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Direct and Indirect Reciprocity: A Study of Willingness to Contribute to Public Goods

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Abstract

The study examines whether direct or indirect reciprocity has an impact on the willingness to contribute to public goods. It also covers the question of whether any specific reciprocal behavior is more efficient than others in generating value to the contributor. We conduct public goods games and indirect reciprocity games on Swedish business students and find that a punishment option and indirect reciprocity are the most efficient ways of making people contribute to public goods. Likewise, the most efficient ways of generating value to the contributor, measured as percentage of maximum possible payoff, are to introduce a punishment option and trough indirect reciprocity. We explain that these conclusions can be applied to several real-world public good problems, such as the fight against global warming and in smaller contexts like group work.

Keywords: Reciprocity, public goods, punishment, contributions, reward, reputation

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1 Introduction

Collective action situations and how they should be resolved have been a controversial issue in current research. Especially, public goods have been a hot topic because they are both non-excludable and non-rivalrous. Up until 1965, the dominating theory suggested that groups would find ways to act in their own collective interest rather than only in the private interest of each individual (Ostrom 2000).

In 1965, Mancur Olson stated that "unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests". Certainly, this was a very controversial statement back then (Olson 1965, p. 2).

According to Ostrom (2000), more recent research claims that the propensity to cooperate is based on social norms even though it is still unclear what contextual variables that actually affect the level of cooperation. One does not only consider individuals to be completely rational, but in reality there is a certain amount of discrepancy between the actual and the rationally expected outcome. To explain this would require a behavioral view of economic theory.

One way of creating and maintaining norms in public goods is through reciprocity. According to Oxford Dictionaries, reciprocity is defined as "the practice of exchanging things with others for mutual benefit, especially privileges granted by one country or organization to another" (Oxford Dictionaries 2012). However, other definitions of reciprocity are common such as "the principle and practice of give and take, of making mutual concessions; the granting of privileges in return for similar privileges" (Ellingsen 2011).

According to Schram and Seinen (2006), scientific literature has mainly dealt with direct reciprocity which is defined as "the motivation to respond to the acts of individuals one has interacted with before" (Schram and Seinen 2006, p. 3). This can be done through positive direct reciprocity (reward) or negative direct reciprocity (punishment). Reciprocal behavior can be observed from a slightly different perspective, and this form of reciprocity is called indirect reciprocity. In indirect reciprocity, cooperative actions are reciprocated by a third actor that is not involved in the original exchange.

The purpose of the thesis is to investigate whether reciprocity has an impact on the willingness to contribute to public goods and if any specific reciprocal behavior is more efficient than others in generating value to the contributor. Previous research has covered this approach in different manners. However, the unique thing with our study is that we focus on both direct and indirect reciprocity and try to make out a difference between the two. The relevance of the study can also be found in how reciprocity best can be used in fighting free-riding behavior in real-world public good problems. This can potentially contribute to more efficient ways of building up certain public good systems, which has often been controversial up until today. People tend to disagree on how such a non-excludable and non-rivalrous good should be managed. Our research will hopefully make people look at this issue from a slightly different view.

Throughout the report, the purpose is achieved through an experiment in which the following research questions are analyzed:

1. *What kind of reciprocal behavior is the most efficient in making people willing to contribute to public goods?*

2. *What kind of reciprocal behavior is the most efficient in generating value to the contributor?*

3. *In what public goods do the different forms of reciprocity generate the most efficient outcome?*

Answers to the research questions are achieved through a hypothetical-deductive method by conducting public goods games and indirect reciprocity games on Swedish business students. The sample delimits conclusions to applications dominated by such individuals. However, considering characteristics of other social groups, applications dominated by these individuals can be discussed as well. Since public good applications can be found in numerous situations in any society or social group, a general approach rather than a focus on a specific good is considered more useful. In order to make the outcome as specific as possible, we intend to present practical applications of the conclusions in the report.

Delimitations of the thesis can also be found in other areas. The thesis does not deal with regulation of how much to contribute, but with social norms and its impact on the individual. This is a considerable delimitation of the study since regulation has also been shown to have a

certain impact on the willingness to contribute in similar collective action situations (Fehr and Gächter 2000). In addition, the thesis does not cover what contextual variables affect the process of teaching and evoking social norms, which Ostrom (2000) found to be relevant for future research. However, the thesis could be used as a supplement for such research.

2 Previous Research

According to previous research, direct reciprocity in public goods games generally shows that punishment is more effective than reward in making people contribute to the good. However, in repeated games reward is found not to be less effective than punishment for maintaining cooperation. In addition, reward leads to higher total payoff. In a repeated public goods game with both punishment and reward opportunities, reward leads to increased contributions and payoff while punishment has no significant effect on contributions and leads to lower payoff (Rand et al. 2009). However, maintaining cooperation with reward is less often exercised by players. It has also been shown that reward cannot sustain long-term cooperation (Sefton 2007).

The term indirect reciprocity was originally introduced by the biologist Richard D. Alexander in his book *The biology of moral systems* from 1987. The definition as stated by Alexander:

> "In indirect reciprocity the return is expected from someone other than the recipient of the beneficence. This return may come from essentially any individual or collection of individuals in the group. Indirect reciprocity involves reputation and status, and results in everyone in a social group continually being assessed and reassessed by interactants, past and potential, on the basis of their interactions with others" (Alexander 1987, p. 85).

Furthermore, Alexander claims that indirect reciprocity has a central role in human societies and that indirect reciprocity is about reputation between individuals trying to maintain their social status. In 1998 Alexander's indirect reciprocity theory was taken into consideration by Nowak and Sigmund who developed a model for indirect reciprocity (Schram and Seinen 2006).

Boyd and Richterson (1989) developed a game for studying indirect reciprocity out of the original concept of indirect reciprocity. The game was then further developed to more precisely study the effects of indirect reciprocity (Nowak and Sigmund 1998). This was then adapted to the public goods game in an attempt to study the effects of indirect reciprocity on "the tragedy of the commons" (Milinski et al. 2002). However, this study does not include any form of direct reciprocity, which indicates a need for further research. Rockenbach and Milinski (2006) found that an interaction between costly punishment and reputation results in

a more efficient cooperative behavior. However, the study does not give a complete explanation to what impact direct and indirect reciprocity have on the willingness to contribute to public goods. There are still substantial gains to be made from further looking at this issue. With a rigorous analysis of a new dataset based on our experiment, the thesis seeks to fill the gap in research.

3 Theory

The study of willingness to contribute to public goods when reciprocal behavior is prevalent requires introduction of some theory commonly used in behavioral economics. In the thesis, the public goods game is the fundamental of measuring the willingness to contribute to the public good. In order to control for the impact of the different treatments of direct reciprocity, a punishment and a reward opportunity are added to the standard game. In addition, when analyzing the impact of indirect reciprocity an indirect reciprocity game is used together with the standard public goods game.

The public goods game is based on the prisoners' dilemma (PD), but instead of involving two players there are now more than two participants in the game. The PD has a risk dominant and a payoff dominant equilibrium and strategies based on reciprocal behavior can be applied to the game. The same fundamentals are found in the public goods game in which there are cooperators and defectors or free riders for instance. The main difference is that in the public goods game each player has a choice of how much to contribute to a common pool, which then benefits each participant equally. Like in the PD, the maximum payoff for the group as a whole is achieved if all players contribute the full amount. However, free riders may withhold their own contribution and thus benefiting from the public pool (Hauert 2005).

What behavior is the most efficient in the game is not only about being rational, but in a social interaction like this other elements are considered. The number of rounds is of great importance in deciding whether to contribute since several rounds would open up an opportunity of reciprocal behavior. This behavior is basically a sociological application and is considered to be prosocial, i.e. voluntary behavior intended to benefit another individual (Brief and Motowidlo 1986). Direct reciprocity among players makes it possible to increase contributions through punishment and reward while indirect reciprocity is about reputation and social status. This is another way to increase contributions. Even though punishment initially generates a social loss since both players' payoffs are reduced net payoffs can still be positive due to the fact that free riding is discouraged. Reward generates a loss to the rewarding player while the player being rewarded is benefited. However, in the long run net payoffs can still be positive for the same reason as in the punishment case (Andreoni et al. 2003).

The indirect reciprocity game means pairing up players individually, keeping their identities hidden, throughout the game. When the opportunity then showed up for reciprocal action they were presented with the donor history of the person they were acting towards. A needed restriction for this behavior to be examined is that the person receiving will never be able to reciprocate back the person giving. This means that the action will be based purely on the history or reputation of that person as a donor and not out of expectations for future benefit (Milinski et al. 2002).

