in social dilemmas. *Rationality and Society*, *18*(4), 443–470.

Sonnemans, J., Schram, A., & Offerman, T. (1998). Public good provision and public bad prevention: The effect of framing. *Journal of Economic Behavior & Organization*, *34*(1), 143–161.

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The consideration of future consequences: Weighing immediate and distant outcomes of behavior. *Journal of Personality and Social Psychology*, *66*(4), 742.

Suleiman, R., & Rapoport, A. (1992). Provision of step-level public goods with continuous contribution. *Journal of Behavioral Decision Making*, *5*(2), 133–153. http://doi.org/10.1002/bdm.3960050205

Tavoni, A., Dannenberg, A., Kallis, G., & Löschel, A. (2011). Inequality, communication, and the avoidance of disastrous climate change in a public goods game. *Proceedings of the National Academy of Sciences*, *108*(29), 11825–11829.

Van Dijk, E., de Kwaadsteniet, E. W., & De Cremer, D. (2009). Tacit coordination in social dilemmas: the importance of having a common understanding. *Journal of Personality and Social Psychology*, *96*(3), 665.

Van Dijk, E., & Grodzka, M. (1992). The influence of endowments asymmetry and information level on the contribution to a public step good. *Journal of Economic Psychology*, *13*(2), 329–342.

Van Dijk, E., & Wilke, H. (1993). Differential interests, equity, and public good provision. *Journal of Experimental Social Psychology*, *29*(1), 1–16.

Van Dijk, E., & Wilke, H. (1995). Coordination rules in asymmetric social dilemmas: A comparison between public good dilemmas and resource dilemmas. *Journal of Experimental Social Psychology*, *31*(1), 1–27.

Van Dijk, E., & Wilke, H. (2000). Decision-induced focusing in social dilemmas: give-some, keep-some, take-some, and leave-some dilemmas. *Journal of Personality and Social Psychology*, *78*(1), 92.

Van Lange, P. A. M., Joireman, J., Parks, C. D., & Van Dijk, E. (2013). The psychology of social dilemmas: A review. *Organizational Behavior and Human Decision Processes*, *120*(2), 125–141.

Wade-Benzoni, K. A., Tenbrunsel, A. E., & Bazerman, M. H. (1996). Egocentric interpretations of fairness in asymmetric, environmental social dilemmas: Explaining harvesting behavior and the role of communication. *Organizational Behavior and Human Decision Processes*, *67*(2), 111–126.

Zelmer, J. (2003). Linear public goods experiments: A meta-analysis. *Experimental Economics*, *6*(3), 299–310.

Appendix A – Instructions participants

There are four 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.

> **Continuous conditions**
> 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. 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. 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, 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 (the costs of $2 million per unit are divided over the three companies)

Step-level conditions

Dumping your waste may create costs for the three companies together, because the lake may needs to be cleaned at the end of each period to return it to its original state. If 46 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 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 if needed, and (2) the waste that was not dumped will be picked up by the waste treatment company, at the associated costs.

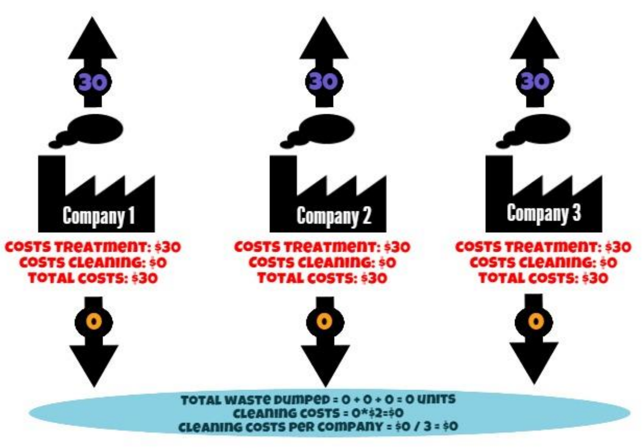
Your costs per period will equal the money you pay to the waste treatment company ($1 million per unit) plus the costs from cleaning the lake (if 46 or more units of waste are dumped, the cleaning costs of $180 million will be shared by the three companies).

