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# An Experimental Test of Direct and Indirect Reciprocity in Case of Complete and Incomplete Information

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# An Experimental Test of Direct and Indirect Reciprocity in Case of Complete and Incomplete Information*

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*Abstract:* Direct reciprocity means to respond in kind to another person whereas indirect reciprocity is understood here as rewarding someone else. We perform corresponding experiments which use a similar underlying structure as the reciprocity experiment of Berg, Dickhaut, and McCabe (1995). Another variation concerns the information about the multiplier of donations where we compare the benchmark case with a commonly known multiplier to a condition where the multiplier is known for sure only by donators. Questions which we try to answer are: Will indirect reciprocity induce higher or lower donations?, will donators with the high multiplier "hide behind the small one?", how do receivers respond to the different situations?

*JEL codes:* C72, C92

*Key words:* Trust, reciprocity, experiment, game

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## 1. Introduction

The names of the following fairy tale may be a bit unusual, but they will be consistent with the notation which will be used throughout the paper: $X_2$ receives a large amount from $Y_1$ with whom he had so far no contact at all. $X_2$ asks $Y_1$: "Why are you so generous?" $Y_1$ answers: "Somebody else – $X_1$! – has been nice to me and I wanted to be thankful." $X_2$ asks again: "Why didn't you try to reward $X_1$?" $Y_1$ answers: "Oh, I would have loved to. But this was impossible. You are the only one I can reward." $X_2$ concludes: "Now I understand. Thanks!"

What may appear like a fairy tale can often be experimentally implemented so that we can learn whether the behavioral assumptions are realistic or not. Our starting point is the *trust game* introduced by Berg, Dickhaut, and McCabe (1995) (henceforth BDM). Here a donator can give as much as he wants of a monetary endowment to a receiver. The amount given by the donator is tripled, and then the receiver may return as much as he wants to the donator. Thus by trust in reciprocity (see Güth and Kliemt, 1994, for a theoretical discussion) players can achieve an enormous efficiency gain. They can triple the amount initially made available.

We perform an experiment in which one treatment is a replication of the BDM set-up. We call this the direct reciprocity treatment. In another treatment we transform the BDM game so that it allows us to explore what we call indirect reciprocity. In this indirect reciprocity treatment a group consisting of four persons interact — two donators and two receivers. Instead of repaying his own donator, as in the direct reciprocity treatment, receivers can only repay *the other* donator.

We also investigate the effect of a third treatment which allows for private information of donators about the factor by which donations are multiplied. In the BDM study, and in our first two treatments, the factor is 3. In our incomplete

information treatment the multiplier is either 2 or 4, each with probability one half and *only donators* are informed about the value of this multiplier. Thus a donator, whose donation will be multiplied by the larger factor of 4, may attempt to "hide his greed" (see Güth, Huck, and Ockenfels, 1996, for experimental evidence) by choosing a donation which looks like a generous one for a multiplier of 2, if such a cunning stratagem is feasible. Private information about the multiplier of donations thus allows us to distinguish between intrinsically motivated donators and those who are only interested in an image of generosity.[5]

In the following section our experimental procedure will be explained in more detail. We then test whether indirect reciprocity induces at least as high donations as direct reciprocity, whether donators with the large multiplier attempt to hide behind the small multiplier, and how receivers react in the various treatments. We finally discuss in the light of these results why receivers reward at all.

**2. Experimental design**

To prevent any confounding effects a group of four individuals was mentioned in the instructions for every treatment (see Appendix A), even though effectively it was only in the indirect reciprocity case that the players were not engaging in two-player games. Let us denote by $X_i$ for $i = 1,2$ the two donators and by $Y_j$ for $j = 1,2$ the two receivers of each group. The distinction between direct and indirect reciprocity is graphically visualized by Figure II.1.

[Insert Fig II.1 here]

[5] Another interesting treatment might be to let only receivers know by which factor donations are multiplied. However, we shall not explore that possibility here.



