Online appendix for the paper: Instrumental reciprocity as an error

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This is the online appendix for the paper Reuben and Suetens (2018). In section A, we demonstrate that the strategy *always defect* is the strategy that maximizes monetary earnings. In section B, we present the details of the data analysis. In section C, we provide the experimental procedures and a sample of the instructions given in the experiment.

A. Always defect as the payoff-maximizing choice

The easiest way of demonstrating that *always defect* weakly dominates all other strategies of second movers in our experiment is to calculate the expected payoff of each strategy for each possible strategy of the first mover. The results of this exercise are shown in Table A1.

In the table, *d* stands for the action to "defect" and *c* for "cooperate". The second mover's strategy is indicated by four letters. The first letter refers to the choice in period 1 given that the first mover cooperates in period 1, the second letter to the choice in period 1 given that the first mover defects in period 1, the third letter to the choice in period 2 given that the first mover cooperates in period 2, and the fourth letter to the choice in period 2 given that the first mover defects in period 2. The strategy of the first mover is indicated by a set of three letters. The first letter refers to their choice in period 1, the second letter to their choice in period 2 given that the second mover chose to cooperate in period 1, and the third letter to the choice in period 2 given that the second mover chose to defect in period 1. In the cells we use the following letters to represent the payoffs of the SPD: *D* is the payoff of mutual defection, *C* is the payoff of mutual cooperation, *T* is the second movers payoff if she defects and the first mover cooperates,

Table A1. Expected payoffs of the second mover's strategies

Second mover's strategy	First mover's strategy							
	ddd	*cdd*	*dcd*	*ddc*	*ccd*	*cdc*	*dcc*	*ccc*
dddd	$D + \delta D$	$T + \delta D$	$D + \delta D$	$D + \delta T$	$T + \delta D$	$T + \delta t$	$D + \delta T$	$T + \delta T$
cddd	$D + \delta D$	$C + \delta D$	$D + \delta D$	$D + \delta T$	$C + \delta T$	$C + \delta D$	$D + \delta T$	$C + \delta T$
dcdd	$S + \delta D$	$T + \delta D$	$S + \delta T$	$S + \delta D$	$T + \delta D$	$T + \delta T$	$S + \delta T$	$T + \delta T$
ddcd	$D + \delta D$	$T + \delta D$	$D + \delta D$	$D + \delta C$	$T + \delta D$	$T + \delta C$	$D + \delta C$	$T + \delta C$
dddc	$D + \delta S$	$T + \delta S$	$D + \delta S$	$D + \delta T$	$T + \delta S$	$T + \delta T$	$D + \delta T$	$T + \delta T$
ccdd	$S + \delta D$	$C + \delta D$	$S + \delta T$	$S + \delta D$	$C + \delta T$	$C + \delta D$	$S + \delta T$	$C + \delta T$
cdcd	$D + \delta D$	$C + \delta D$	$D + \delta D$	$D + \delta C$	$C + \delta C$	$C + \delta D$	$D + \delta C$	$C + \delta C$
cddc	$D + \delta S$	$C + \delta S$	$D + \delta S$	$D + \delta T$	$C + \delta T$	$C + \delta S$	$D + \delta T$	$C + \delta T$
dccd	$S + \delta D$	$T + \delta D$	$S + \delta C$	$S + \delta D$	$T + \delta D$	$T + \delta C$	$S + \delta C$	$T + \delta C$
dcdc	$S + \delta S$	$T + \delta S$	$S + \delta T$	$S + \delta S$	$T + \delta S$	$T + \delta T$	$S + \delta T$	$T + \delta T$
ddcc	$D + \delta S$	$T + \delta S$	$D + \delta S$	$D + \delta C$	$T + \delta S$	$T + \delta C$	$D + \delta C$	$T + \delta C$
cccd	$S + \delta D$	$C + \delta D$	$S + \delta C$	$S + \delta D$	$C + \delta C$	$C + \delta D$	$S + \delta C$	$C + \delta C$
ccdc	$S + \delta S$	$C + \delta S$	$S + \delta T$	$S + \delta S$	$C + \delta T$	$C + \delta S$	$S + \delta T$	$C + \delta T$
cdcc	$D + \delta S$	$C + \delta S$	$D + \delta S$	$D + \delta C$	$C + \delta C$	$C + \delta S$	$D + \delta C$	$C + \delta C$
dccc	$S + \delta S$	$T + \delta S$	$S + \delta C$	$S + \delta S$	$T + \delta S$	$T + \delta C$	$S + \delta C$	$T + \delta C$
cccc	$S + \delta S$	$C + \delta S$	$S + \delta C$	$S + \delta S$	$C + \delta C$	$C + \delta S$	$S + \delta C$	$C + \delta C$