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

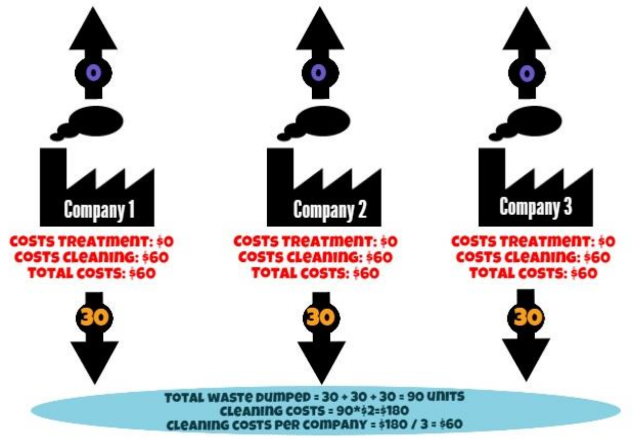
Example 1

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.



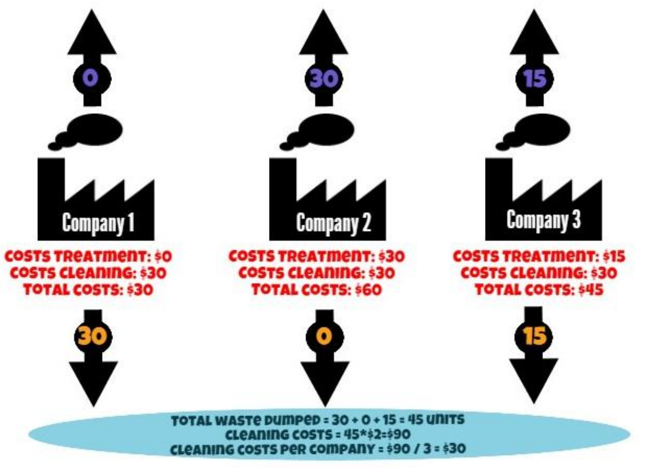
Example 2

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



Example 3

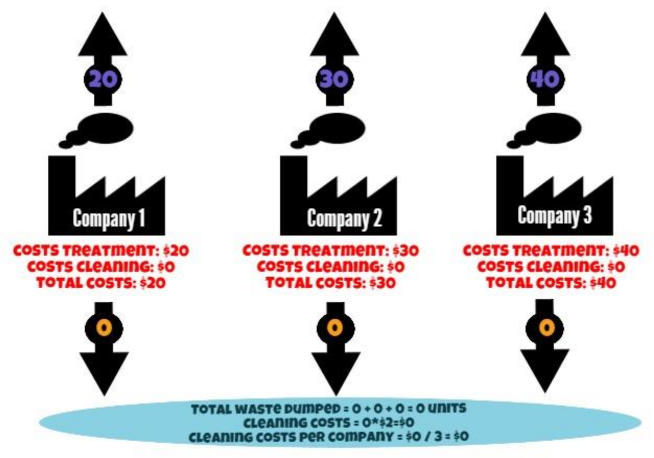
1. In this example company 1 dumped all its waste in the lake, company 2 brought all its waste to the treatment plant and company 3 brought half of its waste to the treatment plant and dumped the other half in the lake. The total amount of waste dumped into the lake is 45 units.
2. The cleaning costs 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.



Examples continuous asymmetric condition

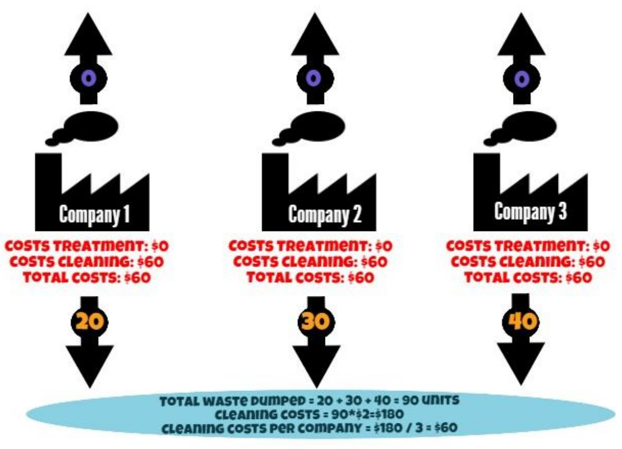
Example 1

1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. 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.
3. The cleaning costs are 0*$2 million = $0, which is $0 per company.
4. Each company pays $1 million per unit of waste that is brought to the treatment plant.
5. The total costs (treatment + cleaning of the lake) are $20 million for company, $30 million for company 2 and $40 million for company 3.