4 Experimental Design

A common game used for testing the willingness to contribute to public goods is the so called public goods game, as used by Rand et al. (2009). This in its pure setting gives rise to the effect known as the tragedy of the commons, where all players starts to mistrust each other and become more and more unwilling to interact with respect to their own self-interests. To study what can be done to prevent this, Rand et al. (2009) use three different settings of the traditional game which involves the options of punishment or rewarding. Another setting used in another experiment by Milinski et al. (2002) brings in the concept of indirect reciprocity and its effects in this game.

Sample pool

As is often otherwise used when conducting these types of experiments we used a subject group of 30 students. As this experiment is conducted using common economic theories and thinking strategies we used a sample of business students advanced in their third year of study at the Stockholm School of Economics. The actual size of the sample is always of large importance for this sort of experiment, the larger the better. A sample size of 30 students may appear small in accordance with this and may also seem to set limitations on the results given. However, since the subject pool is restricted to third year students of the Stockholm School of Economics, there is a high degree of homogeneity among the participants. The extensive precautions taken during the experimentation process serve to reduce outside effects that might influence the outcome. These include restrictions such as prohibitions of all forms of communication and a limited duration for decision making. For these reasons, an increase in sample size would not necessarily generate more accurate results.

Experimentation

The group of test subjects was gathered in an empty classroom where they were seated apart from each other to prevent any eventual forms of interaction in between them. For each experiment, six students participated. All in all, there were a total of five experiments. Forms handed out together with instructions during the experiment can be found in appendix B for further reading.

All of the subjects were designated an individual letter between A and F in the order they were seated. Each of these corresponded to a certain number written on the whiteboard only known by the conductors and not by the players themselves.

The Public Goods Game

The purpose of the public goods game is to study the behavior between players on how willing they are to contribute toward a public good. This is done by having the player freely choose an amount of monetary units to donate toward a common pool. The amount donated is then multiplied by a factor and divided evenly amongst all the players, the optimal single strategy in the pure game is to donate the least possible amount to grab as much of the common pool as possible without losing any of one's endowment in the process. In terms of total wealth the optimal strategy is for all players to donate as much as possible to the pool so that the amount of monetary units in circulation becomes as large as possible.

In our application of this game six players were gathered, all of whom were given a letter from A to F in the order they were seated. Each letter then corresponded to a number on the whiteboard in the classroom where the numbers were only known by the conductors. They were all informed that the winner of the game would be handed the sum of 40 SEK as a means of motivation. All of them were given the starting amount of 75 Monetary Units (MU). They were given forms where they were to write down their personal donation to the common pool and these were collected by the conductors of the experiment at the end of every round. All forms of communication in between players were prohibited so they would have complete anonymity between each other. The players were to choose a contribution of 0-30 MU each round and write it down on the forms in front of them. After the forms were gathered, each of the contributions was written on the board so they could see what amounts was contributed in each round and also if there were any free-riders. The total amount contributed was added together and multiplied with a factor of 1.6, after which it was divided evenly among the players and added to their remaining endowments. The formula calculating the endowments of each player looks like this:

$$Starting\ Endowment - Contribution + 1.6\frac{Total\ amount\ contributed\ by\ all\ players}{6}$$

The last term in the formula is called the payoff: $1.6\frac{Total\ amount\ contributed\ by\ all\ players}{6}$

The maximum payoff possible in this game is when all of the players contribute the maximum amount (30) and the payoff becomes:

$$1.6\frac{30 * 6}{6} = 48$$

When all of this had been calculated the forms were once again handed out to the players and a new round commenced. This was repeated for a number of rounds, unknown to the players, and afterwards all of the forms were recollected.

Direct Reciprocity Treatment

After conducting this pure public goods game we informed the players that a new application with a new stage to the game would be commenced. The first conducted was the Reward-Neutral (RN) treatment, where the players would get the chance to reward other contributors after each round. Here we added another stage to the original experiment where, after the contributions had been made, the players was shown each individual contribution for the other players and then given the option to reward the other players with +12 MU at a cost of -4 MU. The maximum payoff in this version for any single player would be when all players contribute the maximum amount and one player gets rewarded by all the others without giving any reward, this would mean:

$$1.6\frac{30 * 6}{6} + 12 * 5 = 108$$

The payoff possibilities here are much higher than in the pure public goods game, as shown. Each player's personal payoff was calculated and added to the remaining funds and the forms were handed out for another round to start. This was, once again, conducted for a number of rounds unknown to the players.

The next treatment conducted was the Punishment-Neutral (PN) treatment. This treatment has the same settings as the earlier one with the difference that, instead of rewarding, the players get to choose to punish. The punishment option is directed to free-riders who have, in the player's own opinion, donated a low amount. The punishment option gives the receiving player -12 MU and costs the punishing player -4 MU. This again changes the maximum

payoff possible to where all players donate the maximum amount and no punishments are handed out:

$$1.6\frac{30 * 6}{6} - 15 * 0 = 48$$

Just as before the total endowments of each player was calculated at the end of each round and then a new one was started, this was repeated for a number of rounds unknown to the players.

The third treatment was the Reward-Neutral-Punishment (RNP) treatment. This treatment is exactly the same as the two earlier ones, with the difference that all of the above options were available. This means that, after their donations, the players were given the options to reward, punish or do nothing towards the other players. The maximum payoff therefore becomes the same as in the RN treatment where it was:

$$1.6\frac{30 * 6}{6} + 12 * 5 = 108$$

Indirect Reciprocity Treatment

This treatment differs from the other ones in the way that it does not involve direct choices in every round. To implicate the concept of indirect reciprocity the pure public goods game will be alternated with rounds of the indirect reciprocity game. The players were informed that they would be conducting an unknown number of rounds of the public goods game and then at any time it would be interrupted with the indirect reciprocity game. After the indirect reciprocity game was carried out, the public goods game would recommence with their new endowments and could, at any time, be interrupted by the indirect reciprocity game.

The indirect reciprocity game means pairing the players up with each other and assigning each pair with the role of potential donator and potential receiver. The potential giver was then presented with the donation history of the potential receiver and then making a decision of either rewarding or doing nothing against this person. The players were also guaranteed that they would never be given the chance to be a potential donator to someone they had earlier been paired up with as a potential receiver. Each time the indirect reciprocity game was played each player was a potential donator and a receiver at least one time. The maximum payoff in these settings is the same as in the pure public goods game:

$$1.6\frac{30 * 6}{6} = 48$$

The rounds followed by the indirect reciprocity game, on the other hand, enables the player to attain an extra 12 MU if no reward is handed out:

$$1.6\frac{30 * 6}{6} + 12 - 0 = 60$$

This way of alternating games was repeated for a number of times unknown to the players and could be interrupted at any time during the process.

5 Empirical Results

Initial Findings and Results when Reciprocity is Missing

Repeated public goods games with different treatments surely take much time to carry out. For this reason, the experiment was interrupted as soon as a longer-term trend was observed. This resulted in a smaller number of observations, generally consisting of 4 to 9 rounds (periods). This way of conducting the experiment also reduced noise such as irrational behavior caused by the extended period of time required for the experiment.

In order to find what kind of behavior is the most efficient in making people contribute to public goods, we need to present the results of all treatments including the control experiment. The reason for this is that we simply cannot use empirical results from previous studies since that would give us heterogeneous samples. For this reason, we initially present the results of the control experiment, and secondly add each of the four treatments to the analysis. This makes it easier to compare findings between the five different scenarios.

The average contribution to the common pool in the control experiment is significantly lower than in all cases where any form of reciprocity is an option. Statistical evidence for this and similar tests are presented in appendix A. Over all rounds, the average contribution in the control experiment is close to 10. In line with previous findings, we also see that it is obvious that over a longer run there is a decline in the average contribution. It can be seen that the sudden increase in average contribution between round 2 and 4 is a temporary response to the declining average contribution and is not part of a long-term trend (Rand et al. 2009).