S is the first movers payoff if she cooperates and the second mover defects, and δ is the probability that the second period is played.

From Table A1 one can see that cooperation in period 2 is never optimal for second movers, which is straightforward as first movers cannot condition their action in period 2 on the second mover's decision in period 2. In other words, the second mover's strategies that include cooperation in the period 2 are always weakly dominated by at least one strategy that always defects in period 2. For the remaining strategies, we can see that *dddd* (*always defect*) weakly dominates *cddd* (*reciprocate then defect*) for all the strategies of the first mover except for *ccd*. For this strategy, *dddd* dominates *cddd* if $\delta < (T - C) / (T - D)$. Similarly, *dddd* weakly dominates *dcdd* for all the strategies of the first mover except for *dcd*. For this strategy, *dddd* dominates *dcdd* only if $\delta < (D - S) / (T - D)$. Finally, *dddd* weakly dominates *ccdd* if the previous two inequalities hold. In PD-Low the values of the right-hand side of these two inequalities are 0.80 and 0.64 respectively, and

Table B1. Distribution of strategies of second movers

Second movers' strategy	PD-Low		PD-High	
	Inexperienced	Experienced	Inexperienced	Experienced
dddd	71%	74%	58%	59%
cddd	6%	6%	14%	19%
dcdd	0%	0%	0%	0%
ddcd	0%	4%	3%	3%
dddc	0%	0%	3%	1%
ccdd	0%	0%	0%	0%
cdcd	14%	14%	11%	14%
cddc	0%	0%	0%	1%
dccd	0%	0%	0%	1%
dcdc	0%	0%	5%	1%
ddcc	3%	0%	0%	0%
cccd	0%	1%	3%	0%
ccdc	0%	0%	0%	0%
cdcc	0%	0%	0%	0%
dccc	3%	0%	0%	0%
cccc	3%	1%	3%	1%

in PD-High they are 0.52 and 0.64 respectively. Since we implemented $\delta = 0.5$, we can conclude that *dddd* weakly dominates all the other strategies of the second mover in the experiment.

B. Data analysis

B.1. Distribution of strategies of second movers

Table B1 presents the full distribution of the elicited strategies of second movers by treatment and depending on whether participants were experienced or inexperienced. Strategies are described using the same notation as in Table A1.

Table B2 displays the expected payoff of each strategy given the observed distribution of choices of first movers in each treatment and depending on whether participants are experienced of inexperienced. Strategies are described using the same notation as in Table A1.

Table B2. Expected payoff of the second movers' strategies

Second movers' strategy	PD-Low		PD-High	
	Inexperienced	Experienced	Inexperienced	Experienced
dddd	42.56	38.88	37.50	38.93
cddd	39.28	38.21	37.50	38.29
dcdd	32.88	23.50	24.51	24.09
ddcd	41.01	38.75	37.50	38.93
dddc	35.79	30.98	29.50	30.93
ccdd	29.59	22.83	24.51	23.45
cdcd	38.36	37.84	37.50	38.24
cddc	32.01	30.50	29.50	30.36
dccd	27.88	23.50	22.94	23.96
dcdc	28.88	15.50	18.44	16.24
ddcc	34.25	30.85	29.50	30.93
cccd	25.22	22.59	22.94	23.27
ccdc	25.09	15.02	18.44	15.66
cdcc	31.09	30.13	29.50	30.30
dccc	23.88	15.50	16.87	16.12
cccc	20.72	14.78	16.87	15.49

