Interaction of Reasoning Ability and Distributional Preferences in a Social Dilemma*

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Abstract

In a within subjects design we evaluate distributional preferences and reasoning ability to explain choices in the Traveler's Dilemma. We recruit subjects from economics and non-economics majors to have a high variance of preferences and abilities. We find that economists follow the efficiency criterion while non-economists follow maximin. Economists also show a better reasoning ability. We, therefore, confirm the self-selection hypothesis of choosing a major. An equilibrium of an incomplete information version of the Traveler's Dilemma explains the behavior we observe. Subjects with low reasoning ability make choices away from equilibrium. Thus, (non)cooperative behavior might be misinterpreted if subjects reasoning ability is not taken into account.

JEL classifications: C72, C92, D63
Keywords: Reasoning ability, distributional preferences, Traveler's Dilemma, economics education, cooperation.

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1 Introduction

There are many models of social, distributional and norm-dependent preferences that attempt to explain behavior in experimental games (e.g., Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Engelmann and Strobel, 2004; Krupka and Weber, 2013; Kessler and Leider, 2012; Kimbrough and Vostroknutov, 2016, among others). All these models rely on the assumption that preferences are heterogeneous in the population, which makes it possible to reconcile data and theory in games like social dilemmas where pro-social and selfish incentives are typically not aligned (e.g., Prisoner's Dilemma, Ultimatum game, Public Goods game etc.). Another strand of literature focuses on the ability to reason in games. For example, some studies investigate whether different measures of intelligence predict the ability to think strategically (Gill and Prowse, 2015; Fehr and Huck, 2015; Benito-Ostolaza *et al.*, 2016; Kiss *et al.*, 2016). More importantly, the relationship between the measures of intelligence and *preferences* has been found: Benjamin *et al.* (2013) and Burks *et al.* (2009) report correlation between intelligence and intertemporal preferences; Chen *et al.* (2013) show correlation between SAT and GPA scores and generosity; Proto *et al.* (2014) show that high IQ subjects are able to sustain cooperation in a repeated Prisoner's Dilemma, whereas low IQ subjects are not (see also Jones, 2008).[1]

These contrasting findings raise a question Which explanation should we attribute certain behaviors to: heterogeneous preferences or reasoning ability? For example, it is not inconceivable that in a one-shot Prisoner's Dilemma some subjects choose cooperation because the cooperative outcome is a norm, or a desired allocation, and because they do not think about what others might choose they do not act strategically. At the same time, other subjects might choose defection because they reason strategically and assume that their opponent does as well. In this situation, a misinterpretation of the data can occur if we try to explain these observations with heterogeneous distributional preferences: defectors would be wrongly classified as selfish and cooperators as pro-social, even though it is possible that both share the same distributional preferences.

In this paper we investigate the interaction between reasoning ability and distributional concerns and attempt to disentangle their influence on choices in the Traveler's Dilemma (Basu, 1994)—a game which combines elements of social dilemmas and iterative reasoning games à la beauty contest (Nagel, 1995) or Nim (McKinney and Van Huyck, 2007). To achieve this, we need experimental subjects' distributional preferences and abilities to reason to come from a wide enough range. We deliberately recruit students from economics and non-economics majors in order to achieve this goal. In many studies, a difference was found in pro-social behavior of economists and non-economists (e.g., Bauman and Rose, 2011; Faravelli, 2007). In addition, economics students are exposed to much more formal mathematics than students from other social

[1]It should be noted though that from the experiments of Proto *et al.* (2014) it is unclear whether cooperation in high IQ groups emerges because high IQ subjects are more cooperative or because they are more patient.

sciences. Thus, we expect that they differ from non-economics students in their ability to think logically.

The second purpose of our study is to contribute to the literature on the influence of economics education on decision making. We try to understand in which dimensions economics and non-economics students ("economists" and "non-economists") are different and how this is reflected in their choices in the Traveler's Dilemma. In addition, we look at the length of time that students have spent at the university and test the self-selection versus indoctrination hypotheses (Frey and Meier, 2003, 2005).

We use a within subjects design in which each subject plays three games. First, subjects make a choice in one-shot Traveler's Dilemma; then they choose allocations in several three-person Dictator games, allowing for an estimation of the subjects' distributional preferences (Engelmann and Strobel, 2004); finally, subjects play several rounds of the Race to 15 game (Gneezy *et al.*, 2010), a version of Nim, which is a good indicator of reasoning ability (Burks *et al.*, 2009). We hypothesize that economists are more concerned with efficiency or Pareto optima than non-economists, who favor equality (Fehr and Schmidt, 1999) and/or Rawlsian principle of maximin, which allocates the highest wealth to the poorest individual (Rawls, 1971). Moreover, following a previous study (Kimbrough and Vostroknutov, 2016), we conjecture that non-economists should be more inclined to follow social norms and conventions than economists do. We further hypothesize that economists perform better than non-economists in the Race to 15 game. This should imply that they are better at strategic thinking. Finally, in the Traveler's Dilemma, we expect substantial fraction of non-economists to behave non-strategically and choose actions associated with a focal point or a norm and a substantial fraction of economists to act strategically and best respond to non-economists. Overall, we would like to demonstrate that both reasoning ability and distributional preferences should be taken into account in order to explain strategic social behavior.

Several recent studies are dedicated to understanding the behavior in Traveler's Dilemma. Basu *et al.* (2011) investigate the effect of changing bonuses on the choices. Brañas Garza *et al.* (2011) use choices in Traveler's Dilemma to classify subjects into types that further predict behavior in other settings. Chakravarty *et al.* (2010) study pre-play communication. Morone *et al.* (2014) and Morone and Morone (2016) look at group versus individual choice and the influence of focal points. Finally, an early study by Capra *et al.* (1999) shows the difficulties that conventional theories of choice in games face when confronted with the behavior in Traveler's Dilemma. Interestingly, none of these studies mention distributional preferences or reasoning ability as possible explanations.

Our results can be summarized as follows. We do find support for the hypothesis that economists favor efficiency and non-economists favor maximin. However, we find no support for the hypothesis that non-economists (or economists, for that matter) care about inequality. We do find that economists perform better in the Race to 15 game. In the Traveler's Dilemma we find that more than half of non-economists (versus 30% of economists) choose the maximum number of tokens. This corresponds to the most cooperative outcome which is also strictly dominated. We find that the choices of around half of economists lie in the support of a Bayesian Nash equilibrium, which we construct by amending the Traveler's Dilemma with incomplete information about distributional types following the work of Becker *et al.* (2005). Importantly, the non-maximal choices of non-economists do not seem to agree with the equilibrium prediction.

Comparing choices of economists and non-economists in all three games we can strongly reject the indoctrination hypothesis that studying at the university for a long time (or studying economics for a long time) changes preferences, reasoning ability or strategic behavior. Thus, our data support the self-selection hypothesis. We find some evidence that, on average, economists are more selfish than non-economists. However, it should be mentioned that many economists also show a tendency to favor efficiency.

Overall, using the Traveler's Dilemma, we show that behavior in social contexts cannot be used to directly infer social or distributional preferences as the bounds on reasoning ability should be taken into account. We show that in our example the seeming high cooperativeness of economists (as compared to non-economists) cannot be attributed to them caring about the wealth of others. Instead, we show that their choices are driven by strategic considerations. At the same time, the choices of non-economists are consistent with maximin preferences, but do not reveal strategic sophistication.

2 Experimental Design

In the experiment subjects played three different games: the Traveler's Dilemma, a three-person Dictator game and the "Race to 15." We begin with explaining the subject sampling procedure, then we describe the three games. The experiment was programmed in z-Tree (Fischbacher, 2007). There were no pilots or dropped observations or sessions. Overall, 118 subjects participated in the experiment. All sessions were conducted in May 2014 at Maastricht University.

2.1 Subject Sample

We have two subject sample groups: students from bachelor programs in the School of Business and Economics at Maastricht University ("economists") and students who attended various other bachelor programs with no economics courses ("non-economists"). In Section 3.1 we provide the details of our subject sample composition. The subjects were also selected according to the number of years of studying: only first and third year students of each group qualified as subjects. The experiments were run in May, the last month of the academic term. Thus, we had students who spent exactly one academic year at the University and students who spent exactly three. The number of subjects in each of the four groups (economists first year: ECO1;

economists third year: ECO3; non-economists first year: NECO1; non-economists third year: NECO3) are roughly the same (see Table 2 below).

2.2 The Traveler's Dilemma

The first game that subjects played was the Traveler's Dilemma. Two players choose simultaneously an integer number of tokens between 10 and 100. The player who selects the smaller number wins. The payoffs are as follows. The winner, who has chosen a smaller number, receives the payoff equal to the chosen number plus a bonus of 10 tokens. The loser, who has chosen a larger number, receives a payoff equal to the winning (smaller) number minus a penalty of 10 tokens. In case both players have chosen the same number, both receive a payoff equal to the chosen number. In our design one token was worth 10 cents. Thus, possible earnings could be as low as €0 and as high as €10.9 (instructions are provided in Appendix C). Subjects were not informed about their earnings after they made their choice in the Traveler's Dilemma. They were told that this information will be provided at the end of the experiment.