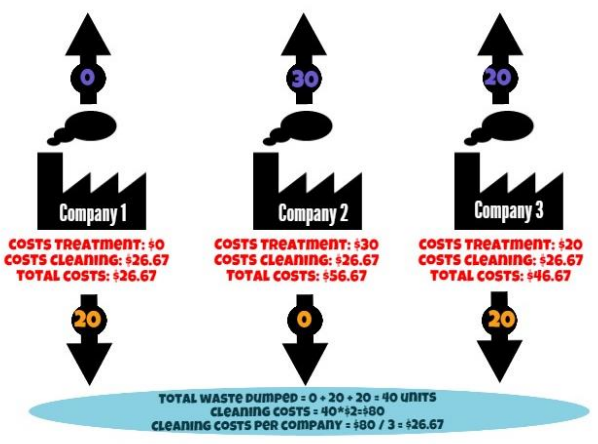
Example 2

1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. 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.
3. The cleaning costs are 90*$2 million= $180 million, which is $60 million per company.
4. No waste is brought to the treatment plant, so the companies do not have to pay for that.
5. The total costs are $60 million for each company



Example 3

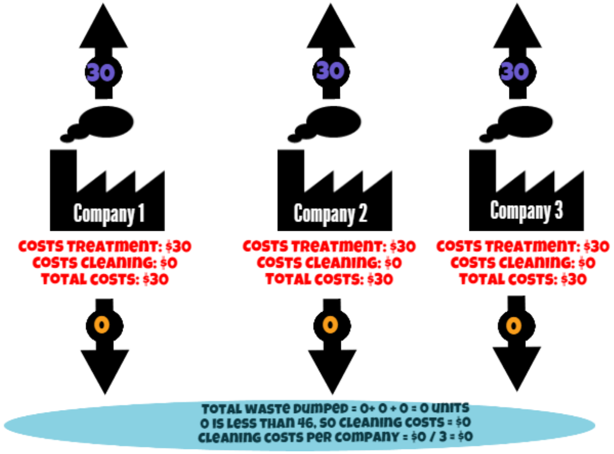
1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. In this example one company 1 dumped all its waste in the lake, company 2 brought all its waste to the treatment plant and company 3 brought half of its waste to the treatment plant and dumped the other half of its waste in the lake. The total amount of waste dumped into the lake is 40 units.
3. The cleaning costs are 40*$2 million= $80 million, which is $26.67 million per company.
4. Each company pays $1 per unit of waste that is brought to the treatment plant. This means that company 1 pays $0 to the treatment plant, company 2 pays $30 million to the treatment plant and company 3 pays $20 million to the treatment plant.
5. The total costs (treatment + cleaning of the lake) are $26.67 million for company 1, $56.67 million for company 2 and $46.67 million for company 3.



Examples step-level symmetric condition

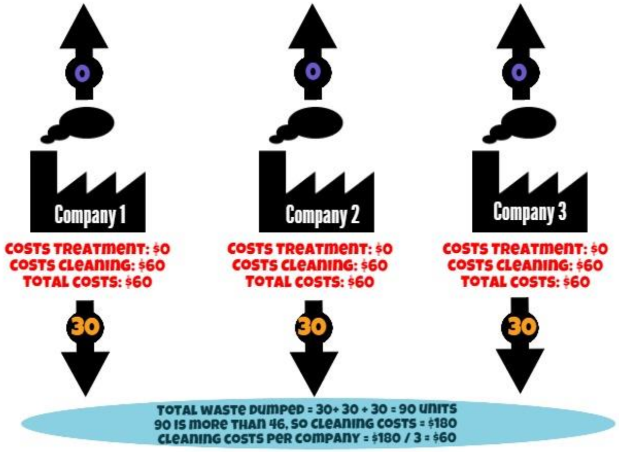
Example 1

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. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 0 is less than 46 units, so the cleaning costs are $0.
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.