B.2. Statistical differences in the second movers' cooperation rates

We run a probit regression to test for statistical differences in the cooperation rates of second movers. The dependent variable equals one if the second mover cooperates and zero if she defects. As independent variables, we use interactions of dummy variables to identify the sixteen scenarios faced by second movers: i.e., PD-High vs. PD-Low × inexperienced vs. experienced × first mover cooperates vs. defects in period 1 vs. period 2. To account for interdependencies due to multiple observations by the same second mover and interaction between subjects in a session, we use robust standard errors clustered on sessions (White, 1980).[1] The resulting estimates are presented in Table B3.

[1] As a robustness check, we ran the same regression with subject random effects. The results are practically identical and are available upon request.

Table B3. Probit estimates of cooperative actions by second movers

Independent variable	coef.	s.e.	*p*-value
PD-Low × inexperienced × first mover defects in period 1	–0.836	0.288	0.004
PD-Low × inexperienced × first mover cooperates in period 2	0.000	0.139	1.000
PD-Low × inexperienced × first mover defects in period 2	–0.624	0.359	0.082
PD-Low × experienced × first mover cooperates in period 1	–0.058	0.217	0.790
PD-Low × experienced × first mover defects in period 1	–1.373	0.339	0.000
PD-Low × experienced × first mover cooperates in period 2	–0.119	0.306	0.698
PD-Low × experienced × first mover defects in period 2	–1.532	0.481	0.001
PD-High × inexperienced × first mover cooperates in period 1	0.235	0.401	0.557
PD-High × inexperienced × first mover defects in period 1	–0.477	0.381	0.210
PD-High × inexperienced × first mover cooperates in period 2	–0.118	0.409	0.773
PD-High × inexperienced × first mover defects in period 2	–0.477	0.438	0.276
PD-High × experienced × first mover cooperates in period 1	0.358	0.370	0.332
PD-High × experienced × first mover defects in period 1	–1.090	0.446	0.015
PD-High × experienced × first mover cooperates in period 2	–0.138	0.390	0.723
PD-High × experienced × first mover defects in period 2	–1.090	0.486	0.025
Constant	–0.744	0.337	0.027
Number of observations/second movers/sessions	1704/71/12		
Log likelihood	–579.465		

Note that the omitted variable is the dummy variable for the first mover cooperating in period 1 in PD-Low for inexperienced second movers.

We use Wald tests to test whether second movers significantly reciprocate the choice of the first mover. We obtain the following p-values:

- p=0.004 for the test PD-Low × inexperienced × first mover defects in period 1 = 0
- p<0.001 for the test PD-Low × experienced × first mover cooperates in period 1 = PD-Low × experienced × first mover defects in period 1
- p<0.001 for the test PD-High × inexperienced × first mover cooperates in period 1 = PD-High × inexperienced × first mover defects in period 1

- $p<0.001$ for the test PD-High × experienced × first mover cooperates in period 1 = PD-High × experienced × first mover defects in period 1
- $p=0.039$ for the test PD-Low × inexperienced × first mover cooperates in period 2 = PD-Low × inexperienced × first mover defects in period 2
- $p<0.001$ for the test PD-Low × experienced × first mover cooperates in period 2 = PD-Low × experienced × first mover defects in period 2
- $p=0.359$ for the test PD-High × inexperienced × first mover cooperates in period 2 = PD-High × inexperienced × first mover defects in period 2
- $p=0.040$ for the test PD-High × experienced × first mover cooperates in period 2 = PD-High × experienced × first mover defects in period 2

As a robustness check, we also run nonparametric testing whether second movers significantly reciprocate the first mover's choice. Specifically, we run Wilcoxon signed-ranked tests using individual choices as observations for tests of inexperienced subjects and using session averages as observations for tests with experienced subjects. We run a test for each of the eight comparisons evaluated above. We obtain the following p-values:

- $p=0.034$ for the test PD-Low × inexperienced × first mover cooperates in period 1 = PD-Low × inexperienced × first mover defects in period 1
- $p=0.035$ for the test PD-Low × experienced × first mover cooperates in period 1 = PD-Low × experienced × first mover defects in period 1
- $p=0.035$ for the test PD-High × inexperienced × first mover cooperates in period 1 = PD-High × inexperienced × first mover defects in period 1
- $p=0.028$ for the test PD-High × experienced × first mover cooperates in period 1 = PD-High × experienced × first mover defects in period 1
- $p=0.025$ for the test PD-Low × inexperienced × first mover cooperates in period 2 = PD-Low × inexperienced × first mover defects in period 2
- $p=0.035$ for the test PD-Low × experienced × first mover cooperates in period 2 = PD-Low × experienced × first mover defects in period 2

Table B4. Marginal effects of the second movers' strategies according to a multinomial probit regression

	Always defect		*Reciprocate then defect*		*Always reciprocate*		*Always cooperate*		Other	
	m.e.	s.e.	m.e.	s.e.	m.e.	s.e.	m.e.	s.e.	m.e.	s.e.
PD-Low × inexperienced	0.714	0.092	0.057	0.034	0.143	0.090	0.029	0.027	0.057	0.034
PD-High × inexperienced	0.583	0.089	0.139	0.049	0.111	0.053	0.028	0.026	0.139	0.049
PD-Low × experienced	0.743	0.042	0.057	0.034	0.143	0.050	0.006	0.005	0.051	0.027
PD-High × experienced	0.589	0.064	0.194	0.051	0.139	0.036	0.006	0.005	0.072	0.033
p-values of Wald tests evaluating equality of marginal effects in PD-Low and PD-High										
Inexperienced	0.309		0.170		0.762		0.983		0.170	
Experienced	0.044		0.025		0.949		0.983		0.628	

- p=0.317 for the test PD-High × inexperienced × first mover cooperates in period 2 = PD-High × inexperienced × first mover defects in period 2
- p=0.074 for the test PD-High × experienced × first mover cooperates in period 2 = PD-High × experienced × first mover defects in period 2

B.3. Statistical differences in the second movers' distribution of strategies

We run a multinomial probit regression to test whether the distribution of strategies chosen by second movers differs significantly depending on the treatment. To run the regression we classify strategies into five categories: *always defect* (*dddd*), *reciprocate then defect* (*cddd*), *always reciprocate* (*cdcd*), *always cooperate* (*cccc*), and other strategies (*dcdd*, *ddcd*, *dddc*, *ccdd*, *cddc*, *dccd*, *dcdc*, *ddcc*, *cccd*, *ccdc*, *cdcc*, and *dccc*). As independent variables, we use dummy variables to identify the four scenarios faced by second movers: i.e., PD-High vs. PD-Low × inexperienced vs. experienced. Once again, we use robust standard errors clustered on sessions (White, 1980). As before, there are 426 observations, 71 second movers, and 12 sessions.

The top part of Table B4 presents the estimated marginal effects and the corresponding standard errors of the independent variables for each of the five categories (naturally, the marginal effects are equal to the observed frequencies reported in Figure 1 in the main body of the paper). To test whether the frequency of a strategy differs significantly between treatments, we use Wald tests comparing the two estimated marginal effects. The p-values of these tests are reported in the bottom part of Table B4. The only significant differences occur for the strategies *always defect* and *reciprocate then defect* among experienced second movers.

C. Experimental procedures

The experiment took one hour and was conducted in 2009 in the laboratory of Northwestern University using z-Tree (Fischbacher, 2007). Participants were contacted through an online recruitment system. In total, 70 students participated in PD-Low and 72 in PD-High. Overall, 62% of the participants were female. Each student participated only once in a session of 10 to 12 people. After their arrival, participants drew a card to be randomly assigned to a seat in the laboratory and consequently to a treatment and role.