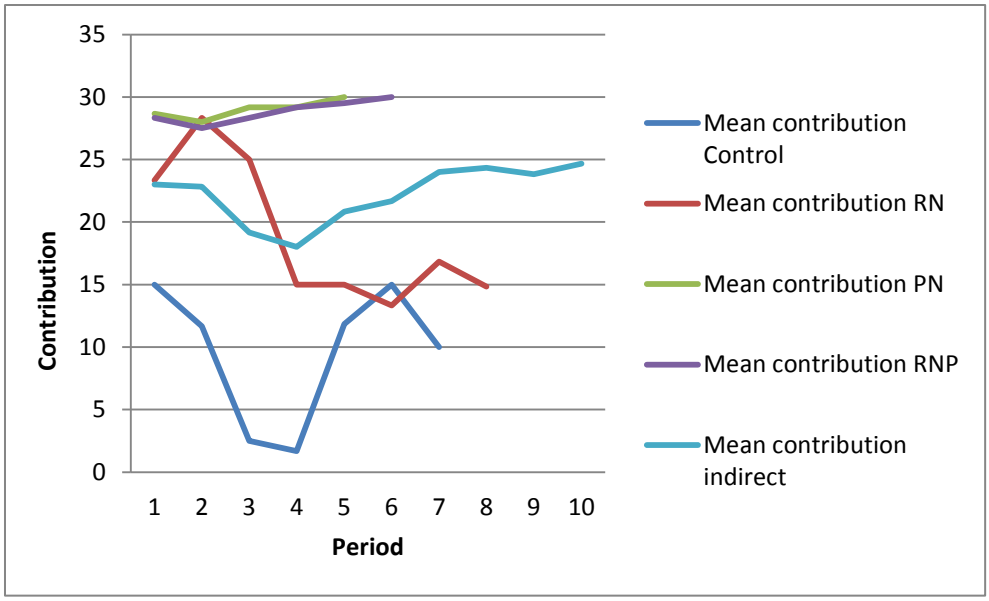

Figure 1. Mean contribution in all treatments including the control experiment.

The Impact of Direct Reciprocity

Contrary to previous research, we find that the willingness to contribute to the public good is dependent on the form of direct reciprocity (Rand et al. 2009). We do not only observe a significant difference in average contribution between the control and the RN, PN and RNP treatments, but we also see that the average contribution level varies within the three treatments of direct reciprocity. The RN, PN and RNP treatments generate higher contributions than the control. However, the average contribution quickly declines in the RN treatment, which results in a significantly lower average contribution than in the PN and RNP treatments. As the average contribution in the PN and RNP cases approaches the maximum level, the reference point for what is a free-riding contribution rises and finally it can be seen that players tend to punish people with contributions close to the maximum amount. The average contribution over all rounds in the RN, PN and RNP treatments are close to 19, 29 and 29, respectively. This means that they are 90%, 190% and 190% greater than the average contribution in the control, respectively.

It can be seen that people are more reluctant to free ride when there is a possibility to get punished than if there is a possibility to be rewarded. In contrast to previous findings, punishment does not only make people contribute any amount, but it also raises each player´s contribution to the highest level (Andreoni et al. 2003). Despite the fact that the reward opportunity is frequently used in the RN treatment, the average contribution does not reach as

high as in the PN and RNP treatments. Obviously, the reference point for when to actually reward is more diffuse compared to cases in which punishment is an option. Therefore, it can be seen that the RN treatment is very inefficient in generating high contributions. The RNP treatment proves that there is a significant correlation between punishment use and average contribution. However, there is no significant correlation between reward use and average contribution. In other words, players are more afraid of being punished than they seek to be rewarded. This is also the case in the long run.

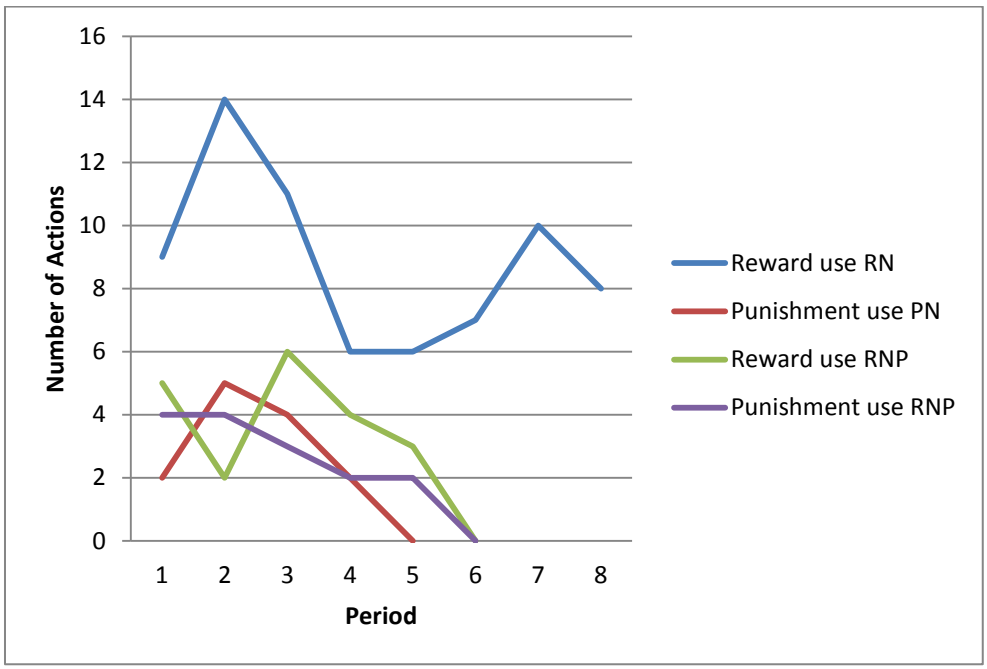

Figure 2. Frequency of the different targeted interactions.

The Impact of Indirect Reciprocity

When reputation in the form of indirect reciprocity is added to the game, an immediate increase in contributions is observed. The average contribution remains at a stable level through all rounds and it is significantly higher than in the control. The average contribution in the indirect reciprocity treatment is close to 22 over all rounds. This means that it is 120% greater than the average contribution in the control, respectively. Even though there is a small dip in contribution just before the first rounds of the indirect reciprocity game is carried out it is clear that this is a temporary decline. As soon as players have taken part in the indirect reciprocity game and actually realized what impact reputation has on the willingness to contribute to the common pool, the average contribution remains stable at a high level.

The Most Efficient Behavior in Making People Contribute

Both direct and indirect reciprocity generates significantly higher contributions than the control. In the latter rounds there is no significant difference in average contribution between the PN and RNP treatments and the indirect reciprocity treatment. However, there is a significant difference in average contribution between the RN treatment and the indirect reciprocity treatment. So, even though the average contribution in the RN treatment initially is relatively high it later stabilizes at a lower level.

It can also be seen that the average contribution in the indirect reciprocity treatment approaches the higher average contribution in the PN and RNP treatments in the long run. In addition to this outcome, we observe that the average contribution in the indirect reciprocity treatment is relatively stable over time despite the absence of a punishment opportunity. In conclusion, indirect reciprocity is an excellent complement for public goods when a punishment option is not preferable.

The Most Efficient Behavior in Generating Value to the Contributor

Generating value to the contributor is not only about generating high contributions. As already shown, indirect reciprocity and a punishment option of direct reciprocity result in high average contributions in the long run. On the other hand, looking at the actual payoffs for players is also of great value. This shows to what extent people benefit in each experiment. Over all rounds, the average payoffs in the control experiment and the RN, PN, RNP and indirect reciprocity treatments are approximately 17, 42, 39, 43 and 37, respectively. This means that the average payoffs in the RN, PN, RNP and indirect reciprocity treatments are about 147%, 129%, 153% and 118% greater than that in the control, respectively.