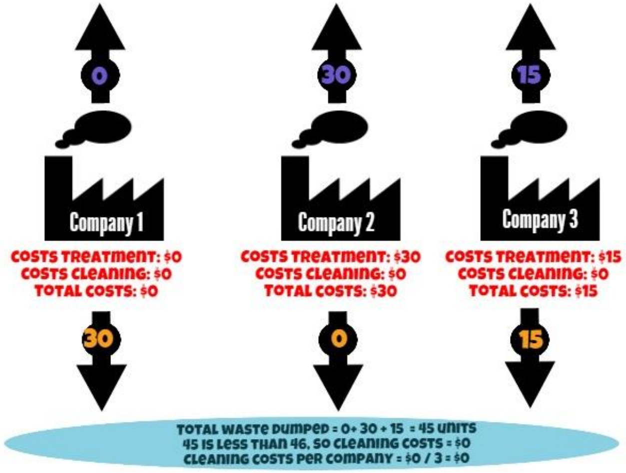
Example 2

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. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 90 is more than 46 units, so the cleaning costs are $180 million, which is $60 million per company.
3. The companies do not have to pay the treatment plant, because they did not make use of it.
4. The total costs (treatment + cleaning the lake) are $60 million for each company



Example 3

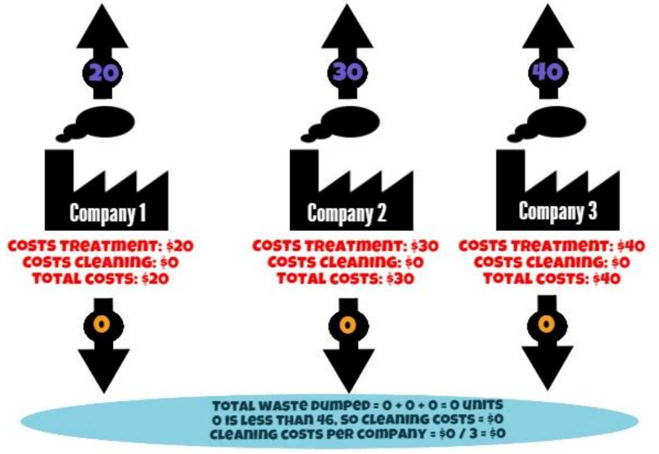
1. In this example company 1 dumped all its waste in the lake, company 2 brought all its waste to the treatment plant and company 3 brought half of its waste to the treatment plant and dumped the other half in the lake.
2. The total amount of waste dumped into the lake is 45 units.
3. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 45 is less than 46 units, so the cleaning costs are $0 million, which is $0 million per company.
4. Each company pays $1 million per unit of waste that is brought to the treatment plant. This means company 1 pays $0, company 2 pays $30 million and company 3 pays $15 million.
5. The total costs (treatment + cleaning of the lake) are $0 for company 1, $30 for company 2 and $15 for company 3.



Examples step-level asymmetric condition

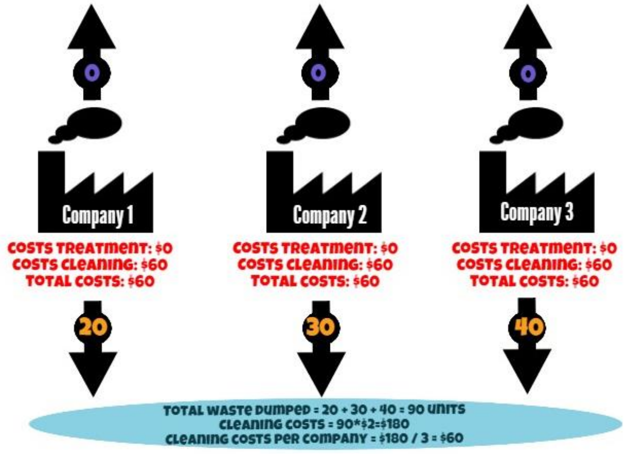
Example 1

1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. 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.
3. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 0 is less than 46 units, so the cleaning costs are $0.
4. Each company pays $1 million per unit of waste that is brought to the treatment plant.
5. The total costs (treatment + cleaning of the lake) are $20 million for company 1, $30 million for company 2 and $40 million for company 3.