In this game a conflicting situation is created: under the assumptions of rationality and common knowledge of rationality the only rationalizable outcome is for both players to choose 10 tokens, which is also the unique Nash and strict equilibrium (Basu, 1994). However, choosing a larger number can potentially yield a much higher payoff assuming the opponent chooses a large number as well. This game investigates the trade-off between a risk-free option (choosing 10) and an uncertain option which, however, might yield larger payoff.

2.3 Three-Person Dictator Games

After the Traveler's Dilemma subjects made choices in nine three-person Dictator games. In each game subjects chose one of the three monetary allocations to three people (see instructions in Appendix C). A typical Dictator game is shown in Table 1.

Allocation	**A**	**B**	**C**
Person 1	32	26	20
Person 2	18	16	14
Person 3	10	6	2

Table 1: An example of a three-person Dictator game.

Subjects were instructed to choose one of the three allocations A, B or C *as if they are Person 2*. Each token was worth 25 cents. No information about payoffs was provided immediately after the Dictator games. At the end of the experiment, one Dictator game was chosen randomly as well as a random role (Person 1, 2 or 3). Subjects, who were assigned the role of Person 1 or 3, were paid according to the choice of another subject who made the corresponding decision as Person 2. The games were presented in random order to avoid any fixed sequence effects. The allocations in the games were taken from Engelmann and Strobel (2004), who first introduced this form of Dictator game. The number of tokens was multiplied by two, in order to have an integer number of tokens in all tables. Our design is different from Engelmann and Strobel (2004) in three ways: 1) they use between subjects design whereas we use within subjects; 2) we change the tables by doubling the number of tokens and 3) we do not make the information about the total number of tokens for each choice available to the subjects. Table 3 shows the allocations used in the nine games.

2.4 The Race to 15 Game

After the Dictator games, the Race to 15 was played. This is a two-player extensive form zero sum game that has been used in several studies to assess the ability of subjects to perform backward induction (Dufwenberg *et al.*, 2010; Gneezy *et al.*, 2010). The performance in this game is also known to be a good predictor of the ability to plan for the future (Burks *et al.*, 2009). We quote Gneezy *et al.* (2010) in order to describe the rules of the Race to 15: "This game is a zero-sum, extensive form perfect information game, denoted by $G(m, k)$, where m and k are two integers with k smaller than m. Players alternate in moving. There is a state variable, which is a number between 1 and m. The initial state is 1. When a player moves, she can add to the current position any number between 1 and k. The player who gets to m first wins. [...] It is a combinatorial game, impartial, under the normal play rule. A combinatorial game is a zero-sum game with two players who alternate in moving, with a finite set of positions, and a set of feasible moves for each position, with no nature or random moves, and where some of the positions are end positions. The game is impartial if for every position the set of admissible moves is the same for both players. It has the normal play rule if the last player to move wins. The basic definitions and properties of these games are given and analyzed in Conway (2000)."

In this study we used $G(15, 3)$, which means that there are 15 positions and each player can move by one, two or three positions (see instructions in Appendix C and screeshots in Appendix D). Subjects played the Race to 15 ten times with a randomly chosen opponent in each period. Each subject was making the first move interchangeably five out of ten times. Earnings were as follows. If a subject won the number of games above the median in the session, she got €10. If she won less than the median number of games, she earned nothing. If she won exactly the median number, she got €4.[2]

Using backward induction it can be shown that the player is in a winning position if and only if his position is *not* 3, 7 or 11 (losing positions). Suppose you are in position 11. It is only possible for you to move to positions 12, 13 or 14, which means that your opponent wins the

[2]This payoff structure is exactly the same as in Gneezy *et al.* (2010).

game. Thus, moving from 11 guarantees a loss. This modifies the game to Race to 11. Whoever moves to 11 wins the game. Using same argument we show that moving to 3 and 7 is a winning strategy. It is always possible to move to 3, 7 or 11 from any other position in the game. Thus, given the knowledge of the winning strategy, whoever starts the game wins. Notice that the winning strategy does not depend on how the other player moves or on the beliefs about what the other will do. Thus, the Race to 15 provides a clean test of the ability to backward induct, which is in contrast with, for example, beauty contests (Nagel, 1995) where beliefs about what others choose influence the best response.

2.5 Questionnaire

At the end of the experiment the subjects filled out a questionnaire which consisted of questions on demographics/field of study and additional questions: 1) *Have you ever played the Move an X Game before?* (Race to 15 game) 2) *Have you had economics classes in high school?* 3) *Do you play video games?* and 4) *Please indicate the amount of money you have available per month minus rent.*

3 Results

3.1 Data Summary

We start with summarizing the demographics of our subjects. Table 2 shows all relevant data. Overall, 118 subjects participated in the experiment. In our sample 39% of subjects were German, 17% Dutch and 39% from other European countries and the USA. Notice that we controlled for the number of years at the University: the averages are very close to 1 and 3.[3]

The only odd thing to notice about Table 2 is the gender composition. There are more males among economists than among non-economists. We recruited subjects with only one restriction: we tried to invite approximately the same number of subjects in all four groups. The gender discrepancy comes from the difference in the actual number of males in Economics/Business majors versus non-economics majors. This can be seen from the gender composition of the students registered in the recruitment database at Maastricht University: 1902 students in the system can be classified as economists, and 52% of them are male. 321 students can be classified as non-economists, and 32% of them are male. These numbers are close to the percentages we report in Table 2.

[3]In the questionnaire we asked in what year did subjects start studying. Some first year students wrote 2014, same year when the experiment was conducted. Thus, the average for first years is slightly less than 1.

Bachelor program	Number of subjects		
	1st Year	3rd Year	Overall
Economists			
Number	28	26	54
Business	1	11	12
Economics	27	15	42
Age	21.86	23.04	22.42
Males	68%	58%	63%
Years at University	0.88	3.73	2.24
Non-economists			
Number	41	23	64
Arts and Culture	1	2	3
European Studies	17	15	32
Law	18	2	20
Psychology	1	1	2
Social Sciences	3	2	5
Literature		1	1
Neuroscience	1		1
Age	22.36	22.96	22.58
Males	44%	26%	37%
Years at University	0.95	3.13	1.73

Table 2: Numbers and demographics of subjects by field of study and years at the University.

3.2 Three-Person Dictator Games

In this section we look at the differences in distributional preferences between the four groups of subjects. Like Engelmann and Strobel (2004) we test three competing models: 1) *efficiency* (choose the allocation with the highest sum of tokens); 2) *inequality aversion* of Fehr and Schmidt (1999) and 3) *maximin* (choose the allocation with the highest minimal payoff).[4] Table 3 shows: the nine Dictator games that we used; the predictions of the three models; the aggregate choices of economists (ECO) and non-economists (NECO); and the Pearson's χ^2 and exact multinomial tests of equality of distributions.[5]

The first thing to notice is that in games 1 and 4, where all three models predict choice A, the vast majority of subjects, more than 89%, do choose A. This tells us that any other model that would predict choice B or C in these games would poorly explain our data. This also suggests that the three models seem to explain around 90% of the data. The next observation relates to the average choices of economists and non-economists. Notice that in *all nine games* the major-

[4]For maximin we assume that if the lowest n minimal payoffs are the same for all three allocations then the allocation with $(n+1)$th highest minimal payoff is chosen. Thus in game 8 below only choice C is maximin-optimal.

[5]In case of inequality aversion, the prediction in all games is the same for all combinations of α and β in Fehr and Schmidt (1999) utility function.

	1			2			3			4			5		
Allocation	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Person 1	34	36	38	42	34	26	32	26	20	32	26	20	32	26	20
Person 2	20	20	20	24	24	24	16	16	16	18	16	14	14	16	18
Person 3	18	10	2	6	8	10	10	6	2	10	6	2	10	6	2
Model															
Efficiency	A			A			A			A			A		
Ineq. Av.	A					C			C	A					C
Maximin	A					C	A			A			A		
ECO															
Count	48	5	1	23	8	23	47	4	3	51	3	0	29	5	20
Percentage	89	9	2	43	14	43	87	7	6	94	6	0	54	9	37
NECO															
Count	63	0	1	16	8	40	58	5	1	61	2	1	39	11	14
Percentage	98	0	2	25	12	63	91	8	1	95	3	2	61	17	22
Tests															
Pearson's χ^2	0.07 $p=.79$			10.84 $p<.01$			1.95 $p=.38$			0.69 $p=.71$			8.94 $p=.01$		
Multinomial	$p=1.00$			$p<.01$			$p=.41$			$p=.58$			$p=.01$		

	6			7			8			9		
Allocation	A	B	C	A	B	C	A	B	C	A	B	C
Person 1	32	26	20	22	16	10	28	22	16	42	34	26
Person 2	15	16	17	24	24	24	8	8	8	18	18	18
Person 3	10	6	2	4	6	8	10	12	14	6	8	10
Model												
Efficiency	A			A			A			A		
Ineq. Av.			C	A					C			C
Maximin	A					C			C			C
ECO												
Count	29	9	16	25	7	22	24	9	21	24	8	22
Percentage	54	16	30	46	13	41	44	17	39	44	15	41
NECO												
Count	49	7	8	21	10	33	18	14	32	22	8	34
Percentage	77	10	13	33	15	52	28	22	50	34	13	53
Tests												
Pearson's χ^2	13.83 $p<.01$			4.70 $p=.10$			6.91 $p=.03$			4.10 $p=.13$		
Multinomial	$p<.01$			$p=.08$			$p=.02$			$p=.14$		

Table 3: Three-person Dictator games that were used in the experiment. For each game the table shows the choice predicted by the three models, aggregate choices of economists and non-economists and tests that compare the distributions.

ity of economists choose the allocation consistent with the efficiency model while the majority of non-economists *always* choose in accordance with the maximin model. Both the majority of economists and non-economists choose according to the inequality aversion in only 3 out of 9 games. This suggests that economists rely more on the efficiency criterion whereas non-economists prefer maximin. Inequality aversion does not seem to play a big role in the decisions of our subjects: the match of 3 out of 9 games might have happened by chance, because the choice predicted by inequality aversion model coincides with either efficiency or maximin (see related discussion in Fehr *et al.* (2006) and Engelmann and Strobel (2006)).