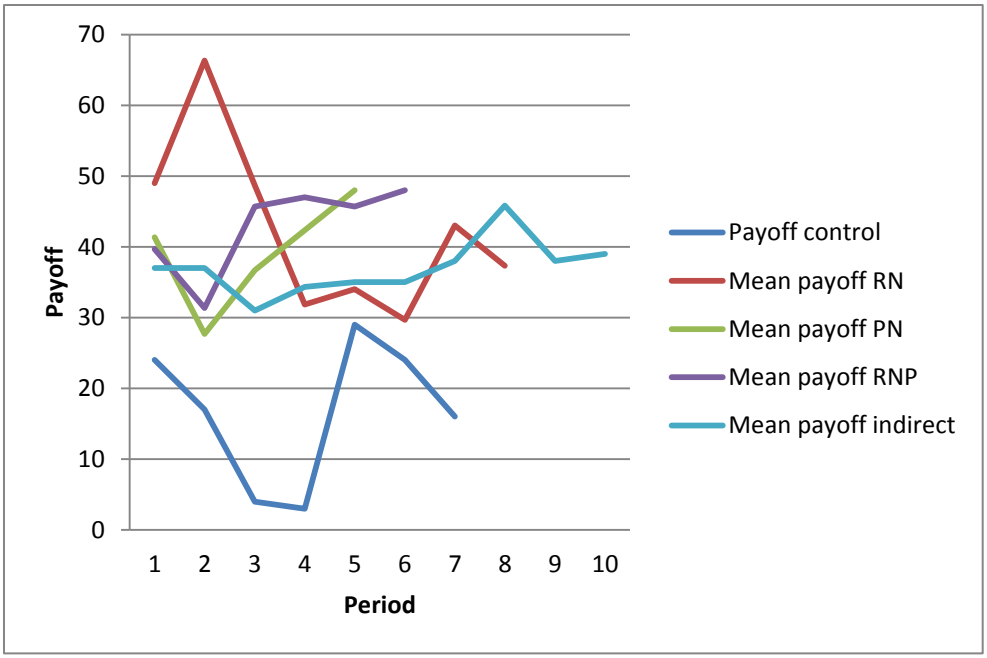

Figure 3. Mean payoff in all treatments including the control experiment.

Apart from a significant difference in average payoff between players in the control experiment and in the reciprocity treatments, there is no significant difference in average payoff between the reciprocity treatments. However, since there is a correlation between contribution and payoff, we can see that the PN, RNP and indirect reciprocity treatments are relatively stable throughout the game.

Previous research suggests that a reward opportunity does not only result in a high contribution, but also in an average payoff exceeding that of scenarios without such an opportunity (Rand et al. 2009). Contrary to these findings, we do not see that a reward opportunity generates a higher average payoff compared to other reciprocity treatments. This is a remarkable finding because targeted interactions bring the payoff up or down according to table 13-19 in appendix A. In other words, the payoff should rise in the RN treatment and decline in the PN treatment. In our case though, average payoffs stabilize at more or less the same level. This is due to the fact that even though players reward others in the RN treatment, contributions remain relatively low. At the same time contributions are at a very high level in the PN and RNP treatments, which results in an absence of punishment use. Also when analyzing average payoffs, we conclude that players are more afraid of being punished than they seek to be rewarded.

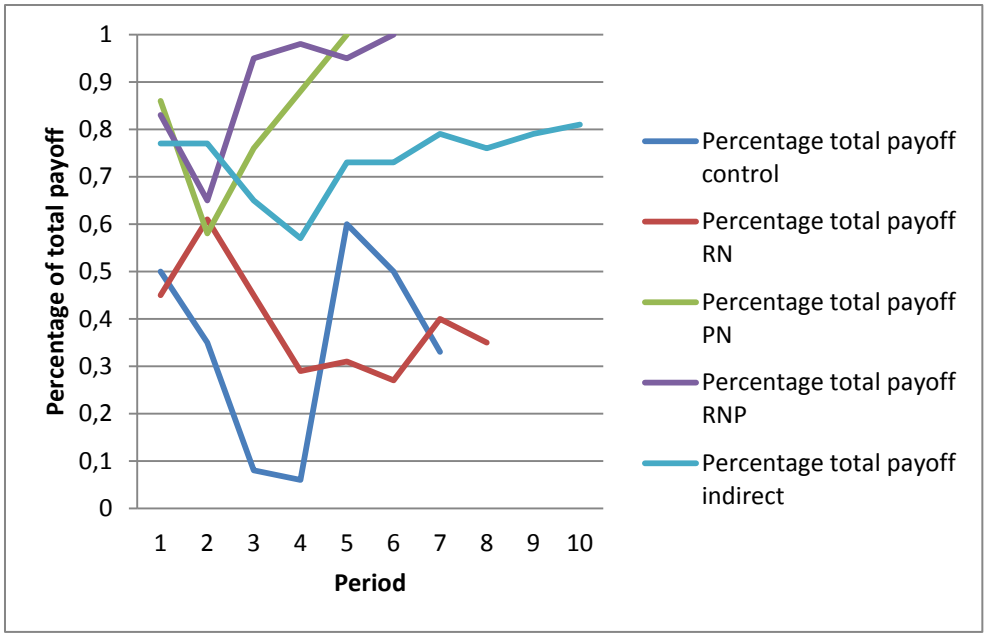

Figure 4. Mean payoff as the percentage of the maximum possible payoff in all treatments including the control experiment.

This discussion ends up in an analysis where we should not only look at the average payoff, but rather at the percentage of the maximum possible payoff. This is because we would like to investigate what kind of reciprocal behavior is the most efficient in generating value to the contributor. It is reasonable to assume that the additional payoff added in the interaction process has to be provided to the game by some external party. The external party could be an institution for instance.

When looking at the percentage of the maximum possible payoff, we see that the PN and RNP treatments generate values close to maximum in the long run. We also see that there is no significant difference between these values and the value in the indirect reciprocity treatment. Thus, a punishment option and reputation are the most efficient ways to generate value to the contributor. Over all rounds, the percentages of the maximum possible payoffs in the control experiment and the RN, PN, RNP and indirect reciprocity treatments are about 35%, 39%, 82%, 89% and 74%, respectively. This means that the average payoffs in the RN, PN, RNP and indirect reciprocity treatments are close to 11%, 134%, 154% and 111% greater than that in the control, respectively.

In our study, we controlled for each treatment individually. However, previous research suggests that an interaction of costly punishment and reputation results in a more efficient cooperative behaviour (Rockenbach and Milinski 2006). In our study, it can also be seen that

both the control and the RN treatment generate a significantly lower percentage of their maximum possible payoffs and are considered less efficient in generating value to the contributor.

Generating Efficient Outcomes in Real-World Public Good Problems

In order to investigate what form of reciprocity could make people contribute to a certain public good and generate value to the contributor, the underlying features of the public good need to be investigated. According to Kaul et al. (1999), public goods can be either intergenerational or intragenerational, but also regional or global. In society, public good problems arise more often than we tend to think they do (Rand et al. 2009).

One of the greatest public goods games ever played by humans is the game of maintaining the earth´s climate in order to reduce the effects of global warming (Milinski et al. 2006). The game of fighting global warming is certainly an intergenerational and global process. For this reason, actions against climate change should not be the same across the globe because different countries have different views on how to solve such problems. According to Ostrom (2000), it has been observed that regulation may "crowd out" social norms. Therefore, reciprocity as a norm enforcing phenomenon would probably be most efficient in countries mainly built up on social norms. As a result, instead of reducing CO_2 emissions through legislation in these countries, we believe people's contributions in maintaining the earth´s climate could be raised through reciprocity.

Considering the empirical results of this study, we believe two different options can be applied to the fight against global warming. At least as long as costly punishment is anonymous we see this as a conceivable solution. For instance, a system where people can pay a certain amount and get permission to increase some anonymous person´s cost of polluting the environment is an option. In our experiment, punishment was mainly used to discourage free riding. Since there are more players and no obvious definition of what the maximum contribution is in the global warming application of the public goods game, it is more likely that people will punish. Thus, punishment can now be seen as a destructive solution and cause a social loss because punishment is costly for both parties. On the other hand, if people expect sufficiently many people to respond reciprocally to how much they contribute, they would increase their contributions and punishment use would decline in the long run.

The other option, which is indirect reciprocity, may be an even more efficient option. For instance, people´s contributions can be published to the public and thus people with high contributions would get a good reputation. As a consequence, other people would notice this and support this behavior in various ways, rewards being one of them. Therefore it would be desirable for more people to establish a good reputation as contributors.

The way of thinking just explained can also be taken into account when dealing with other public goods involving many people, such as broadcasting. In cases where less people are involved, public good problems can also arise. Considering group work at school or doing one's share of work at the office, conditions are a bit different. Here it is more difficult to be anonymous when acting reciprocally. Thus, in order to get punishment to work in such non-anonymous situations, people do not only need to expect sufficiently many people to respond reciprocally to their contributions, but they also need to believe reciprocal types have the courage required to stand up for their opinion when punishing free-riders, despite a certain risk of retaliation of any kind. If these conditions are fulfilled, punishment can be a good solution to this application. For instance, one way of punishing free-riders is simply to shirk. In other words, self-interested types free ride because they are selfish, while reciprocal type's free ride because they act reciprocally.

A complement to the punishment option is certainly indirect reciprocity. By contributing to the good, people get a good reputation and hopefully someone responds by making an effort contributing. This solution is less harsh, and it is of great importance that people´s contributions really make an impression on others so that a reputation is created.