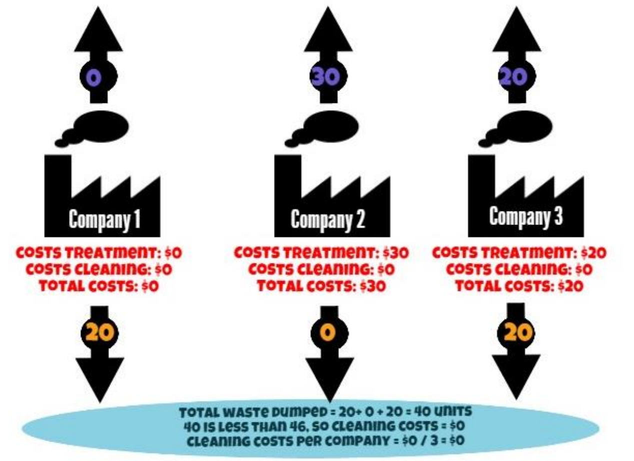
Example 2

1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. 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.
3. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 90 is more than 46 units, so the lake needs to be cleaned. The cleaning costs are $180 million, which is $60 million per company.
4. No waste is brought to the treatment plant, so the companies do not have to pay for that.
5. The costs are $60 million for each company



Example 3

1. In this example company 1 produces 20 units of waste, company 2 produces 30 units of waste and company 3 produces 40 units of waste.
2. In this example company 1 dumped all its waste in the lake, company 2 brings all of its waste to the treatment plant and company 3 brings half of its waste to the treatment plant and dumps the other half in the lake. The total amount of waste dumped into the lake is 40 units.
3. If 46 or more units are dumped in the lake, the lake needs to be cleaned. 40 units is less than 46, so the cleaning costs are $0.
4. Each company pays $1 per unit of waste that is brought to the treatment plant. This means company 1 pays $0 to the treatment plant, company 2 pays $30 million to the treatment plant and company 3 pays $20 million to the treatment plant.
5. The total costs (treatment + cleaning of the lake) are $0 for company 1, $30 million for company 3 and $20 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 45 or less units of waste, the costs for cleaning the lake are $0. If the three companies together dumped 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.**

Continuous symmetric condition

1) What will be your costs if:
    - You (company 1) dumps 0 units of waste in the lake
    - Company 2 dumps 15 units of waste in the lake
    - Company 3 dumps 30 units of waste in the lake

   The costs for my company will be $....... million

2) What will be your costs if:
- You (company 1) dumps 30 units of waste in the lake
- Company 2 dumps 20 units of waste in the lake
- Company 3 dumps 0 units of waste in the lake

   The costs for my company will be $........ Million

Continuous asymmetric condition

1) Assume that company 1 produces 40 units of waste, company 2 produces 30 units of waste and company 3 produces 20 units of waste.
   What will be your costs if:
    - You (company 1) dumps 0 units of waste in the lake
    - Company 2 dumps 15 units of waste in the lake
    - Company 3 dumps 20 units of waste in the lake

   The costs for my company will be $......... million

2) Assume that company 1 produces 40 units of waste, company 2 produces 30 units of waste and company 3 produces 20 units of waste.
   What will be your costs if:
- You (company 1) dumps 40 units of waste in the lake
- Company 2 dumps 10 units of waste in the lake
- Company 3 dumps 0 units of waste in the lake

   The costs for my company will be $........ Million

Step-level symmetric condition

1) What will be your costs if:
    - You (company 1) dumps 0 units of waste in the lake
    - Company 2 dumps 15 units of waste in the lake

- Company 3 dumps 30 units of waste in the lake

The costs for my company will be $.......... million

2) What will be your costs if:

- You (company 1) dumps 30 units of waste in the lake
- Company 2 dumps 20 units of waste in the lake
- Company 3 dumps 0 units of waste in the lake

The costs for my company will be $........... Million

Step-level asymmetric condition

1) Assume that company 1 produces 40 units of waste, company 2 produces 30 units of waste and company 3 produces 20 units of waste.

   What will be your costs if:

   - You (company 1) dumps 0 units of waste in the lake
   - Company 2 dumps 15 units of waste in the lake
   - Company 3 dumps 20 units of waste in the lake

   The costs for my company will be $......... million

2) Assume that company 1 produces 40 units of waste, company 2 produces 30 units of waste and company 3 produces 20 units of waste.