In Figure II.1 the variable $x_i$ with $0 \leq x_i \leq e$ is what $X_i$ gives away where e denotes $X_i$'s endowment, $i = 1,2$. In all treatments e was equal to 10 "points", with each point worth 8 New Israeli Shekels (NIS).[6] What $X_i$ receives is $3x_i$. From this $Y_i$ can return any amount $y_i$ with $0 \leq y_i \leq 3x_i$. Whereas the receiver of $y_i$ is $X_i$ in case of direct reciprocity, it is $X_j$ with $j \neq i$ when only indirect reciprocity is possible.

Whereas the multiplier of donations is commonly known in the complete information treatments, *only donators know* whether the value of this parameter is 2 or 4 in the incomplete information treatment. Receivers $Y_i$ were told in their instructions for the incomplete information treatment that half of the donators have the large multiplier of 4 and the other half the smaller one of 2 and that this is commonly known. Thus the expected multiplier is 3 as in the treatments with complete information as well as in the original BDM study.

The monetary payoffs $U_i$ of a donator $i = 1,2$ and $V_i$ of a receiver $i = 1,2$ are in the cases of direct reciprocity and complete information

$$U_i = e - x_i + y_i$$
$$V_i = 3x_i - y_i$$

and analogously in the cases of indirect reciprocity for $i,j = 1,2$, $i \neq j$:

$$U_i = e - x_i + y_j$$
$$V_i = 3x_i - y_i$$

In the case of direct reciprocity and incomplete information the factor 3 in the definition of $V_i$ has to be substituted by 2 or 4, respectively.

[6] At the time of the experiment, 3.5 NIS equaled approximately one US dollar.

The "classical" solution would assume that players are only interested in their own monetary payoff: Since receivers $Y_i$ act in subgames the structures of which are effectively dictator games, their optimal decision would be to choose $y_i = 0$ in each treatment. Anticipating that nothing will be given back, donators $X_i$ will therefore avoid positive donations and choose $x_i = 0$. Formally, this solution behavior can be derived by once repeated elimination of (weakly) dominated strategies or as a subgame perfect equilibrium (assuming only equilibrium behavior would not rule out positive choices of $y_i$ following positive donations $x_i$ which are not chosen in some particular equilibrium).

The complete design is visualized in Figure II.2 showing that we do not want to test for interaction effects.

[Insert Fig II.2 here]

Further details of the experimental procedure should become evident from the Instructions (see Appendix A). After a pilot experiment at Uppsala University the main experiments were performed at the University of Haifa. In our (statistical) analysis we just use the results of the main experiments although those of the pilot experiment would have strengthened our conclusions.

In Figure II.3, using the format of Figure II.2, we list the average earnings in NIS, the time (in minutes needed), and the number of participants for each treatment.

[Insert Fig II.3 here]



**3. Experimental results**

A first impression of the experimental results can be gained from Table III.1 which, with treatments visualized as in Figure II.2, lists for all three treatments the averages, medians, standard deviations, and the numbers of observations both for donations $x_i$ (left column) as well as for amounts returned $y_i$ (right column).

[Insert Table III.1 here]

Whereas the interest rate, defined as

$$r = [(\text{mean } y) / (\text{mean } x) - 1] \cdot 100,$$

is negative (-6.62 %) for direct reciprocity, it is higher (+22.87 %) for indirect reciprocity. This difference of $1 + r = 1.2287$ and $1 + r = .9338$ is, however, not significant ($p = .4351$ with a Mann-Whitney test comparing the different samples of individual interest rates defined as $r_i = [(y_i / x_i) - 1] \cdot 100$ for direct reciprocity and $r_i = [(y_j / x_i) - 1] \cdot 100$ for indirect reciprocity.

Although direct reciprocity inspires more donations on average (the difference is insignificant — $z = .807$, $p = .4197$ with a Mann-Whitney test), these investments in trust in reciprocity are poorly rewarded. For indirect reciprocity such investment appear like a reasonable investment chance.

In case of incomplete information the interest rate $r = -12.06\%$ is again negative as for direct reciprocity with a commonly known multiplier. Here it is, of course, interesting to distinguish between pairs with the large multiplier of 4 and those with the small multiplier of 2 (see Table III.2).