6 Conclusion

The results presented from this experiment are quite clear in the aspect that introducing the concept of reciprocity towards public goods shows a positive effect. We observe a large effect on the willingness to contribute, but also on the value generated to the contributor, from all forms of reciprocity introduced. There is also a variation as to what level of efficiency it has. We observed that, in the experiment conducted, the most efficient way to increase contribution of all players was to introduce an option of punishment. The second most efficient way was to apply indirect reciprocity.

Our results differ a bit from previously conducted experiments in showing that punishment is the most effective method to heighten contributions, which is in contrast to rewards. A probable cause of this differing observation is the increase in number of players by 50% from earlier studies. Because of the donation situation as it is, most players tend to be more afraid of punishment than to seek rewards. With a 50% increase of players the potential punishment value was increased by 67% from the original one, the same percentage applies to potential reward value, and this heightened risk proved to be sufficient to produce different results than earlier studies. The aspect of indirect reciprocity also proved to be very fruitful, though this involves far fewer actions, and produced a mean result which placed itself in between the two forms of direct reciprocity. This means that indirect reciprocity might arguably be the most efficient way of increasing contributions, even though the results indicate that a punitive option gives the highest efficiency increase. As indirect reciprocity involves being rewarded for having a good reputation, building and maintaining this requires a lower level of interaction, contrary to any direct reciprocal system. These conclusions can be applied to several real-world public good problems, such as the fight against global warming and in smaller contexts like group work.

The purpose of this paper has been to further investigate the effects of reciprocity applied towards public goods and therein extend a further understanding of how to use these. An interesting result here has been that introducing more players to the game generated a different outcome than previous studies. Therefore, it might be of interest for future studies to further investigate these extended effects. Furthermore, applying reciprocity to specific public goods is still of great interest. This opens up a possibility of adding different forms of regulation in order to investigate whether reciprocal inclinations are affected.

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Appendix A

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Mean contribution control	7	1,67	15,00	9,6667	5,49326
Valid N (listwise)	7				

Table 1. Descriptive statistics. Mean contribution over all rounds.

Test Statistics[a]

	Mean contribution RN - Mean contribution control	Mean contribution PN - Mean contribution control	Mean contribution RNP - Mean contribution control	Mean contribution indirect - Mean contribution control
Z	-1,753[b]	-1,604[b]	-1,826[b]	-2,023[b]
Asymp. Sig. (2-tailed)	,080	,095	,068	,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 2. Wilcoxon signed-rank test. Mean difference in contribution identified at a 5% or 10% significance level.

Test Statistics[a]

	Mean contribution PN - Mean contribution RN	Mean contribution RNP - Mean contribution RN
Z	-1,604[b]	-1,826[b]
Asymp. Sig. (2-tailed)	,095	,068

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 3. Wilcoxon signed-rank test. Mean difference in contribution identified at a 5% or 10% significance level.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Mean contribution control	7	1,67	15,00	9,6667	5,49326
Mean contribution RN	8	13,33	28,33	18,9583	5,70766
Mean contribution PN	5	28,00	30,00	29,0000	,73598
Mean contribution RNP	6	27,50	30,00	28,8056	,91540
Valid N (listwise)	5				

Table 4. Descriptive statistics. Mean contribution over all rounds.

Correlations

			Reward use RNP	Punishment use RNP	Mean contribution RNP
Spearman's rho	Reward use RNP	Correlation Coefficient	1,000	,441	-,406
		Sig. (2-tailed)	.	,381	,425
		N	6	6	6
	Punishment use RNP	Correlation Coefficient	,441	1,000	-,940**
		Sig. (2-tailed)	,381	.	,005
		N	6	6	6
	Mean contribution RNP	Correlation Coefficient	-,406	-,940**	1,000
		Sig. (2-tailed)	,425	,005	.
		N	6	6	6

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5. Spearman correlation. Significant correlation identified between mean contribution RNP and punishment use, however not between mean contribution RNP and reward use.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Mean contribution control	7	1,67	15,00	9,6667	5,49326
Mean contribution indirect	10	18,00	24,67	22,2333	2,27466
Valid N (listwise)	7				

Table 6. Descriptive statistics. Mean contribution over all rounds.

Test Statistics[a]

	Mean contribution indirect - Mean contribution control
Z	-2,023[b]
Asymp. Sig. (2-tailed)	,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 7. Wilcoxon signed-rank test. Mean difference in contribution identified at a 5% significance level.

Test Statistics[a]

	Mean contribution RNP - Mean contribution PN	Mean contribution indirect - Mean contribution PN	Mean contribution indirect - Mean contribution RNP
Z	-1,000[b]	-1,342[b]	-1,504[b]
Asymp. Sig. (2-tailed)	,317	,180	,109

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

Table 8. Wilcoxon signed-rank test. No mean difference in contribution identified at a 10% significance level given that period > 3.

Test Statistics[a]

	Mean contribution indirect - Mean contribution RN
Z	-2,023[b]
Asymp. Sig. (2-tailed)	,043

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 9. Wilcoxon signed-rank test. Mean difference in contribution identified at a 5% significance level given that period > 3.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Payoff control	7	3,00	29,00	16,7143	10,06171
Mean payoff RN	8	29,67	66,33	42,4792	12,10648
Mean payoff PN	5	27,67	48,00	39,2000	7,60336
Mean payoff RNP	6	31,33	48,00	42,8889	6,36192
Mean payoff indirect	10	31,00	45,83	37,0167	3,87494
Valid N (listwise)	5				

Table 10. Descriptive statistics. Mean payoff over all rounds.

Test Statistics[a]

	Mean payoff RN - Payoff control	Mean payoff PN - Payoff control	Mean payoff RNP - Payoff control	Mean payoff indirect - Payoff control
Z	-2,366[b]	-2,023[b]	-2,201[b]	-2,366[b]
Asymp. Sig. (2-tailed)	,018	,043	,028	,018

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 11. Wilcoxon signed-rank test. Mean difference in payoff identified at a 5% significance level.

Test Statistics[a]

	Mean payoff PN - Mean payoff RN	Mean payoff RNP - Mean payoff RN	Mean payoff indirect - Mean payoff RN	Mean payoff RNP - Mean payoff PN	Mean payoff indirect - Mean payoff PN	Mean payoff indirect - Mean payoff RNP
Z	-,405[b]	-,314[c]	-,840[b]	-1,214[c]	-,944[b]	-1,482[b]
Asymp. Sig. (2-tailed)	,686	,753	,401	,225	,345	,112

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

Table 12. Wilcoxon signed-rank test. No mean difference in payoff identified at a 10% significance level.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5,500	5,391		1,020	,347		
	Reward use RN	4,167	,583	,946	7,141	,000	1,000	1,000

Table 13. Regression of mean payoff RN on reward use RN.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,946[a]	,895	,877	4,24264	1,293

a. Predictors: (Constant), Reward use RN

b. Dependent Variable: Mean payoff RN

Table 14. Adjusted R-square is relatively high. However, since the Durbin-Watson statistic is < 1.5-2.5 there is risk for autocorrelation.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	48,996	1,825		26,854	,000		
	Punishment use PN	-3,768	,583	-,966	-6,464	,008	1,000	1,000

a. Dependent Variable: Mean payoff PN

Table 15. Regression of mean payoff PN on punishment use PN.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,966[a]	,933	,911	2,27228	2,579

a. Predictors: (Constant), Punishment use PN

b. Dependent Variable: Mean payoff PN

Table 16. Adjusted R-square is relatively high. However, since the Durbin-Watson statistic is > 1.5-2.5 there is a minor risk for autocorrelation.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	48,208	,818		58,950	,000		
	Punishment use RNP	-5,261	,340	-1,254	-15,474	,001	,627	1,594
	Reward use RNP	2,350	,239	,798	9,845	,002	,627	1,594

a. Dependent Variable: Mean payoff RNP

Table 17. Regression of mean payoff RNP on punishment use RNP and reward use RNP.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,994[a]	,988	,979	,91317	1,871

a. Predictors: (Constant), Reward use RNP, Punishment use RNP

b. Dependent Variable: Mean payoff RNP

Table 18. Adjusted R-square is relatively high. Since the Durbin-Watson statistic is within the interval 1.5-2.5 there is no risk for autocorrelation.