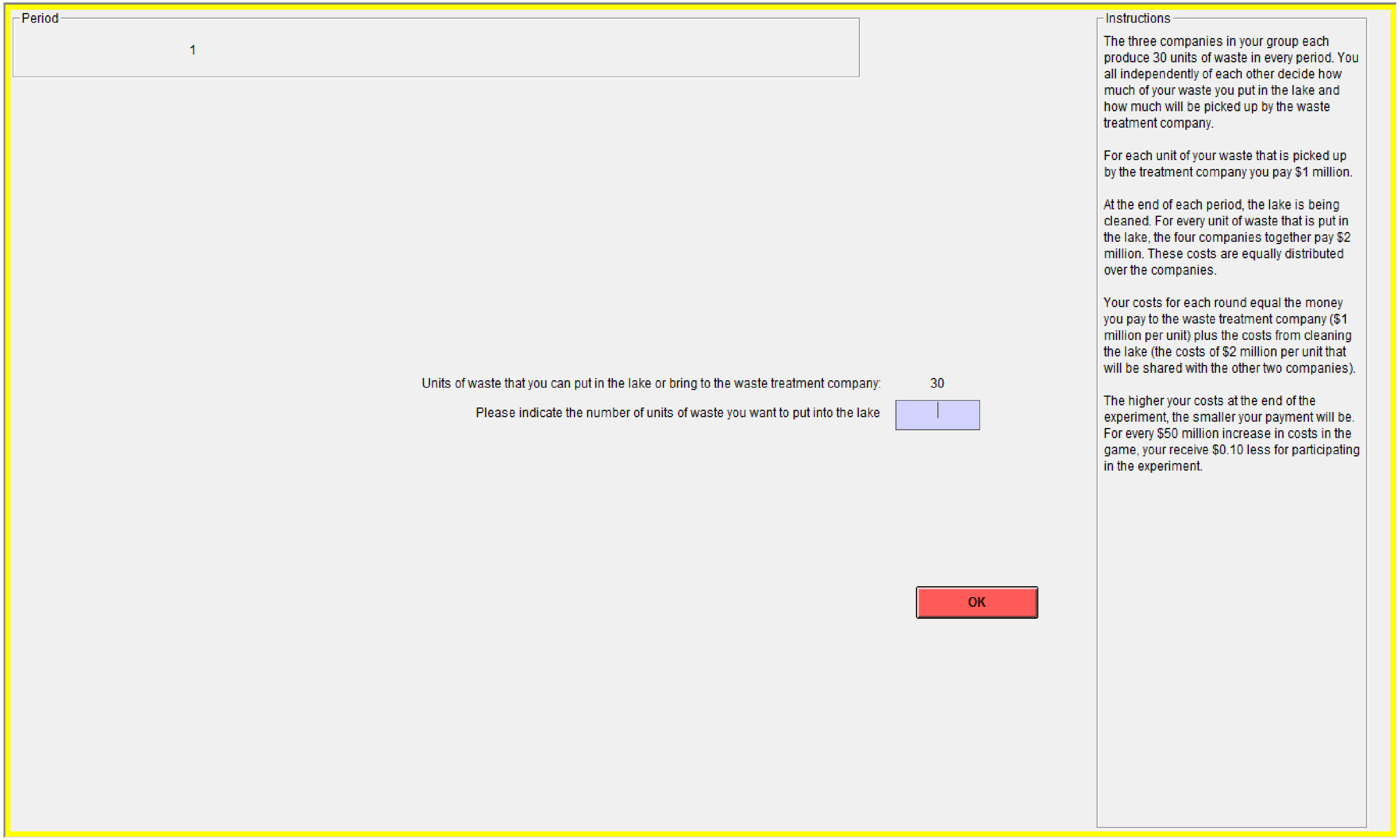
   What will be your costs if:

- You (company 1) dumps 40 units of waste in the lake
- Company 2 dumps 10 units of waste in the lake
- Company 3 dumps 0 units of waste in the lake

The costs for my company will be $........ Million

Please raise your hand when you have finished answering the questions.

Appendix B - Z-tree screenshots



Period

1

The total amount of waste you and the other three players in this period together have put in the lake: 45

The total costs of the cleaning for this period (in million $): 90.00

Your share in the costs of cleaning the lake (in million $): 30.00

	Units of waste produced	Units dumped in the lake	Costs in this period (in million $)
You	30	15	45.00
Player 2	30	30	30.00
Player 3	30	0	60.00

Instructions

The three companies in your group each produce 30 units of waste in every period. You all independently of each other decide how much of your waste you put in the lake and how much will be picked up by the waste treatment company.

For each unit of your waste that is picked up by the treatment company you pay $1 million.

At the end of each period, the lake is being cleaned. For every unit of waste that is put in the lake, the four companies together pay $2 million. These costs are equally distributed over the companies.