Now we turn to the comparison of distributions. In four games (2, 7, 8 and 9) efficiency and maximin models make different predictions. In games 2, 7 and 8 the multinomial distributions are significantly different between economists and non-economists: both the exact multinomial test and Pearson's χ^2 approximation show significance (in game 7 at 10% level). In game 9 we do not observe significant difference of distributions even though it is almost identical to game 2 where distributions are significantly different. We do not have a specific explanation for this discrepancy.

It is also interesting to see what happens in the three games where efficiency and maximin make the same prediction which is different from the prediction of inequality aversion (games 3, 5 and 6). In two of them (5 and 6) we see significant difference in the choices of economists and non-economists. In both cases high proportion of economists chooses option C predicted by inequality aversion, which would usually suggest that fairness considerations drive their choices. However, it is worth looking at game 3. This game is different from games 5 and 6 only in the payoffs of the person who chooses the allocation (Person 2). While in games 5 and 6 the payoffs of Person 2 increase from A to C, in game 3 they are constant. Moreover, in game 3 we do not see a significant difference between the distribution of choices of economists and non-economists. If economists were indeed driven to choose C by inequality aversion, they should have chosen C substantially more often in game 3 as well as in games 5 and 6. Since we do not observe that, we conclude that it is unlikely that inequality aversion causes this drift towards C among economists. High proportions of C in games 5 and 6 can be simply explained by selfish motives because Person 2's payoffs from C are higher than from A (which is not the case in game 3).

To further support our findings above we turn to the within subjects analysis. Since all subjects make choices in all nine games we can try to estimate their distributional preferences from their choices. We construct three variables, ef, ia and mn, which show how consistent the choices of each subject are with efficiency, inequality aversion and maximin models. For a given model we calculate the number of times that each subject chose according to it. For example, if a subject chooses as maximin in 4 games out of 9, then $\mathsf{mn} = 4$.

Figure 1 shows the histograms of ef, ia and mn separately for economists and non-economists. First, notice that 19% of all subjects choose the options predicted by efficiency model 8 or 9 times

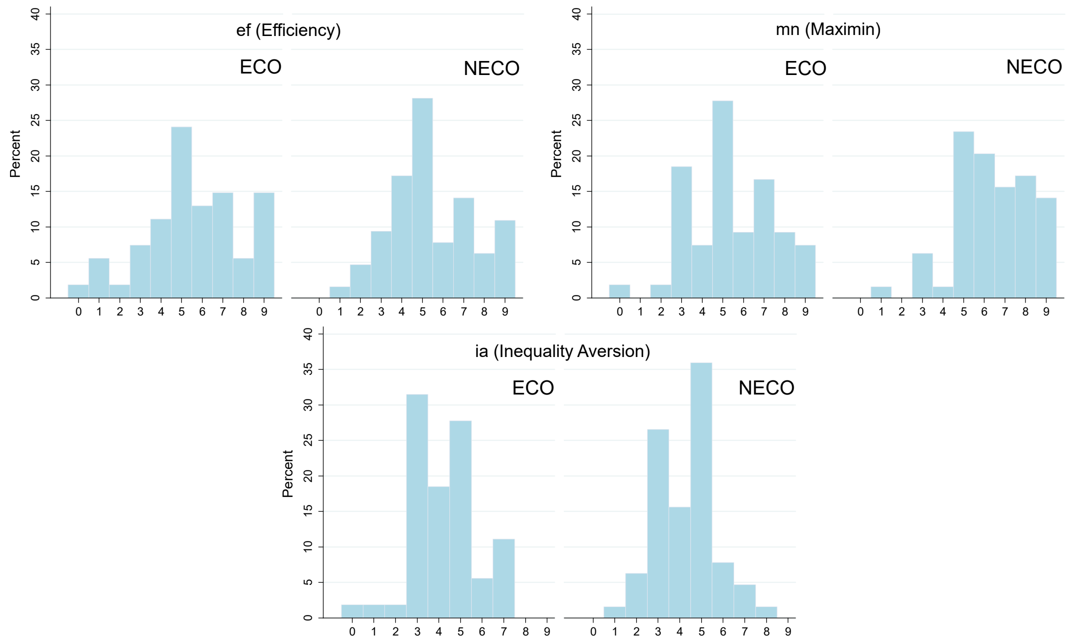

Figure 1: Histograms of ef, ia and mn for economists and non-economists.

out of 9; 25% choose 8 or 9 times what maximin model predicts and only 1 subject chooses 8 or 9 times what inequality aversion model predicts. This again points toward efficiency and maximin models being good predictors of the choices in our Dictator games.

It should be noted that simple counts of the number of times that subjects chose in accordance with some model do not necessarily indicate that subjects indeed use that model. The reason for this is simple: there are only three choices in our Dictator games which are designed so that option B is rarely chosen. This essentially leaves us with two options in each game. Thus, a subject who chooses randomly between options A and C will on average have ef, mn and ia equal to 4.5 out of 9. We, therefore, ask ourselves a question How many times should a subject choose in accordance with a model in order for us to conclude that she indeed uses it? In other words How many choices in accordance with the model should be made to consider these choices non-random? A simple binomial test of a number of choices consistent with a model versus the hypothesis that the data come from uniform distribution provides an answer. If we observe 7 choices in accordance with a model and 2 inconsistent choices, binomial test gives a one-sided p-value of 0.09. For 8 consistent choices we have a one-sided p-value of 0.02. Thus, we can only attribute subject's choices to some model if she chose 8 or 9 times in accordance with it.[6]

Now we can look at the differences in distributional preferences among four groups of subjects that we defined above. We drop the inequality aversion model from consideration since only 1 subject out of 118 has chosen according to it in 8 out of 9 games and analyze only efficiency and maximin models. Let isef and ismn denote indicator variables for a subject to score 8 or 9 times in accordance with efficiency and maximin. Overall, 25% of subjects are classified as

[6]The same calculations could have been done with three options and multinomial test. This, however, would make the rejections of H_0 unnaturally too frequent since option B is rarely chosen.

choosing according to maximin (ismn is equal to 1) and 19% are classified as choosing according to efficiency (isef is equal to 1). Thus, the choices of roughly half of our subjects can be considered non-random and attributed to a specific model. Importantly, notice that *none* of the subjects was attributed to both models. This comes from the choice of the games: efficiency and maximin predict the same option in three games. Thus, it is impossible to be consistent with both models 8 or 9 times. However, if we look at the lower threshold of 7 choices or more, then only 5 subjects score 7 times or more in both models. This shows that subjects use only one or the other model.

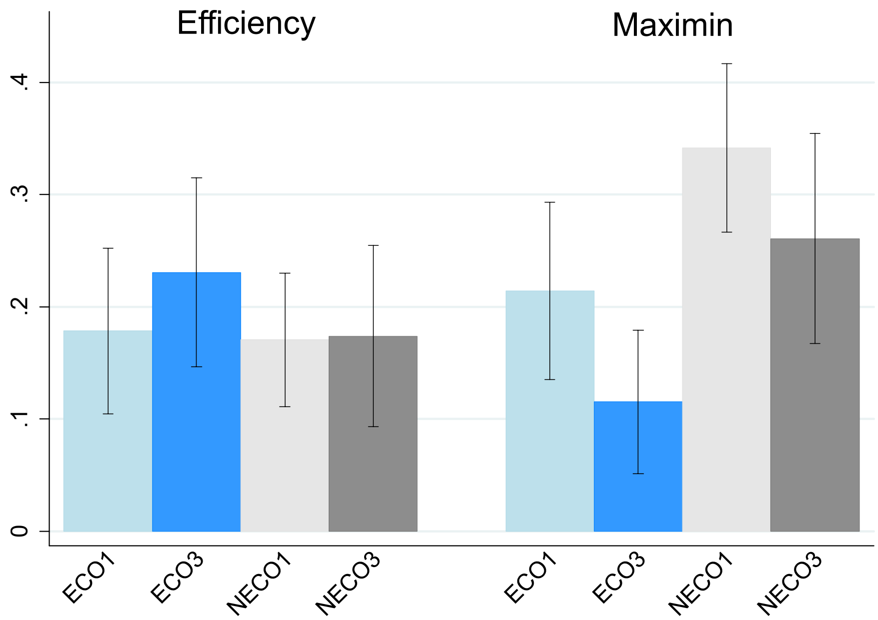

Figure 2: Proportions of subjects (isef and ismn) whose choices can be attributed to efficiency and maximin models in four conditions. Error bars are ±1 SE.