Once everyone was seated, participants were given the instructions of the experiment. The instructions were written with neutral language (see the sample below). Participants were informed that the experiment consists of multiple parts and that the instructions for the subsequent parts would be provided after the first part had finished. After reading the instructions, they answered control questions to corroborate their understanding of the game. Thereafter, participants learned whether their role would be that of the first or the second mover. They kept the same role throughout the experiment. At the end of the session, participants were paid in private. Mean earnings were \$16.10 and ranged from \$11.70 to \$24.40.

C.1. Instructions for participants in the experiment

Below are the instructions given to participants in PD-High. In PD-Low the only difference is that the earnings of both first and second movers when both choose A are 30 points instead of 37 points.

General Instructions

You are participating in an experiment on economic decision making and will be asked to make a number of decisions. If you follow the instructions carefully, you can earn money. At the end of the experiment, you will be paid your earnings in cash.

You are not allowed to communicate with other participants. If you have a question, raise your hand and we will gladly help you.

The experiment is *anonymous*: that is, your identity will not be revealed to others and the identity of others will not be revealed to you.

The experiment consists of independent parts. The instructions below are for the first part. You will get the instructions for the other parts once the first part has finished.

Instructions for part 1

In this part of the experiment, you will be randomly divided into groups of two. You will interact with the other participant in your group for one or two periods.

In each group, one participant will be randomly assigned to the *first mover* position. The other participant in the group will be in the *second mover* position. You will remain in the same position throughout part 1.

Your decision in each period

You will interact for one or two periods. In both periods you will play the same game. In the game, both the first and the second mover make a choice between option A and option B. The table below shows what the first and second movers earn (in points) depending on their choices.

	first mover's earnings	second mover's earnings
both choose A	37	37
first mover chooses A and the second mover chooses B	9	50
first mover chooses B and the second mover chooses A	50	9
both choose B	25	25

One or two periods?

You will always play the *first* period. Whether you play a *second* period or not is determined *randomly*. At the end of the first period, we will throw a coin to determine whether the experiment stops or continues to a second period---heads means you get to play the second period and tails means you do not. Thus, the probability that you play one period is 50% and the probability that you play two periods is 50%.

Your total earnings in points for this part of the experiment equal your earnings from the first period plus your earnings from the second period (if played).

After period 1, before you (possibly) play period 2, you will receive feedback concerning your earnings in that period.

The decision of the first mover

In each period (that is, in period 1 and, potentially, in period 2), the first mover makes the following decision:

- Do you choose A or B?

The decision of the second mover

The second mover makes the following decisions in period 1:

- What do you choose in period 1, *if the first mover chooses A*: A or B?
- What do you choose in period 1, *if the first mover chooses B*: A or B?
- What do you choose in period 2 if the experiment continues and *the first mover chooses A*: A or B?
- What do you choose in period 2 if the experiment continues and *the first mover chooses B*: A or B?

If the first mover chooses A in period 1, the outcome of the game in that period will depend on the second mover's answer to the first question. If the first mover chooses B in period 1, the outcome of the game in that period will depend on the answer to the second question.

If the result of the coin toss is that you play two periods and the first mover chooses A in period 2, the outcome of the game in period 2 will depend on the answer to the third question. If the result of the coin toss is that your play two periods and the first mover chooses B in period 2, the outcome of the game in period 2 will depend on the answer to the fourth question.

If the result of the coin toss is that you play only one period, there is no period 2 and your earnings are determined only by the outcome of period 1.

Instructions for part 2

For the second part of the experiment you will play the same game as in part 1. However, this time you will play it *15 consecutive times*. We will refer to each play of the game as a *round*. Therefore, you will play for 15 rounds. Note that each game can have one or two periods (depending on the coin toss). Therefore, you will be playing between 15 and 30 periods.

Your total earnings in points for this part of the experiment equal the sum of earnings from all 15 rounds.

Allocation to groups

In each round, you will be randomly divided into groups of two. Therefore, you will interact with the same participant during the one or two periods within each round but with different participants between rounds. The randomization is done such that you will not play with the same participant in two consecutive rounds. In other words, *in every round you will play with a different participant as the one from the previous round*.

References

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