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Punishment use RNP	Reward use RNP
1	1	2,759	1,000	,02	,02	,02
	2	,145	4,356	,93	,08	,30
	3	,095	5,387	,04	,90	,68

a. Dependent Variable: Mean payoff RNP

Table 19. Since the condition index in the second dimension is < 20 there is no risk for multicollinearity.

Test Statistics[a]

	Percentage total payoff RNP - Percentage total payoff PN	Percentage total payoff indirect - Percentage total payoff PN	Percentage total payoff indirect - Percentage total payoff RNP
Z	-1,214[b]	-1,214[c]	-1,504[c]
Asymp. Sig. (2-tailed)	,225	,225	,109

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

Table 20. Wilcoxon signed-rank test. No mean difference in percentage of total payoff identified at a 10% significance level.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Percentage total payoff control	7	,06	,60	,3482	,20962
Percentage total payoff RN	8	,27	,61	,3933	,11210
Percentage total payoff PN	5	,58	1,00	,8167	,15840
Percentage total payoff RNP	6	,65	1,00	,8935	,13254
Percentage total payoff indirect	10	,57	,81	,7378	,07474
Valid N (listwise)	5				

Table 21. Descriptive statistics. Percentage of total payoff over all rounds.

Test Statistics[a]

	Percentage total payoff PN - Percentage total payoff control	Percentage total payoff PN - Percentage total payoff RN	Percentage total payoff RNP - Percentage total payoff control	Percentage total payoff RNP - Percentage total payoff RN	Percentage total_payoff indirect - Percentage total payoff control	Percentage total payoff indirect - Percentage total payoff RN
Z	-2,023[b]	-1,753[b]	-2,201[b]	-2,201[b]	-2,366[b]	-2,521[b]
Asymp. Sig. (2-tailed)	,043	,080	,028	,028	,018	,012

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 22. Wilcoxon signed-rank test. Mean difference in percentage of total payoff identified at a 5% or 10% significance level.

Appendix B

Written Instructions Translated into English

Instructions to experiment in economics

Bachelor's thesis at the Stockholm School of Economics

Thank You for your participation in this experiment about decision making. Please read through the instructions carefully and if you have any questions we are open to answer them before the experiment starts. Apart from initial questions answered before the experiment, all forms of communication during the experiment are prohibited. All information collected in the experiment will be dealt with confidentially and used for research purposes only. Each winner will receive a monetary compensation of 40 SEK.

The sample in this experimental occasion is 6 people. Each participant will initially be given an endowment of 75 monetary units (MU) and based on the actions of each participant you will have the opportunity to earn more money than the original amount. The first stage is to within 20 seconds leave a contribution of 0-30 MU to a public good. The total amount given is multiplied by the factor 1.6 and the product will be divided equally between all participants. In other words, the monetary endowment of each participant after the current round is calculated by the equation:

75 – (your contribution to the public good) + 1.6 x (sum of all contributions) / (total number of participants)

For instance, if all participants contribute the monetary amount of 20 to the public good, the total endowment for each participant is as follows:

$$75 - 20 + \frac{1.6*120}{6} = 87$$

It is also possible for each participant to leave a contribution smaller than the maximum amount and thus earn a higher proportion of the total payoff. For instance, if one player contributes the amount of 0 MU and the other players contribute 20 MU, each participant will end up with the following endowments:

P1: $75 - 20 + \frac{1.6*100}{6} = 82$ (contribution 20)

P2: $75 - 20 + \frac{1.6*100}{6} = 82$ (contribution 20)

P3: $75 - 20 + \frac{1.6*100}{6} = 82$ (contribution 20)

P4: $75 - 0 + \frac{1.6*100}{6} = 102$ (contribution 0)

P5: $75 - 20 + \frac{1.6*100}{6} = 82$ (contribution 20)

P6: $75 - 20 + \frac{1.6*100}{6} = 82$ (contribution 20)

The process described will be repeated an unknown number of times and after each round all players' contributions from the previous round will be presented.

In this experiment another stage is added to the previously conducted experiment. When all participants' donations have been made public every participant will get the option to choose if they want to take action towards each other. The options available are:

A: You get -4 MU and the receiver gets +12 MU (reward)

B: No action

C: You get -4 MU and the receiver gets -12 MU (punishment)

You will have 20 seconds to make your choices. After this stage each participant's contribution will be calculated and made public. This process will be repeated for an unknown number of rounds.

The experiment will be conducted in three different variations:

1. Choose between A and B (reward and no action)
2. Choose between B and C (no action and punishment)
3. Choose between A, B and C (reward, no action and punishment)

This experiment keeps the same form as the first one but will alternate with a bit different variant.

What this means it that you will first go through a number of rounds of the first experiment, when these have been made you will each be paired up with another person. You will be divided in potential donors and potential receivers. The donor will be presented with the donation history of the previous 6 rounds for their respective receiver. After that the donor will be given the choice to reward or do nothing towards the receiver. The options given will be:

A: You get -4 MU and the receiver gets +12 MU

B: No action

You will have 20 seconds to decide what to do. After this the first experiment will commence again for a number of rounds and then this addition will be repeated again. Every participant will get to act as a potential donor and a potential receiver at least once.

A donor will never get to act as a receiver from someone that it has acted as a donor towards. This means that if person A is a potential donor and person B potential receiver then person B will never act as a donor to person A.

Written Instructions in the Original Language Swedish

Instruktioner till experiment i nationalekonomi

Kandidatuppsats vid Handelshögskolan i Stockholm

Tack för Ert deltagande i detta experiment som handlar om beslutsfattande. Läs igenom instruktionerna noggrant och har Ni några frågor besvaras de innan experimentet börjar. Frånsett eventuella frågor innan experimentet börjar, är alla former av kommunikation under experimentet ej tillåtna. All information som insamlas under experimentet kommer behandlas konfidentiellt och endast användas i denna studie. Varje vinnare tilldelas en monetär ersättning av 40 SEK.

Urvalsgruppen i detta tillfälle för experimentet är 6 personer. Varje deltagare tilldelas inledningsvis 75 monetära enheter (ME) och beroende på hur varje deltagare agerar under experimentets gång har Ni möjlighet att tjäna mer än den ursprungliga summan. Till att börja med kommer Ni få 20 sekunder på er att lämna ett bidrag på 0-30 ME till en gemensam tillgång. Den totala summan kommer att multipliceras med faktorn 1,6 och produkten sedan fördelas jämt mellan alla deltagare. Detta betyder att varje deltagares monetära summa efter omgången beräknas enligt följande formel:

75 – (ditt bidrag till den gemensamma tillgången) + 1.6 x (summan av alla bidrag) / (totala antalet deltagare)

Exempelvis om alla deltagare bidrar med den monetära summan 20 till den gemensamma tillgången blir den totala summan för varje deltagare:

$$75 - 20 + \frac{1.6 * 120}{6} = 87$$

Det är också möjligt för varje deltagare att bidra med ett belopp lägre än det maximala och på så sätt tjäna en större andel av den totala utdelningen. Exempelvis om en deltagare bidrar med 0 ME och de andra bidrar med 20 ME blir utfallet för varje deltagare:

P1: $75 - 20 + \frac{1.6*100}{6} = 82$ (bidrag 20)

P2: $75 - 20 + \frac{1.6*100}{6} = 82$ (bidrag 20)

P3: $75 - 20 + \frac{1.6*100}{6} = 82$ (bidrag 20)

P4: $75 - 0 + \frac{1.6*100}{6} = 102$ (bidrag 0)

P5: $75 - 20 + \frac{1.6*100}{6} = 82$ (bidrag 20)

P6: $75 - 20 + \frac{1.6*100}{6} = 82$ (bidrag 20)

Den beskrivna processen kommer att upprepas ett okänt antal gånger och efter varje omgång offentliggörs varje deltagares bidrag i den föregående omgången.

I detta experiment läggs ett nytt steg till det nyss utförda experimentet. Efter att alla deltagares bidrag offentliggjorts har varje deltagare en möjlighet att agera mot övriga deltagare. De olika aktionerna är:

A: Du får -4 ME och mottagaren får +12 ME (belöning)

B: Ingen aktion

C: Du får -4 ME och mottagaren får -12 ME (bestraffning)

Ni kommer att få 20 sekunder på er att göra dessa val. Efter detta steg beräknas varje deltagares bidrag och offentliggörs. Den beskrivna processen kommer att upprepas ett okänt antal gånger.