Your costs for each round equal the money you pay to the waste treatment company ($1 million per unit) plus the costs from cleaning the lake (the costs of $2 million per unit that will be shared with the other two companies).

The higher your costs at the end of the experiment, the smaller your payment will be. For every $50 million increase in costs in the game, your receive $0.10 less for participating in the experiment.

Continue

Period

1

	Units of waste produced in this period	Units dumped in the lake in this period	Costs in this period (in million $)	Total costs (in million $)
You	30	15	45.00	45.00
Player 2	30	30	30.00	30.00
Player 3	30	0	60.00	60.00

Instructions

The three companies in your group each produce 30 units of waste in every period. You all independently of each other decide how much of your waste you put in the lake and how much will be picked up by the waste treatment company.

For each unit of your waste that is picked up by the treatment company you pay $1 million.

At the end of each period, the lake is being cleaned. For every unit of waste that is put in the lake, the four companies together pay $2 million. These costs are equally distributed over the companies.

Your costs for each round equal the money you pay to the waste treatment company ($1 million per unit) plus the costs from cleaning the lake (the costs of $2 million per unit that will be shared with the other two companies).

The higher your costs at the end of the experiment, the smaller your payment will be. For every $50 million increase in costs in the game, your receive $0.10 less for participating in the experiment.

Continue

Appendix C –Questionnaire

You are now going to be asked a number of questions. Do not think too long about your answer to each question; your first instinct is usually best.

Please answer the questions as honestly as possible; there are no right or wrong answers. We are only interested in your personal opinion.

Please enter your computer number (you can find it on your left).

Demographics

<u>What gender do you identify with?</u>

- Male
- Female

<u>What is your age?</u>

Drop-down list from 15 – 100 years

<u>What is the highest level of education you have completed?</u>

- Primary School Degree
- Middle School Degree
- High School Degree
- Undergraduate Degree
- Graduate Degree
- Other

<u>What is your major field of study?</u>

<u>What is your nationality?</u>

Numeracy items (Kirby et al., 1999)

Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips? ____times out of 1,000. Fill in your answer in the box below.

In the BIG BUCKS LOTTERY, the chance of winning a $10 prize is 1%. What is your best guess about how many people would win a $10 prize if 1000 people each buy a single ticket to BIG BUCKS?____person(s) out of 1,000. Fill in your answer in the box below.

In ACME PUBLISHING SWEEPSAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSAKES win a car?____%."

New Ecological Paradigm Scale (Dunlap et al., 2000)

Listed below are statements about the relationship between humans and the environment. For each one, please indicate whether you STRONGLY DISAGREE, MILDLY DISAGREE, are UNSURE, MILDLY AGREE or STRONGLY AGREE with it.

- We are approaching the limit of the number of people the Earth can support.
- Humans have the right to modify the natural environment to suit their needs.
- When humans interfere with nature it often produces disastrous consequences
- Human ingenuity will insure that we do NOT make the Earth livable
- Humans are severely abusing the environment
- The Earth has plenty of natural resources if we just learn how to develop them.
- Plants and animals have as much right as humans to exist
- The balance of nature is strong enough to cope with the impacts to modern industrial nations.
- Despite our social abilities humans are still subject to laws of nature.
- The so-called 'ecological crisis' facing humankind has been greatly exaggerated.
- The earth is like a spaceship with very limited room and resources.
- Humans were meant to rule over the rest of nature.
- The balance of nature is very delicate and easily upset.
- Humans will eventually learn enough about how nature works to be able to control it.
- If things continue on their present course, we will soon experience a major ecological catastrophe.

Social value orientation (Murphy et al., 2011):

In this task you have been randomly paired with another person, whom we will refer to as the other. This other person is someone you do not know and will remain mutually anonymous. All of your choices are completely confidential. You will be making a series of decisions about allocating resources between you and this other person. For each of the following questions, please indicate the distribution you prefer most by ticking the respective box. You can only make one mark for each question.

Your decisions will yield money for both yourself and the other person. In the example below, a person has chosen to distribute money so that he/she receives 50 dollars, while the anonymous other person receives 40 dollars.

There are no right or wrong answers, this is all about personal preferences. After you have made your decision, write the resulting distribution of money on the spaces on the right. As you can see, your choices will influence both the amount of money you receive as well as the amount of money the other receives.