Figure 2 plots averages of isef and ismn for the four groups of subjects. There is not much difference in efficiency averages among groups, we cannot reject the null hypotheses that the distributions are different. But there is an effect in average maximin. With a binomial test we can reject the null hypothesis of equality of proportion of maximin-classified subjects between 1$^{\text{st}}$ year economists and non-economists ($p = 0.04$). The same is true if we look only at 3$^{\text{rd}}$ year economists and non-economists ($p = 0.04$). If we compare all economists to all non-economists the binomial test gives $p = 0.003$. Thus, we conclude that there are more maximin subjects among non-economists than among economists and there is an equal number of efficiency driven subjects in both groups. Moreover, it seems that distributional preferences are stable over time: we found no significant differences in proportions of either efficiency or maximin subjects between years for economists or non-economists.

Result 1. *We can attribute the choices of around a quarter of our subjects to the efficiency model; a quarter (disjoint) to the maximin model and none to the inequality aversion model. Half of the subjects choose in a way inconsistent with any model we considered. On average, the majority of economists choose according to the efficiency criterion whereas the majority of non-economists according to maximin criterion. There* *are more maximin subjects among non-economists than among economists and the proportions do not change over time, which is consistent with the self-selection hypothesis.*

3.3 The Race to 15

In Section 2.4 we described the winning strategy in the Race game which is to move to positions 3, 7, 11, and 15 whenever possible. We call positions 3, 7, 11 *losing positions*, since any player who has to move from these positions loses the game when playing against an opponent who follows the winning strategy. The rest of the positions except 15 we call *winning positions*: a player who moves from a winning position and knows the winning strategy wins no matter what the opponent does. To analyze how well our subjects do in the Race game we follow Gneezy *et al.* (2010) and look at *errors* that subjects can make. What constitutes an error in this game? The winning strategy prescribes to move to 3, 7, 11 and 15. Thus, an error is to *fail* to move to one of these positions. We define four types of errors that subjects can make: Error type 1 is to fail to move from positions 1 and 2 into position 3; Error type 2 is to fail to move from 4, 5, 6 to 7; Error type 3 is to fail to move from 8, 9 and 10 to 11; and type 4 is to fail to move from 12, 13, 14 to 15 (there are no type 4 errors in our data). Gneezy *et al.* (2010) show that errors of types 1 to 3 are not made at the same rate. In this study it is shown that, as subjects learn the game, they first stop making errors of type 3, then of type 2 and, finally, of type 1. This constitutes the evidence that subjects learn the game from the end as any backward induction argument would suggest.

We start with the replication of this result in order to make sure that the amount of errors in the Race game can indeed be a measure of the ability to backward induct. Figure 3 shows the evolution of error rates for economists and non-economists (1st and 3rd years pooled together).

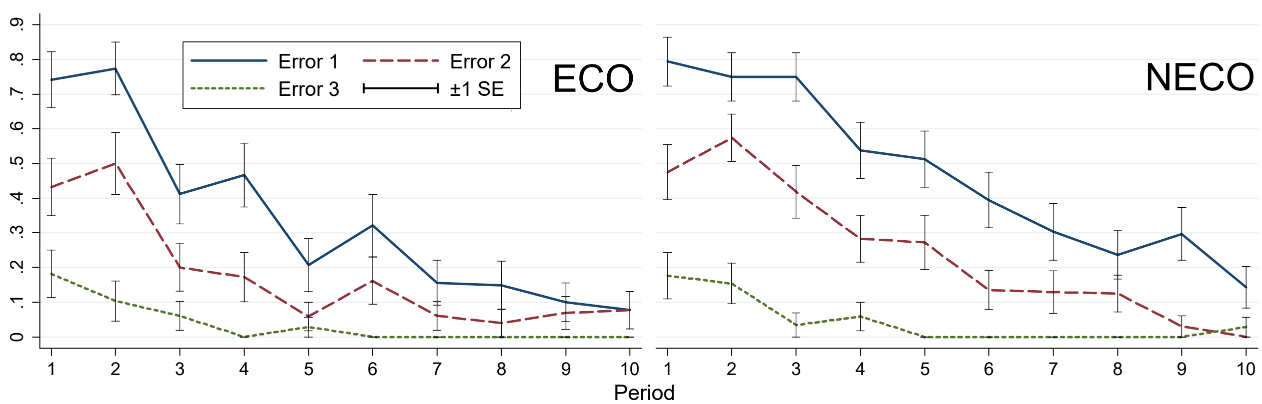

Figure 3: Errors of three types in Race to 15 game for economists and non-economists.

The rate of Errors 3 goes to zero in period 5 or 6. For non-economists the rates of Errors 2 and 1 are significantly different in all ten games with the rate of Error 1 staying at around 15% in the last game. For economists, the rates of Errors 2 and 1 become not significantly different around game 8 or 9 at values of 5% to 8%. Overall, Figure 3 looks exactly as Figure 1 in Gneezy *et al.* (2010) which shows that we were able to replicate the results of the previous study. The difference in the error rates in late games between economists and non-economists is a first indication that there might be differences in learning rates between the two groups.

Next, we explicitly compare the error rates for economists and non-economists. Table 5 in Appendix A shows the exact binomial tests and χ^2 approximations for the comparison of binomial distributions of errors of economists and non-economists overall and in each game separately. If we pool all data together we see that overall errors between economists and non-economists are very significantly different: 21% for non-economists versus 15% for economists (exact $p < 10^{-6}$). The same holds if we look only at Errors 1 and 2. Errors 1 are 48% for non-economists vs. 35% for economists and Errors 2 are 27% for non-economists and 19% for economists (exact $p = 5 \cdot 10^{-6}$ and $p = 5.11 \cdot 10^{-4}$).

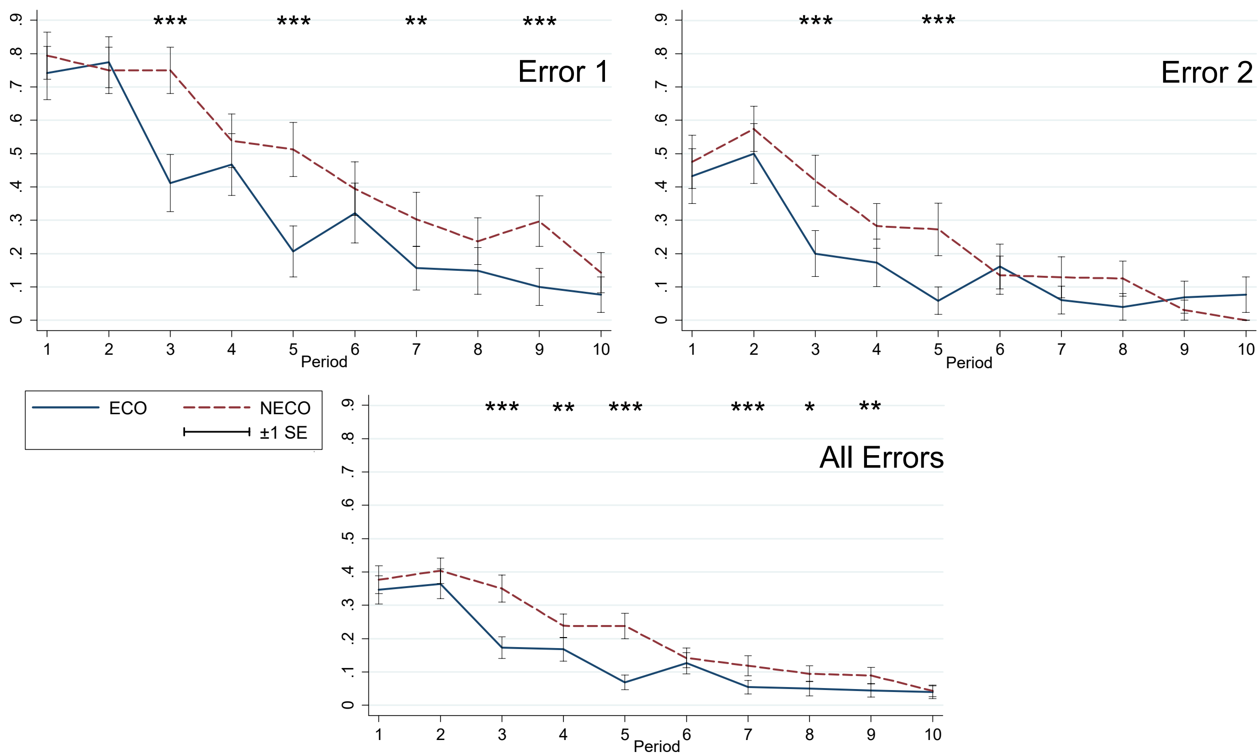

Figure 4: Errors of type 1 and 2 and all errors graphed separately for economists and non-economists for the ten Race to 15 games. Stars denote the significance of the exact binomial test of the equality of distributions (see Table 5 in Appendix A for the tabulated data). $* - p < 0.1$; $** - p < 0.05$; $*** - p < 0.01$.