Experimentet kommer utföras i tre olika varianter:

1. Välj mellan A och B (belöning och ingen aktion)
2. Välj mellan B och C (ingen aktion och bestraffning)
3. Välj mellan A, B och C (belöning, ingen aktion och bestraffning)

Detta experiment innehåller samma typ som det första men kommer att varvas med en lite annorlunda variant.

Detta innebär att Ni först kommer genomföra ett antal rundor av det första experimentet, när de har gjorts så kommer ni att paras ihop och få agera mot en person i taget. Ni kommer att bli bemärkta som potentiella givare och potentiella mottagare. Givaren kommer att bli presenterad med bidragshistoriken för de senaste 6 rundorna hos respektive mottagare. Därefter kommer givaren att bli presenterad med ett val att belöna eller inte göra någonting mot mottagaren.

A: Du får -4 ME och mottagaren får +12 ME

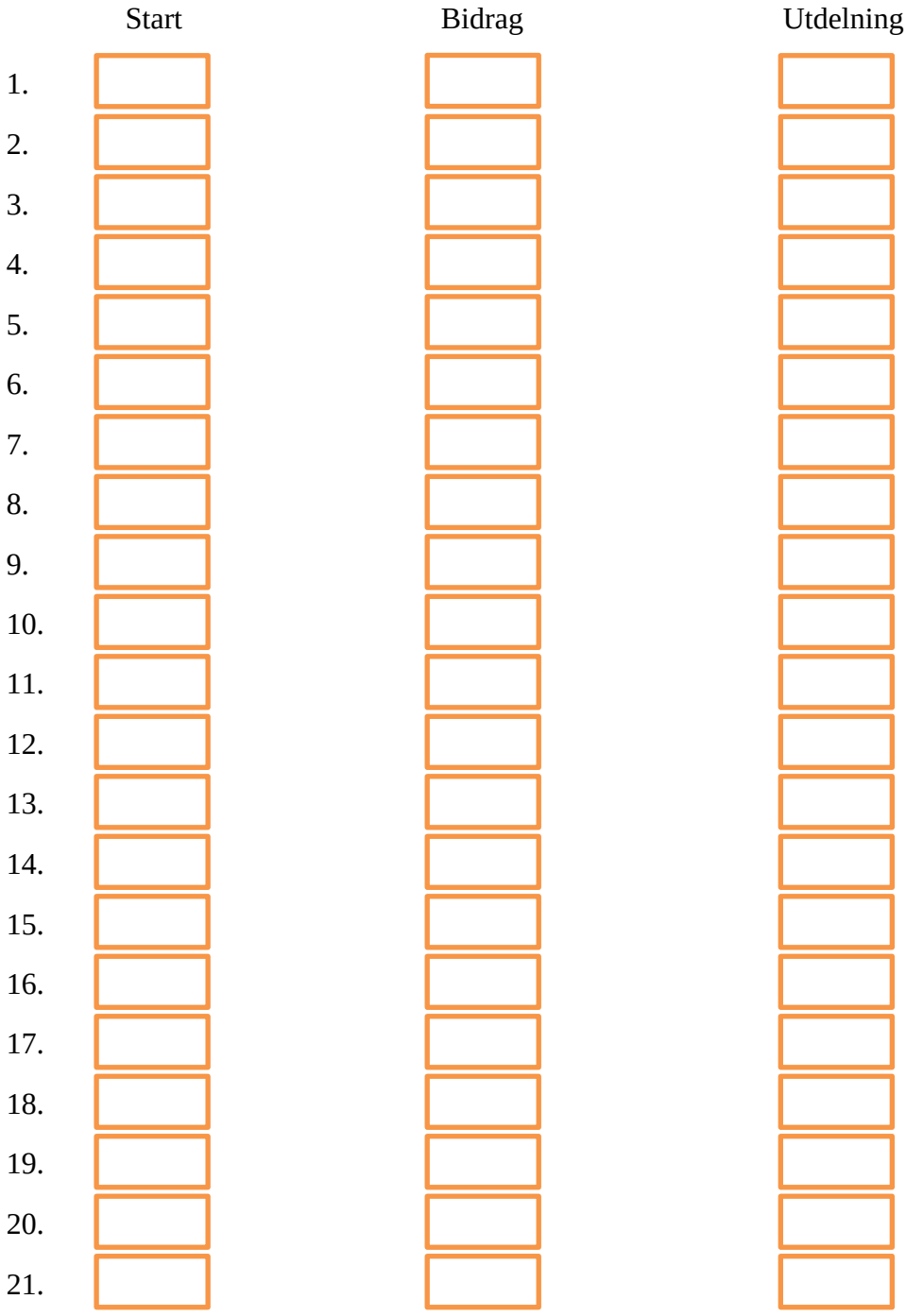
B: Ingen aktion

Ni kommer att få 20 sekunder på er att genomföra detta val. Därefter kommer det första experimentet att återigen påbörjas och efter ett antal rundor så kommer detta experiment upprepas ytterligare en gång. Alla deltagare kommer att få agera potentiell givare och potentiell mottagare en gång vardera.

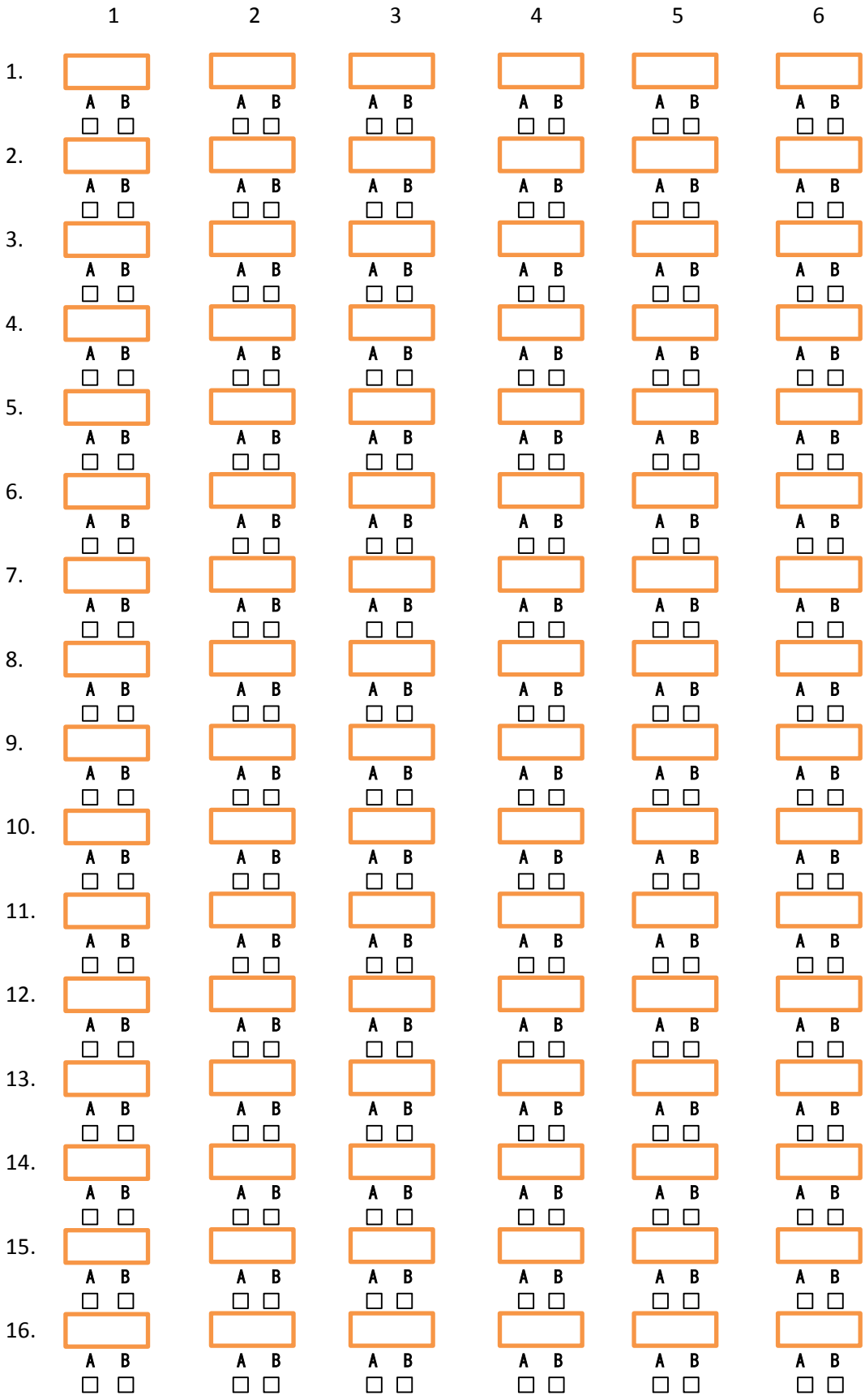
En givare kommer aldrig att agera mottagare till någon som denna tidigare varit givare mot, detta betyder att om person A är potentiell givare och person B potentiell mottagare så kommer person B aldrig att vara givare till person A.