You receive	85	85	85	85	85	85	85	85	85
Other receives	85	76	68	59	50	41	33	24	15

You receive	85	87	89	91	93	94	96	89	100
Other receives	15	19	24	28	33	37	41	46	50

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	98	96	94	93	91	89	87	85

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	89	79	68	58	47	36	26	15

You receive	100	94	88	81	75	69	63	56	50
Other receives	50	56	63	69	75	81	88	94	100

You receive	100	98	96	94	93	91	89	87	85
Other receives	50	54	59	63	68	72	76	81	85

Consideration of future consequences (Strathman et al., 1994)

Answers are given on a seven-point scale: Not at all like me – Not like me – Not much like me - Neutral – Somewhat like me – Like me – Just like me

- I consider how things might be in the future, and try to influence those things with my day to day behavior
- Often I engage in a particular behavior in order to achieve outcomes that may not result for many years
- I only act to satisfy immediate concerns, figuring the future will take care of itself
- My behavior is only influenced by the immediate (i.e., a matter of days or weeks) outcomes of my actions
- My convenience is a big factor in the decision I make or the actions I take
- I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes
- I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years
- I think it is more important to perform a behavior with important distance consequences than a behavior with less-important immediate consequences
- I generally ignore warnings about possible future problems because I think the problems will be resolved before they reach crisis level
- I think that sacrificing now is usually unnecessary since future outcomes can be dealt with at a later time
- I only act to satisfy immediate concerns, figuring that I will take care of future problems that may occur at a later date

- Since my day to day work has specific outcomes, it is more important to me than behavior that has distant outcomes

Temporal discounting

For each of the next 9 choices, please indicate which reward you would prefer: the smaller reward today, or the larger reward in the specified number of days.

- Would you prefer $54 today, or $55 in 117 days?
- Would you prefer $47 today, or $50 in 160 days?
- Would you prefer $25 today, or $60 in 14 days?
- Would you prefer $40 today, or $55 in 62 days?
- Would you prefer $27 today, or $50 in 21 days?
- Would you prefer $49 today, or $60 in 89 days?
- Would you prefer $34 today, or $50 in 30 days?
- Would you prefer $54 today, or $60 in 111days?
- Would you prefer $20 today, or $55 in 7 days?

Purpose

What do you think is the purpose of this study?

This was the last question of this study! Please click the 'continue' button and raise your hand.

Appendix D – Spoken instructions

Welcome to this study!

I'll read some instructions aloud now. It's important that you pay attention to them and don't talk to each other. If you have questions, please raise your hand and I will answer them individually.

You have just received the consent form to participate in this research. Please, read it carefully and sign it.

This study will last one hour or less, but not more than that.

After you have signed the consent form, you can read the instructions for the study on your screen. Please take time to read them carefully; it's essential for the rest of the study that you understand everything well. Everything that is said in the instructions is true, we are using no deception.

This is a paid study, which means that you will not receive credit for participating. As you will read in the instructions the height of you payment depends on the decisions you are making in the study.

Communication and the use of mobile phones are not allowed during the study. You may have to wait sometimes, but please do not use you cell phone.

Now you can start reading the consent form and after that the instructions. Again, if you have any questions, just raise your hand.

I will now show an example of what the program you are going to play the game in looks like. It is too small to read on the screen, but it will be readable on your screen.

On the first screen you will see the instructions in short on the right, in case you forgot them. On top you see the period number. In the box in the middle you see the number of units of waste you have produced and a box in which you have to enter how much of that waste you want to dump in the lake. After you have entered how much waste you are dumping you click the 'OK' button on the right bottom of the page.

After everyone has entered how much waste he or she is dumping and had clicked the OK-button, this screen appears. Again you see the instructions and the period number. In the middle you see how much waste you have dumped, how much waste in total has been dumped and what your costs of cleaning the lake are. In the table you see how much waste the other players have dumped and what their costs for this round are. These costs are the summed costs of cleaning the lake and of the payment to the treatment plant for each player. When you're finished with these results, click the 'continue' button on the right bottom.

You will now get to see a screen with the same table as on the previous page, but now with the total costs of each player over the rounds that you have played. When you are finished reading this table, please click the continue button at the bottom of the page. You will be directed to a waiting screen until the other players have finished as well. Then you move on to the next period.

That was the first block of the game. I am now going to change the groups and start the next block. Your total costs are set to 0 again, but they do still count for your payment.