Figure 4 shows Errors 1, 2 and overall errors (Errors 3 are shown in Figure 7 in Appendix A). For non-economists, the rates of Errors 2 are higher than those of economists until game 6 with very significant difference in games 3 and 5. After game 6 the rates are the same, which shows that the majority of subjects from both groups did learn to move to position 7 after 6 repetitions of the game. Interestingly, the Error 2 rates are the same for economists and non-economists in the first two games, the pattern that persists in Errors 3 and overall errors as well. We hypothesize that in the first two games subjects get acquainted with the game and that game

3 is pivotal. In game 3 economists' error rates drop sharply: from 75% to 40% for Errors 1, from 40% to 20% for Errors 2 and 35% to 17% overall, whereas the rates of non-economists do not change significantly in all three graphs. The same difference in error rates was found in the study by Hawes *et al.* (2012), where subjects were divided into quick and slow learners. The former showed rapid drops in error rates in early games while the latter demonstrated this drop only several games later. If we look at the rates of all errors, we see that even when taken game by game the error rates of non-economists are significantly higher than economists' error rates in almost all games from 3 to 9. This gives an additional support to the hypothesis that economists are better in backward induction than non-economists.

The next question is if the number of years of studying at a university influences the ability to backward induct. We look at the error rates in ten Race to 15 games separately for economists and non-economists and for 1st and 3rd years. Figure 8 in Appendix A shows that there is no difference in error rates between years of study. This tells us that any difference in learning speed that we see between economists and non-economists comes again from self-selection to the major effect.

Result 2. *Economists learn quicker than non-economists to backward induct in the Race to 15 game. Number of years of studying at the University does not change the error rates. Thus, the difference in learning comes from self-selection to the major.*

3.4 The Traveler's Dilemma

Now we look at the differences in behavior in the Traveler's Dilemma (TD). Figure 5 shows the histograms of the choices in TD for four groups of subjects. The most striking observation is that many subjects choose 100 tokens while the Nash Equilibrium is to choose 10 tokens. In the group of 3rd year non-economists more than 50% of subjects choose 100 tokens.

We would like to see if there is a difference between groups in TD choices. Given that we have a large point mass at 100 tokens we need to test a specific hypothesis of whether or not there are more non-economists choosing 100 tokens than economists. On average there are 31% of economists and 51% of non-economists who do so. To test this hypothesis we use a permutation test.[7] The statistic we use is the difference in proportions of economists and non-economists who choose 100 tokens. To be more specific, for each permutation of the data if there are n economists and m non-economists who choose 100 tokens the statistic is $m/64 - n/54$, since there are 64 non-economists and 54 economists overall. We generate hundred thousand permutations using Monte Carlo simulation and count the number of permutations which have a more extreme value of the statistic than our data, which gives us an approximation of the p-value. For

[7] Permutation tests are very useful for testing specific hypotheses like this (relative size of point mass at 100 tokens). Standard non-parametric tests, like rank-sum, for example, compare whole distributions and do not allow testing of hypotheses related to the specific features of the distributions.

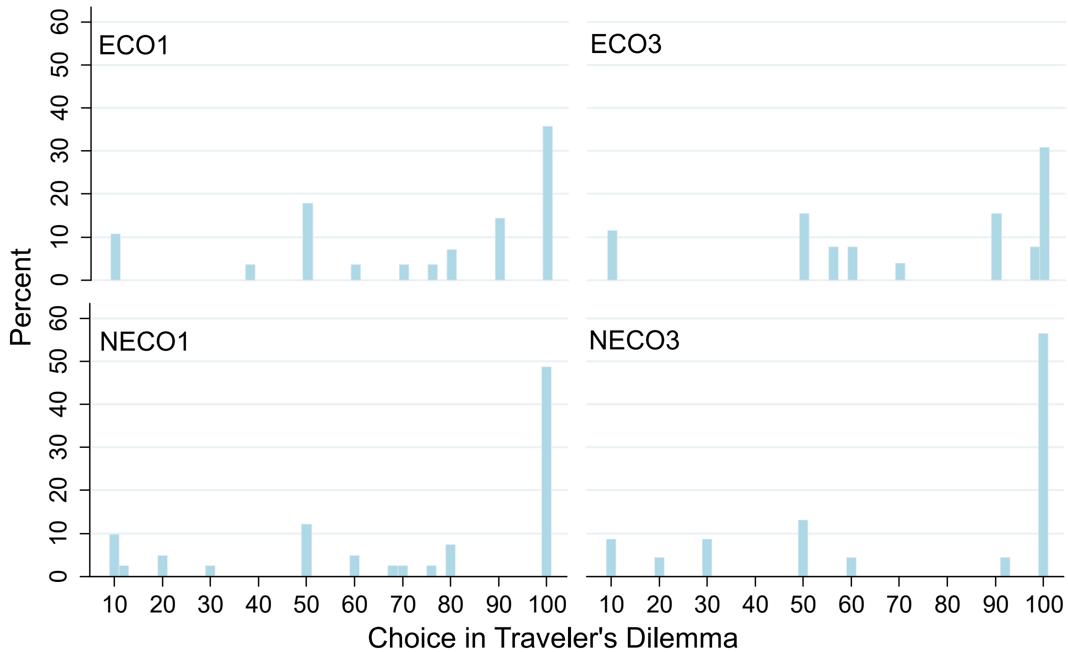

Figure 5: Histograms of the choice in Traveler's Dilemma in four conditions.

the permutation test of the difference in the proportion of economists and non-economists who choose 100 tokens we get one-sided $p = 0.02$ with 95% confidence interval of $[0.0214, 0.0233]$ and two-sided $p = 0.04$ with 95% confidence interval $[0.0390, 0.0415]$. We ran similar permutation tests to check if there is a difference between 1$^{\text{st}}$ and 3$^{\text{rd}}$ year students as well as between the four groups, but found no significant effect anywhere. Nevertheless, we can conclude that the difference in 100 tokens choices is not random and non-economists consistently choose 100 tokens more often than economists.

When analyzing the influence of being an economist or not and years of studying on the less than 100 tokens choices, we find that the average of the less than 100 tokens choices among non-economists is 43.39 tokens (SE: 4.59) and 60.11 (SE: 4.68) among economists. With the Mann-Whitney rank-sum test we can reject the null hypothesis of the equality of distributions ($p = 0.02$). Thus, non-economists choose on average lower number than economists if the choice is below 100 tokens. No other rank-sum test between years of study or between all four groups gives any significance. So, again, there is a difference between choices of economists and non-economists, but it is not influenced by time.

Result 3. *A large proportion of subjects chooses 100 tokens in the Traveler's Dilemma. More than half non-economists choose 100 tokens, which is significantly more than the number of economists who choose 100 tokens. Among those subjects who choose less than 100 tokens, economists, on average, choose higher number than non-economists. There are no changes in choices between years of studying.*

3.5 Within Subjects Analysis of the Traveler's Dilemma

In this final section we would like to shed some light on the choices of our subjects in TD. In particular, we would like to see if we can explain the choice of 100 tokens versus less than 100 tokens in TD with the information from the Dictator games and the Race to 15, and find some regularities in the choices below 100 tokens. This would bring together all our findings into one coherent picture.

As we mentioned in the introduction, we chose the Traveler's Dilemma because of its arcane interaction of reasoning ability and social concerns. On the one hand, individuals who follow a "chain of reasoning" to eliminate actions in TD choose 10 tokens, the unique Nash Equilibrium, assuming the other player understands the logic of "undercutting." On the other hand, ten times more money could be made if both players choose 100 tokens, a strictly dominated action. Moreover, this is not only desirable because of the selfish money maximizing motives, but also because of the social welfare considerations. Our data clearly show that the choice of 100 tokens is not negligible among both economists and non-economists (more than 30% of subjects choose 100 tokens). Our goal in this section is to understand how this choice can be rationalized.

We adopt the framework of Becker *et al.* (2005) who studied the same question. Becker and colleagues do not per se explain how and why subjects choose 100 tokens, but rather add incomplete information to TD in order to show that even if there is a very small number of subjects who choose 100 tokens *unconditionally*, then the support of a Bayesian Nash equilibrium moves into the vicinity of 100 tokens (specifically the interval $[94, 99]$ for their parameters).[8] In the setup of Becker *et al.* there are three types of players: 1) those who unconditionally choose 10 tokens; 2) those who unconditionally choose 100 tokens; and 3) selfish players. The authors show that this model fits the observed data rather well.

We want to go further and see what exactly leads to the choices of 100 tokens. We hypothesize that subjects with strong maximin preferences are those who choose 100 tokens much more often than subjects with efficiency preferences or subjects without any firm social preferences. Intuitively, this might happen because maximin subjects suffer a loss in utility whenever non-equal numbers are chosen: they care about the payoff of the player who is penalized, whereas efficiency subjects are not experiencing such disutility since penalty and bonus cancel each other out when the payoffs are summed. Moreover, if maximin subjects choose 100 tokens, then the incentives in TD change completely: "undercutting," and eventually choosing 10 stops being the dominant action. Instead, choosing actions close to 100 tokens becomes optimal. In Appendix B we construct a Bayesian Nash equilibrium in TD with two types: a maximin type and an efficiency type. We show that there is an equilibrium in which strong maximin types choose 100 tokens, given that their proportion in the population is high enough, and efficiency types play

[8] Becker *et al.* argument is related to that of Kreps *et al.* (1982), which shows that cooperation can be sustained in equilibrium if a marginal fraction of unconditional cooperators is introduced into finitely repeated Prisoners' Dilemma.

mixed strategy with interval support $\{x, ..., 99\}$, where x varies from 87 to 95 depending on the proportion of the strong efficiency types.