[Insert Table III.2 here]

The positive difference of donations $x_i$ for the small and the large multiplier is not significant ($z = -1.321$, $p = 0.1864$).

We thus can conclude:

- Indirect reciprocity induces only insignificantly smaller donations than direct reciprocity.
- Donators with the large multiplier do not donate significantly more, i.e. we observe "hiding of greed" as Güth, Huck, and Ockenfels (1996)[7].
- Receivers are more rewarding in the case of indirect reciprocity in the sense that they pay a positive interest rate r only in case of indirect reciprocity, whereas r is negative in both direct reciprocity treatments. However, this difference is not significant.

We find the last of these results rather surprising. We initially expected higher rates of return in the direct reciprocity treatment than in the indirect reciprocity treatment. Instead, there is no clear difference between the treatments. If anything, the difference goes the opposite way to what we expected!

[7] Note that even if the multiplier $\mu$ is initially known only by the donator, many choices will unambiguously "signal" its value. For example, for a donation of 7 the receiver gets 14 or 28, and in either case the value of $\mu$ will be apparant. Nevertheless, the donator can always "hide" by donating for example 4.



**4. On rewarding**

If receivers reward positive donations, one may view donations as risky investments. If such investments do not pay as in case of the direct reciprocity treatments, one may ask, of course, whether this is due to overly optimistic expectations or to other motives, e.g. a desire for efficiency. To test this, one would have to elicit the beliefs of donators in order to find out how much they expect to get back. In a somewhat similar game, Dufwenberg and Gneezy (2000) elicit beliefs and report some evidence that first-movers may be motivated by efficiency rather than a hope for monetary gain. Conceivably, a similar effect could operate in the current design. Since we did not measure beliefs we do not discuss this further. Instead, we focus on the following issue: Why do some receivers reward?

Unlike in dictator games, where no reciprocity argument can explain positive donations[8], all our treatments provide a ready justification for positive rewards, namely that receivers were rewarded before. The hypothesis "positive rewards ($x_i > 0$) trigger positive reactions ($y_j \geq x_i$) for $i = j$ and $i \neq j$" would apply to both, direct and indirect reciprocity. A distinction between direct and indirect reciprocity could be based on the degree of obligation which a positive donation implies. It seems reasonable to assume that one feels more obliged to reciprocate directly than indirectly. After all the direct reciprocity game suggests an implicitly agreed upon mutual exchange whereas any similar justification for the indirect reciprocity game appears rather farfetched.

[8] If one excludes indirect reciprocity in the sense that dictators reward receivers since they got their position for free (from the experimenters).

In the light of this, our finding that the receivers are most rewarding in the indirect reciprocity treatment is odd. A call for more research, specifically aimed at revealing what psychological forces can explain this anomaly, seems warranted. In this connection, let us note an aspect which might be important to consider when designing future related experiments. The obligation to reward if one is rewarded could be strengthened by allowing to observe others' behavior. The reason would be that one feels ashamed if one does not properly reward after a favor (see Hoffman et al., 1994, who claim less rewarding in double blind dictator experiments, and Bolton and Zwick, 1995, for other results). Our experiments were not double-blind, but interaction was anonymous. The direct reciprocity results seem to suggest that usually receivers feel not at all ashamed not to reward properly. Nevertheless one might perform an experiment where the essential treatment variation concerns how much the others (in one's 4 participant-group) learn about the own behavior (Guth, Konigstein, and Nehring, 1999).

One may ask why receivers should feel at all obliged or ashamed in case of anonymous interaction (without a shadow of the future like it would exist in case of repeated trust games). Guth and Kliemt (1994) provide an evolutionary justification only if the receiver's moral type can be more or less reliably detected. This is ruled out by anonymity.

It is possible, however, that we do not decide in each instance of life anew whether or not we trust, e.g. by donating, or reward trust, e.g. by rewarding donators. In other words: We do not play lots of games but just the game of life. Consequently an evolutionary argument should not be based on a highly specific instance and its special information conditions but on the usual situation of human interaction where knowing others' moral types is rather likely. In other words: Experimental participants import their usual attitudes in the laboratory, for instance, a general obligation to reward trust (in reciprocity).