Appendix C

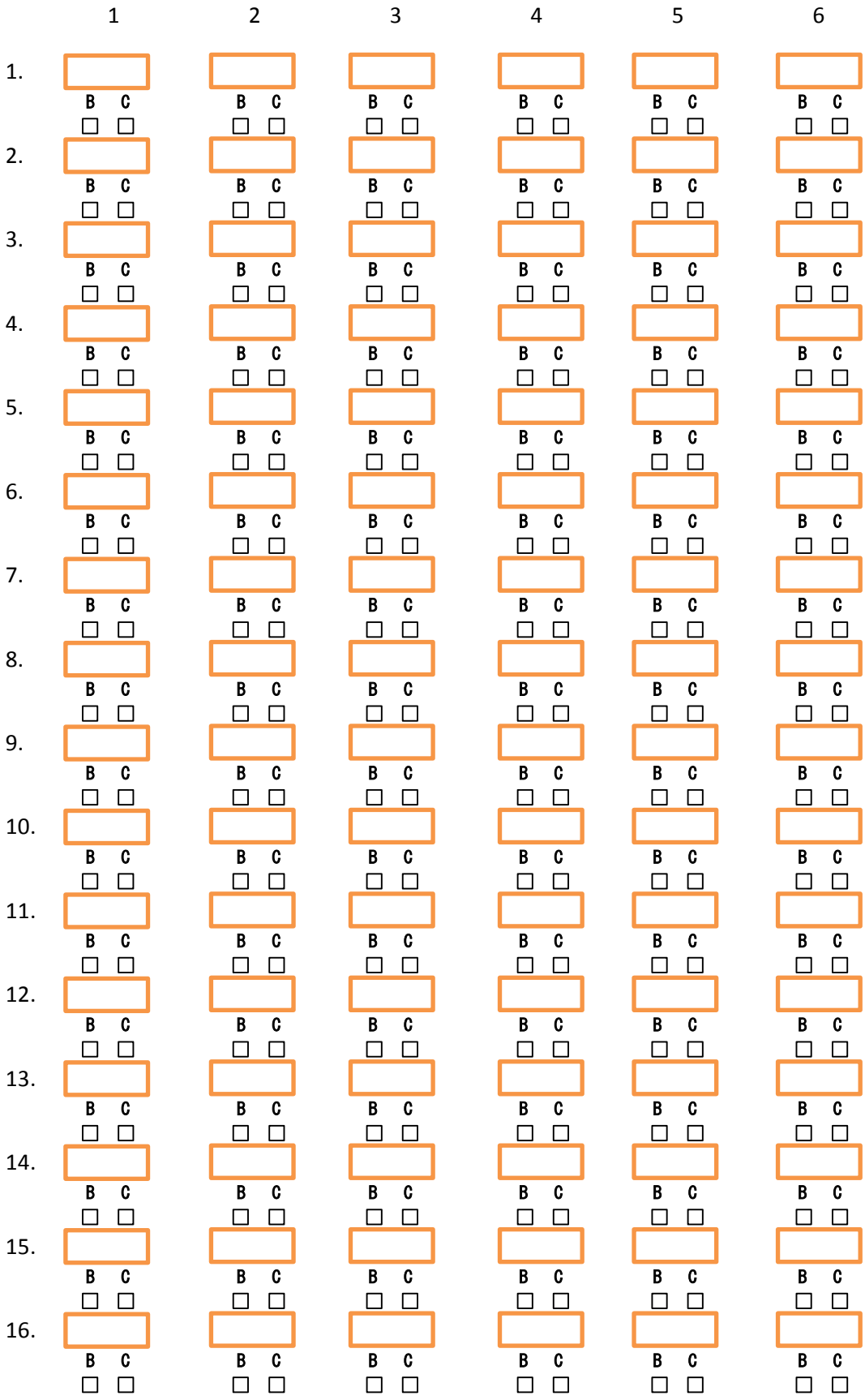
Hand-Out Sheet 1: Public Goods Game



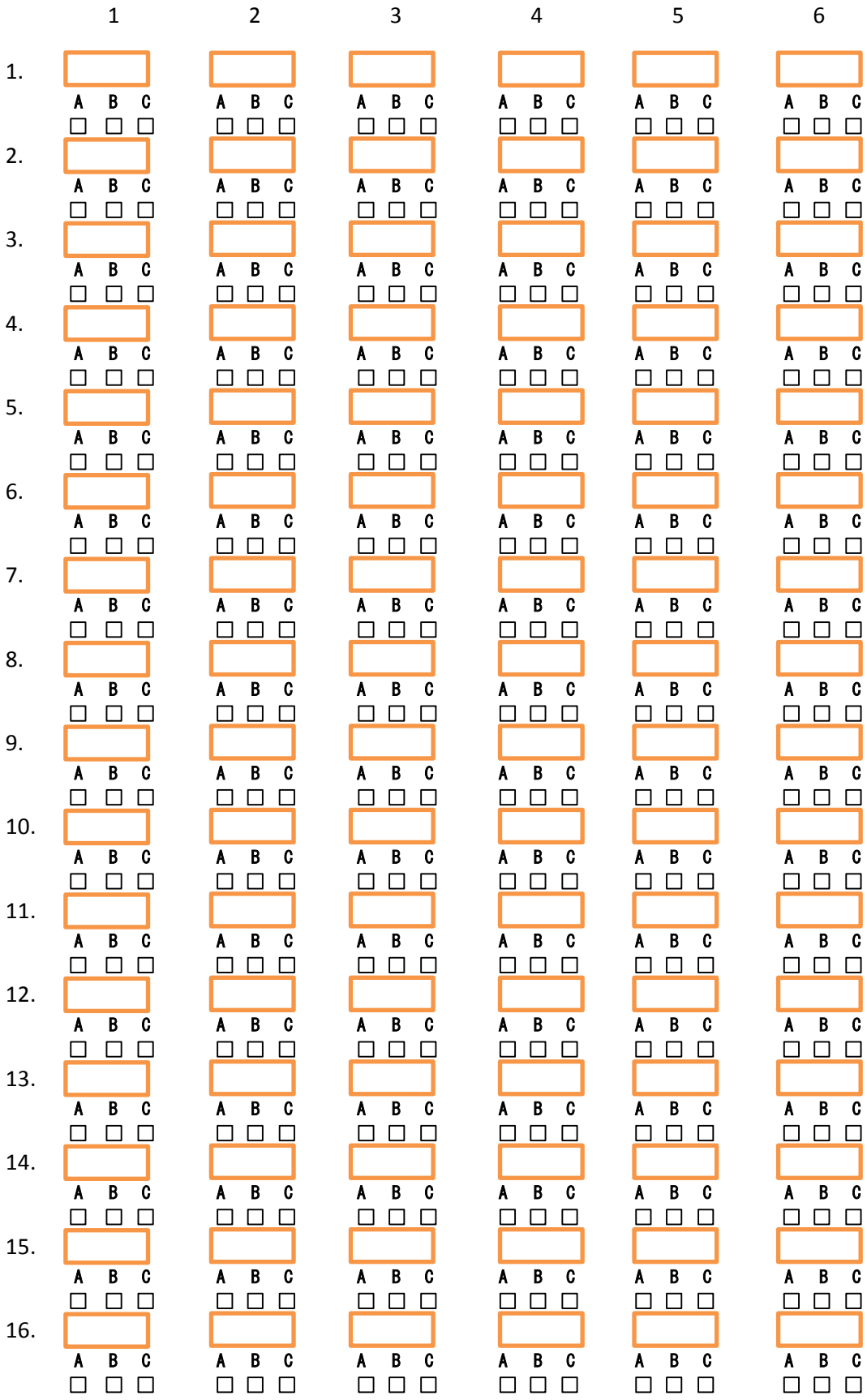
Hand-Out Sheet 2: Reward Treatment



Hand-Out Sheet 3: Punishment Treatment



Hand-Out Sheet 4: Reward-Neutral-Punishment Treatment



A B

A B

A B

A B