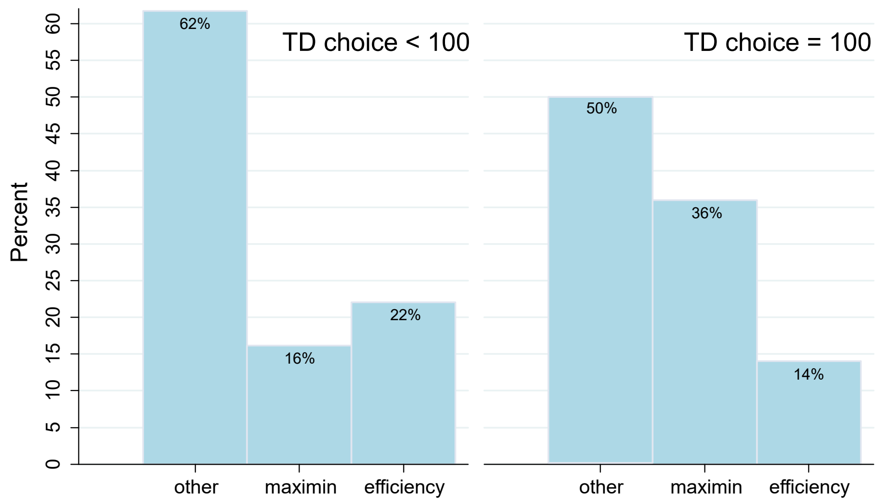

Figure 6: Percentages of distributional types by choices in TD.

To see if our model can explain the data we construct Figure 6. It shows the composition of subjects by choices in TD. We see that 36% of subjects who choose 100 tokens are maximin whereas only 16% of those who choose less than 100 tokens are. This qualitatively supports our hypothesis. If we look at the division by field of study we see similar results: among those who chose 100 tokens only 34% are economists, while among those who chose less than 100 tokens there are 54% of economists. This is consistent with our previous finding that maximin preferences are more spread among non-economists.

Next, we would like to find out if the performance in the Race to 15 game has some influence on the choices in TD. In the following regressions in Table 4 we 1) provide additional support to our hypothesis that being maximin increases the chances of choosing 100 tokens and 2) provide evidence that the ability to reason as revealed by the number of mistakes in the Race to 15 influences the behavior in TD in the way consistent with the BNE.

In Columns 1 to 4 of Table 4 the dependent variable is is100, which is equal to 1 if a subject chose 100 tokens and 0 otherwise. Independent variables are mn $\in [0, 1]$ - a normalized number of Dictator games in which a subject chose according to maximin; ef $\in [0, 1]$ - a normalized number of Dictator games where the choice was in accordance with efficiency; higherr, which is equal to 1 if a subject made the above median number of errors in Race to 15 game and isneco - the dummy for non-economists.[9] Being maximin significantly increases the chances of choosing 100 tokens, which supports our hypothesis (logit regression in Column 1 and OLS in Column 2). The linear probability model in Column 2 shows that the change from 0 to full maximin preferences

[9]We use continuous variables mn and ef instead of dummy variables ismn and isef as above in order to not loose half of the data, since only half of the subjects could be classified as having maximin or efficiency preferences.

Dependent variable	is100				tdchoice	
	(1)	(2)	(3)	(4)	(5)	(6)
mn	2.472**	0.548***	2.468**	0.549***	22.973	
	(1.007)	(0.198)	(0.987)	(0.200)	(14.280)	
ef	0.018	–0.010			–19.007	
	(0.893)	(0.164)			(13.148)	
isneco	–0.031	–0.004	–0.030	–0.004	–14.368	–13.130
	(0.584)	(0.135)	(0.583)	(0.134)	(10.191)	(9.754)
higherr	–1.284*	–0.254**	–1.283*	–0.255**	–6.095	–5.345
	(0.742)	(0.123)	(0.740)	(0.122)	(9.950)	(9.930)
isneco·higherr	1.716*	0.353**	1.715*	0.354**	–2.844	–3.813
	(0.927)	(0.177)	(0.924)	(0.176)	(13.771)	(13.822)
cons	–1.959**	0.072	–1.946***	0.065	60.482***	62.130***
	(0.955)	(0.149)	(0.692)	(0.132)	(10.856)	(5.849)
N	118	118	118	118	68	68
R^2					0.16	0.10

Table 4: Logit and OLS regressions of is100 (Columns 1, 3 - logit; Columns 2, 4 - OLS) and tdchoice (OLS - Columns 5, 6). In all OLS regressions errors are robust. $* - p < 0.1$; $** - p < 0.05$; $*** - p < 0.01$.

changes the probability of choosing 100 tokens by 54.8%. Also, a significant coefficient on higherr in Column 2 shows that economists with below median reasoning ability tend to choose 100 tokens 25% less often. This suggests that they might not understand that in the situation where there is a significant amount of people who choose 100 tokens it is worthwhile to choose it as well.[10] Notice that for non-economists the number of mistakes in Race to 15 does not influence the probability of choosing 100 tokens (the sum of coefficients higherr + isneco·higherr is not significant). This suggests that norm following (choosing 100 tokens is socially appropriate) might be the reason behind their choices. To sum up, we find an effect of the Race to 15 performance on the choice between 100 tokens and less only among economists.

Next we analyse the choices strictly below 100 tokens. The dependent variable in Columns 5 and 6 is tdchoice - the number of tokens chosen conditional on this number being less than 100. We see that neither mn nor ef play any role here. However, there is an effect of higherr and isneco. Non-economist subjects who scored below median in the Race to 15 game choose 23 tokens less (the sum of coefficients isneco+isneco·higherr+higherr is -23.3^{***} and -22.3^{***} in Columns 5 and 6 respectively, $p = 0.008$). This is the same direction as we saw in previous paragraph: below median reasoning ability subjects tend to choose lower number of tokens.

In our opinion this effect can have two explanations. First, subjects with below median reasoning ability might not realize that many others will choose 100 tokens, which can reflect their

[10]The same coefficient in the logit specification is only significant at the 10% level. Columns 3 and 4 report the same regressions as Columns 1 and 2 only without ef variable.

inability to think about others. Second, even if they do understand that many others will choose 100 tokens, they might be unable to realize that the undercutting strategy (which is rather simple to understand) is no longer optimal. Unfortunately, with the current design we are unable to disentangle these two possibilities and leave it for future research.

Lastly, it is worth to emphasize one more result. There is a stark difference between economists and non-economists in choices below 100 tokens: the average number chosen by economists is 60.11 tokens whereas non-economists choose on average 43.39 tokens. With the rank-sum test we can reject the null hypothesis of equality of distributions (two-sided $p = 0.02$). Thus, we see that economists tend to be closer to the BNE (at least the mixed part of it) than non-economists. Given our findings that economists tend to make less errors in Race to 15 game, we can conclude that reasoning ability indeed plays a role in subjects being more optimal in the Traveler's Dilemma.

Result 4. *Distributional preferences play a role in choices in the Traveler's Dilemma. Having maximin preferences significantly increases the chances of choosing 100 tokens. This is explained by the disutility that maximin subjects receive when unequal numbers are chosen (which is not true for efficiency subjects). Some subjects who are below median in the number of errors they made in Race to 15 game tend to choose less tokens, which shows that they are worse at reasoning about the optimal strategy.*

4 Conclusion

In this paper we studied the effects that an interaction between reasoning ability and distributional preferences has on behavior in games. We considered two groups of student subjects, economists and non-economists, which are different in the exposure to formal mathematical education. In a within subjects design, we measured distributional preferences by means of a series of three person Dictator games and found that economists tend to be more efficiency prone while non-economists prefer maximin. We measured reasoning ability with a version of the Nim game (Race to 15). We found that economists make overall less errors and learn the optimal strategy faster than non-economists. Finally, we looked at the behavior in the Traveler's Dilemma (TD), a game in which reasoning ability interacts with payoff maximization. To incorporate the data on distributional preferences we constructed an incomplete information version of TD with maximin and efficiency types and showed that the resulting BNE qualitatively explains our data. In particular, the equilibrium predicts that strong enough maximin types should choose 100 tokens, a strictly dominated action (in the stage game), which, however, has a high expected payoff if the probability of the other player choosing 100 tokens is high. Indeed, in our data we see a significant tendency of maximin subjects to choose 100 tokens. We also find that subjects with low reasoning ability tend to choose smaller number of tokens than high reasoning ability subjects, which, given that substantial number of subjects choose 100 tokens, is not an optimal choice. For below 100 tokens choices, economists tend to be closer to equilibrium than non-economists.

We show that in order to understand cooperative behavior it is not enough to consider social or distributional preferences alone. Reasoning ability plays a role in determining the strategy that is chosen in social dilemmas. This holds not only for complex games like the Traveler's Dilemma, but also for simple games like the one-shot Prisoner's Dilemma, where (for example) level-k reasoning might distort cooperative behavior. Therefore, without taking reasoning ability into account, false conclusions can be made about the motivations behind choices.