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**Appendix A:**

**Instructions for Player A in the indirect treatment**

(Translated from Hebrew)

Welcome to this experiment in decision-making. In this experiment, you may earn some money that will be paid to you, privately and in cash, at the end.

The interaction in the experiment will be in groups of four participants, where the students in each group are called A, A', B, and B'. You are called Student A. At the beginning of the experiment both you and student A' will receive 10 "points". Students B and B' will not receive points.

You are asked to decide whether you want to send any amount of these 10 points to student B; and if so, how much. We will triple the amount you send and give it to student B; that is, for every 1 point that you send, student B will receive 3 points. Student A' will be asked to decide how much to send to student B' in a similar way.

Then we will ask student B' (who received the money from student A') to decide if (s)he wants to send to you any amount of the points (s)he received from A' and if so, how much. This amount will not be tripled. Student B will be asked if (s)he wants to send money to student A' in the same fashion.

This will end the experiment, and the money will be paid to you (for every point you will have at the end we will pay you NIS 8).

Your ID number: _____

Number of points you want to send to student B: _____ (Please remember that this amount should be between 0 and 10 points.)



**Instructions for Player B in the indirect treatment**

(Translated from Hebrew)

Welcome to this experiment in decision-making. In this experiment, you may earn some money that will be paid to you, privately and in cash, at the end.

The interaction in the experiment will be in groups of four participants, where the students in each group are called A, A', B, and B'. You are called Student B. At the beginning of the experiment both student A and student A' will receive 10 "points". You and student B' will not receive points.

Student A will be asked to decide whether to send any amount of these 10 points to you; and if so, how much. We will triple this amount and give it to you; that is, for every 1 point that student A will send you will receive 3 points. Student A' will be asked to decide how much to send to student B' in a similar way.

Then we will ask you to decide if you want to send any amount of the points to student A' (not to A) and if so, how much. This amount will not be tripled. Student B' will be asked if (s)he wants to send money to student A in the same fashion.

This will end the experiment, and the money will be paid to you (for every point you will have at the end we will pay you NIS 8).

Your ID number: _____

The amount of points sent to you by student A (after we tripled it): _____

Number of points you want to send to student B: _____ (Please remember that this amount should be between 0 and the amount you received.)

**Appendix B: Individual decision data**

| | Full information | | | | Incomplete information | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct reciprocity | | Indirect reciprocity | | Direct reciprocity | | | |
| | *x* | *y* | *x* | *y* | *x* | All *y* | *y* (*2) | *y* (*4) |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| **2** | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| **3** | 0 | 0 | 0 | 0 | 1 | 0 | | 0 |
| **4** | 1 | 0 | 0 | 0 | 1 | 0 | 0 | |
| **5** | 3 | 0 | 0 | 0 | 1 | 1 | 1 | |
| **6** | 3 | 3 | 1 | 0 | 2 | 0 | 0 | |
| **7** | 5 | 0 | 2 | 1 | 2 | 1 | 1 | |
| **8** | 5 | 5 | 2 | 2 | 4 | 4 | 4 | |
| **9** | 5 | 5 | 4 | 3 | 5 | 0 | 0 | |
| **10** | 5 | 7 | 5 | 0 | 5 | 2 | 2 | |
| **11** | 5 | 7 | 5 | 3 | 5 | 3 | | 3 |
| **12** | 5 | 8 | 5 | 5 | 5 | 5 | | 5 |
| **13** | 5 | 6 | 5 | 5 | 5 | 5 | | 5 |
| **14** | 6 | 9 | 5 | 5 | 5 | 5 | 5 | |
| **15** | 6 | 10 | 5 | 10 | 5 | 7 | | 7 |
| **16** | 6 | 3 | 5 | 15 | 5 | 7 | 7 | |
| **17** | 7 | 7 | 7 | 5 | 5 | 10 | | 10 |
| **18** | 7 | 7 | 7 | 7 | 5 | 10 | | 10 |
| **19** | 7 | 9 | 7 | 10 | 5 | 10 | 10 | |
| **20** | 9 | 7 | 8 | 7 | 6 | 0 | 0 | |
| **21** | 9 | 10 | 8 | 8 | 6 | 3 | | |
| **22** | 10 | 0 | 8 | 12 | 7 | 7 | 7 | |
| **23** | 10 | 0 | 9 | 14 | 7 | 7 | 7 | |