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Appendix (for online publication)

A Additional Analyses

Game	Obs	Observed Errors	Expected Errors	Assumed Probability	Observed Probability	Exact p	χ^2	p
All Errors	**1181**	**174**	**252.77**	**0.21**	**0.15**	$\mathbf{< 10^{-6}}$	**31.23**	**0.00**
1	130	45	48.99	0.38	0.35	0.27	0.52	0.47
2	118	43	47.63	0.40	0.36	0.22	0.75	0.39
3	133	23	46.55	0.35	0.17	$5.00{\cdot}10^{-6}$	18.33	0.00
4	113	19	26.94	0.24	0.17	0.05	3.07	0.08
5	132	9	31.38	0.24	0.07	$< 10^{-6}$	20.93	0.00
6	111	14	15.74	0.14	0.13	0.38	0.23	0.64
7	129	7	15.31	0.12	0.05	0.01	5.11	0.02
8	100	5	9.46	0.09	0.05	0.08	2.32	0.13
9	113	5	10.12	0.09	0.04	0.05	2.84	0.09
10	102	4	4.40	0.04	0.04	0.55	0.04	0.84
Errors 1	**298**	**104**	**142.21**	**0.48**	**0.35**	$\mathbf{5.00{\cdot}10^{-6}}$	**19.64**	**0.00**
1	31	23	24.62	0.79	0.74	0.30	0.52	0.47
2	31	24	23.25	0.75	0.77	0.69	0.1	0.76
3	34	14	25.50	0.75	0.41	$2.90{\cdot}10^{-5}$	20.75	0.00
4	30	14	16.15	0.54	0.47	0.27	0.62	0.43
5	29	6	14.87	0.51	0.21	$7.31{\cdot}10^{-4}$	10.86	0.00
6	28	9	11.05	0.39	0.32	0.28	0.63	0.43
7	32	5	9.70	0.30	0.16	0.05	3.26	0.07
8	27	4	6.39	0.24	0.15	0.20	1.18	0.28
9	30	3	8.92	0.30	0.10	0.01	5.59	0.02
10	26	2	3.71	0.14	0.08	0.26	0.92	0.34
Errors 2	**311**	**58**	**83.30**	**0.27**	**0.19**	$\mathbf{5.11{\cdot}10^{-4}}$	**10.5**	$\mathbf{1.20{\cdot}10^{-3}}$
1	37	16	17.58	0.48	0.43	0.36	0.27	0.60
2	32	16	18.37	0.57	0.50	0.25	0.72	0.40
3	35	7	14.65	0.42	0.20	0.01	6.87	$8.80{\cdot}10^{-3}$
4	29	5	8.20	0.28	0.17	0.13	1.74	0.19
5	34	2	9.27	0.27	0.06	0.00	7.84	$5.10{\cdot}10^{-3}$
6	31	5	4.19	0.14	0.16	0.77	0.18	0.67
7	33	2	4.26	0.13	0.06	0.18	1.37	0.24
8	25	1	3.13	0.13	0.04	0.16	1.65	0.20
9	29	2	0.88	0.03	0.07	0.94	1.48	0.22
10	26	2	0.00	0.00	0.08	1.00	0.15	0.69

Table 5: Exact binomial and χ^2 tests of equality of distributions of errors of economists and non-economists (ECO and NECO) in ten Race to 15 games. *Obs* shows the number of moves from winning positions that economists made; *Observed Errors* is the number of mistakes they made; *Expected Errors* is the number of errors that non-economists made; *Assumed Probability* is the estimated chance of error for non-economists; *Observed Probability* is the estimated chance of error for economists.

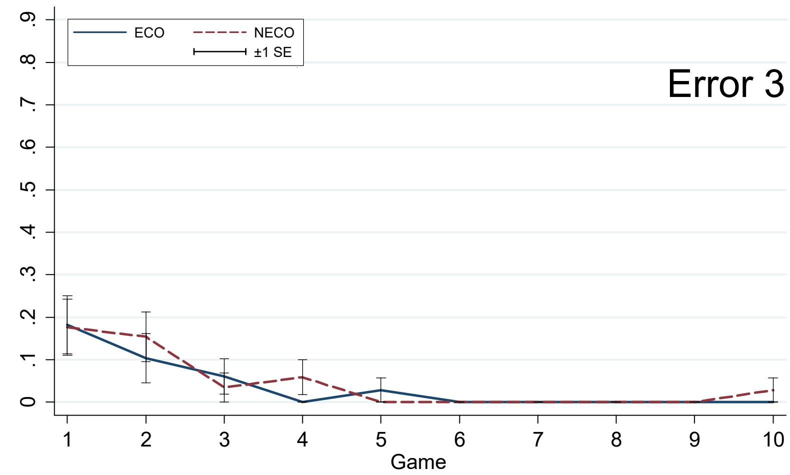

Figure 7: Errors of type 3 for economists and non-economists for the ten Race to 15 games.

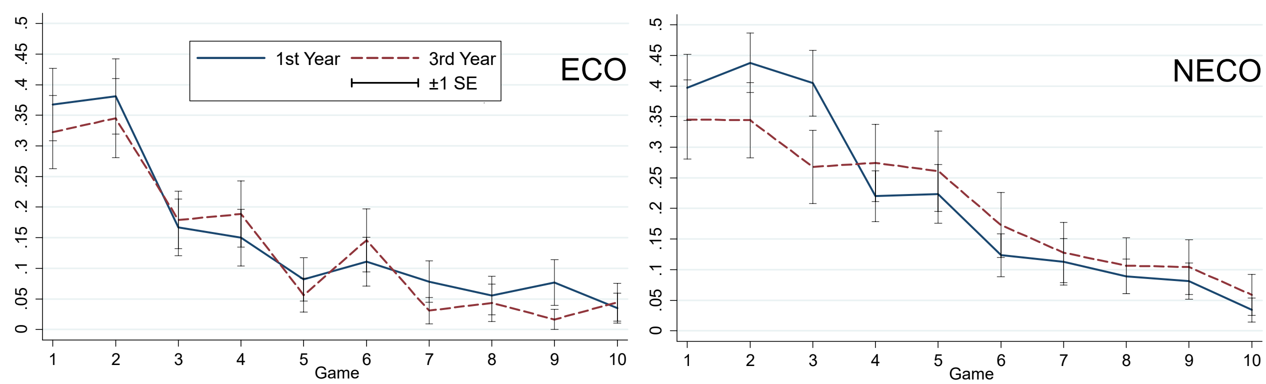

Figure 8: Error rates in Race to 15 by years of study.

B Traveler's Dilemma with Incomplete Information

In this section, we take the model of Becker *et al.* (2005) and extend it by introducing types with distributional preferences instead of simply assuming the types which choose fixed action. Following our experimental design, we assume that there are two types of players: 1) players who care about efficiency and 2) players who care about maximin. Given the monetary outcome (x_i, x_{-i}) of the game, we define utility for the efficiency type to be $u_i^e(x_i, x_{-i}) = x_i + \gamma_i(x_i + x_{-i})$ and the utility for the maximin type to be $u_i^m(x_i, x_{-i}) = x_i + \delta_i \min\{x_i, x_{-i}\}$, where $\gamma_i, \delta_i \in [0,1]$ (we assume that the players' distributional concerns are no stronger than selfish ones).

Let the action choices be $a_i, a_{-i} \in \{10, ..., 100\}$. Then the monetary payoffs are defined as in Section 2.2:

$$\pi(a_i, a_{-i}) = \begin{cases} (a_i + b, a_i - b), & \text{if } a_i < a_{-i} \\ (a_{-i}, a_{-i}), & \text{if } a_i = a_{-i} \\ (a_{-i} - b, a_{-i} + b), & \text{if } a_i > a_{-i}, \end{cases}$$

where b is the bonus-penalty. Notice that the monetary payoffs do not depend on types.

Before we continue, let us first transform the utility of efficiency type. The utility is given by

$$u_i^e(\pi(a_i, a_{-i})) = \begin{cases} (1+2\gamma)a_i + b, & \text{if } a_i < a_{-i} \\ (1+2\gamma)a_{-i}, & \text{if } a_i = a_{-i} \\ (1+2\gamma)a_{-i} - b, & \text{if } a_i > a_{-i} \end{cases}$$

which is the same as

$$u_i^e(\pi(a_i, a_{-i})) = \begin{cases} a_i + b/(1+2\gamma), & \text{if } a_i < a_{-i} \\ a_{-i}, & \text{if } a_i = a_{-i} \\ a_{-i} - b/(1+2\gamma), & \text{if } a_i > a_{-i}. \end{cases}$$

Thus, efficiency types are equivalent to selfish players whose bonus-penalty is smaller: $b/(1+2\gamma)$ instead of b.

B.1 Equilibria in the Stage Game

Before proceeding to the incomplete information model, we first find Nash equilibria in the stage game for both types. For the efficiency type the unique Nash equilibrium is the same as in the standard TD: both players choose 10. For the maximin type the situation is a little different. The utility of maximin type is given by

$$u_i^m(\pi(a_i, a_{-i})) = \begin{cases} a_i + b + \delta(a_i - b), & \text{if } a_i < a_{-i} \\ (1+\delta)a_{-i}, & \text{if } a_i = a_{-i} \\ a_{-i} - b + \delta(a_{-i} - b), & \text{if } a_i > a_{-i}. \end{cases}$$

To find the best response correspondence let us modify this expression:

$$u_i^m(\pi(a_i, a_{-i})) = \begin{cases} (1+\delta)a_{-i} - (1+\delta)(a_{-i} - a_i) + b(1-\delta), & \text{if } a_i < a_{-i} \\ (1+\delta)a_{-i}, & \text{if } a_i = a_{-i} \\ (1+\delta)a_{-i} - b(1+\delta), & \text{if } a_i > a_{-i}. \end{cases}$$

In case $a_i < a_{-i}$, for δ close enough to 1, we will have $-(1+\delta)(a_{-i} - a_i) + b(1-\delta) < 0$. This condition can be rewritten as

$$\delta > \frac{b - (a_{-i} - a_i)}{b + (a_{-i} - a_i)}$$

which is decreasing in $(a_{-i} - a_i) > 0$. Thus the highest value of the right hand side is when $a_{-i} - a_i = 1$, which gives $\delta > \frac{9}{11}$. Thus, given any fixed a_{-i} and $\delta > \frac{9}{11}$, "undercutting," or deviation to lower numbers than a_{-i}, becomes not profitable. Deviation to numbers higher than a_{-i} is not profitable either. Therefore, the unique best response to any a_{-i} is $BR_i^m[a_{-i}] = a_{-i}$.