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **24** | 10 | 5 | 10 | 5 | 7 | 14 | | |
| **25** | 10 | 10 | 10 | 10 | 8 | 4 | 4 | |
| **26** | 10 | 10 | 10 | 10 | 8 | 5 | | |
| **27** | 10 | 15 | 10 | 15 | 10 | 0 | | |
| **28** | 10 | 15 | 10 | 30 | 10 | 5 | | |
| **29** | | | | | 10 | 9 | 9 | |
| **30** | | | | | 10 | 10 | | |
| **31** | | | | | 10 | 10 | | |
| **32** | | | | | 10 | 10 | 10 | |
| | | | | | | | | |
| **Average** | 6.04 | 5.64 | 5.29 | 6.5 | 5.47 | 4.81 | 5.44 | 5.44 |
| **Std.dev.** | 3.28 | 4.55 | 3.54 | 6.71 | 3.07 | 4.07 | 3.75 | 4.40 |

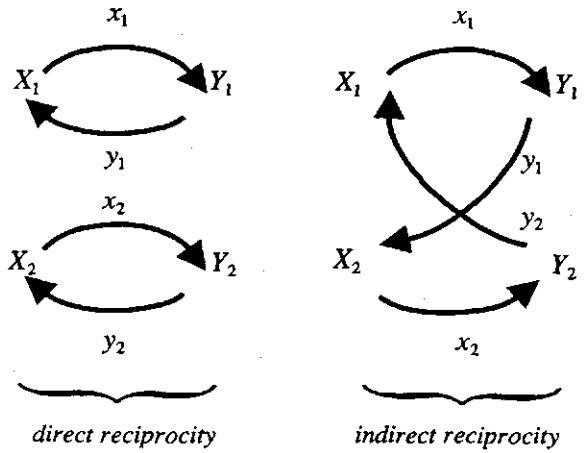


*Figure II.1.* A graphical illustration of the exchanges with direct and indirect reciprocity



| Multiplier information | Reciprocity | |
|---|---|---|
| | **Direct** | **Indirect** |
| **Complete** (multiplier commonly known) | | |
| **Incomplete** (multiplier known only to donators) | | |

*Figure II.2.* The three treatments

| Multiplier information | Reciprocity | |
|---|---|---|
| | **Direct** | **Indirect** |
| **Complete** | 176.48 | 164.64 |
| | ≈30 | ≈30 |
| | 28 | 28 |
| **Incomplete** | 307.24 | Average earnings |
| | ≈30 | Time needed |
| | 32 | Number of observations |

*Figure II.3.* Average earnings (NIS), time needed (in minutes) and number of participants in all three treatments.

| Multiplier information | Reciprocity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Direct | | | | Indirect | | | |
| | *x* | | *y* | | *x* | | *y* | |
| Complete | 6.04 | 6 | 5.64 | 7 | 5.29 | 5 | 6.5 | 5 |
| | 3.28 | 28 | 4.55 | 28 | 3.54 | 28 | 6.7 | 28 |
| Incomplete | 5.47 | 5 | 4.81 | 5 | | | | |
| | 3.07 | 32 | 4.07 | 32 | | | | |

*Table III.1.* Averages, medians (upper line) and standard deviations, numbers of observations (lower line) for all three treatments, depicted as in Figure II.2

| | | Multiplier | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\mu = 2$ | | | | $\mu = 4$ | | | |
| | | *x* | | *y* | | *x* | | *y* | |
| Mean | Median | 5.2 | 5 | 4.2 | 4 | 5.9 | 5 | 5.4 | 5 |
| Std.dev. | # of obs | 2.8 | 16 | 3.3 | 16 | 3.6 | 16 | 4.3 | 16 |

*Table III.2.* The results of the incomplete information treatment separately for pairs with small (2) and large (4) multiplier

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