A Traveler's Dilemma with maximin preferences has 91 Nash equilibria in which both players choose the same number. Notice that maximin preferences essentially turn TD into a coordination game in which there is a linear Pareto order of equilibria with the equilibrium $(100, 100)$ being Pareto dominant. Thus, equilibrium $(100, 100)$ is a natural focal point that might attract a considerable fraction of maximin players.

B.2 Incomplete Information

Now we demonstrate that there is a Bayesian Nash equilibrium in which maximin types choose 100 tokens and selfish types choose numbers close to 100. Our model is the same as one of Becker *et al.* (2005) with one difference, we have an additional constraint: maximin types should not want to deviate from choosing 100 tokens (Becker and colleagues assume that the type that chooses 100 tokens does so unconditionally, so no profitable deviations are possible).

We look for a Bayesian Nash equilibrium in which the maximin type chooses 100 tokens and efficiency types choose a mixed strategy on some interval $[x, 99]$. Becker *et al.* (2005) directly compute such an equilibrium (without no deviation constraint for the maximin type). All we need to do is to make sure that adding the no deviation constraint for the maximin type does not destroy such an equilibrium. As we have seen in the previous subsection, if only maximin types with sufficiently high δ are present, then the outcome $(100, 100)$ is the Nash equilibrium. Thus, in incomplete information game, as the prior probability of meeting maximin type p goes to 1 and δ is high enough at some moment BNE will resemble Nash equilibrium of the maximin type's stage game and there will be no profitable deviation from the outcome $(100, 100)$. This argument ensures that no deviation condition is satisfied for some intervals of p and δ.

We have computed such BNE for the parameters close to our data. We tried to find p and δ as low as possible. For $p = 0.52$ and $\delta = 0.92$ we have BNE with the support of the mixed strategy of efficiency type being $\{87, ..., 99\}$ with $\gamma = 0$ (selfish players); with support $\{89, ..., 99\}$ with $\gamma = 0.125$ and with support $\{95, ..., 99\}$ $(\gamma = 0.9)$. Figure 9 illustrates.

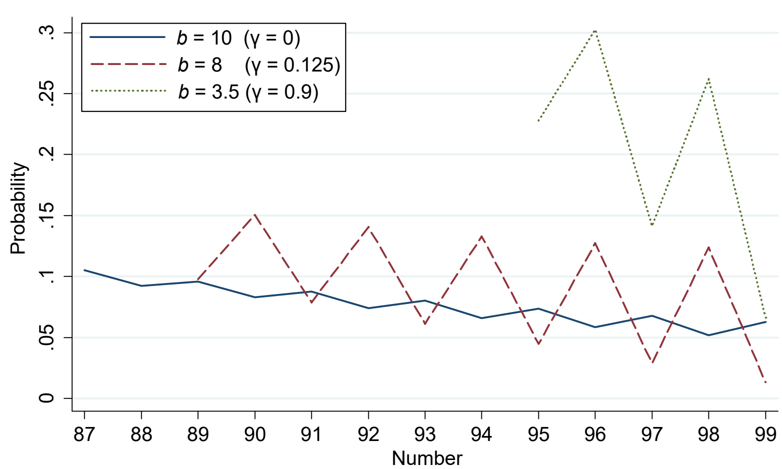

Figure 9: Mixed strategies of the efficiency type in BNE for three levels of γ.

Just to illustrate how equilibrium support of the strategy of the efficiency type depends on parameters we also plot equilibria for $\gamma = 0$, $\delta = 1$ and three of p: $p \in \{0.5, 0.7, 0.85\}$ (see Figure 10).

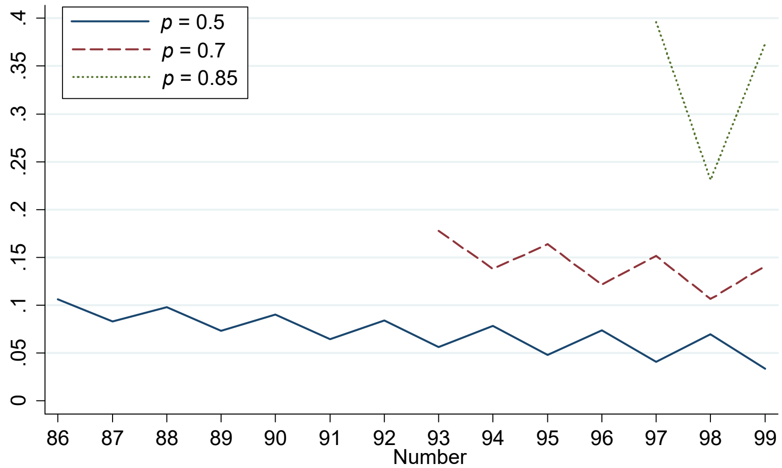

Figure 10: Mixed strategies of the efficiency type in BNE for three levels of p.

C Instructions

C.1 General Instructions

You are now participating in a decision making experiment which consists of three parts and a questionnaire. If you follow the instructions carefully, you can earn a considerable amount of money depending on your decisions and the decisions of the other participants. Your earnings will be paid to you in CASH at the end of the experiment.

During the experiment you are not allowed to communicate with anybody. In case of questions, please raise your hand. Then we will come to your seat and answer your questions. Any violation of this rule excludes you immediately from the experiment and all payments. This research is funded by the Marie Curie action of the EU.

Click **OK** when you are ready to go on.

C.2 Traveler's Dilemma

In this part of the experiment you are paired with one other person in this room. The choices that **both** you and the other person make will determine the amount that you earn. The earnings of each participant will be determined on the basis of the outcomes as explained below. Your earnings are expressed in tokens where **1 token is equal to 10 cents**.

You have to choose a number of tokens between **10 and 100**. At the same time, unknowingly to you, the person with whom you have been paired also has to choose a number of tokens between 10 and 100.

If the numbers of tokens chosen by you and the other person are **the same**, you will both earn the number of tokens chosen.

If the numbers of tokens chosen are **different**, you will both earn a number of tokens equal to the **lower** of the two chosen numbers, plus a **bonus or penalty** determined as follows:

If the number you have chosen is **lower** than the number chosen by the other person, you will receive a **bonus of 10 tokens** and the other person will get a penalty of 10 tokens.

If the number you have chosen is **higher** than the number chosen by the other person, you will get a **penalty of 10 tokens** and the other person will receive a bonus of 10 tokens.

In short the rules can be expressed as follows:

Suppose that you choose X tokens and the other person chooses Y tokens.

If $X = Y$, you get X, and the other gets Y.
If $X > Y$, you get $Y - 10$ tokens, and the other gets $Y + 10$ tokens.
If $X < Y$, you get $X + 10$ tokens, and the other gets $X - 10$ tokens.

The choices that you and the other subject will make, and the corresponding results, will not be communicated to you until the end of the whole experiment.

C.3 Three Person Dictator Games

In this part of the experiment you need to choose among monetary allocations. Monetary allocation is an assignment of some amounts of money to three people.

Together with two other participants whom we randomly select, you will form a group. You will not get to know anything concerning the identity of these other participants. In the same way, others cannot identify you and your decisions.

As for the role assignment within the groups, in the end of this part of the experiment we will randomly assign you to one of three roles (Person 1, Person 2 or Person 3).

The payment that you and the other two members of your group will receive will be determined by the choice of **Person 2** in your group.

On the right of your screen you see the choice you will need to make. The decision table consists of three possible allocations: A, B and C among which you need to choose. Each allocation corresponds to one column of the table. The cells in the table specify the monetary amounts that Person 1, 2 and 3 can receive. These amounts are expressed in tokens where **1 token is equal to 25 cents**.

Your Task:
You will be presented with 9 different decision tables. In each of these tables please choose among three allocations (A, B or C) which you as **Person 2 would prefer for the group**. To make your choice please press on the corresponding cell underneath the allocation.

To determine the payments in your group, the decision of Person 2 in a randomly chosen decision table will be applied. In case you are assigned the role of Person 1 or Person 3, your decision will thus be irrelevant. In case you are assigned the role of Person 2, however, a random selection of a column that you have selected in a random decision table will determine the payments of all three persons in your group.

The choices that you and the other people make, and the corresponding results, will not be communicated to you until the end of the whole experiment.

C.4 Move an X Game

In this part of the experiment you play a simple game with one other person in this room.

You will play this game **10 times** in a row. Every round you are paired with a **different** person. In the game two players move one after the other: first, one player moves, then the other player moves, and so on.

One player (either you or the other player) starts from position 1, and can then move the X by either **1, 2 or 3** positions to the right. Then the next player can move the X by 1, 2 or 3 positions to the right from the position where X is after the previous move. Both players can move the X only to the right. The player who reaches 15 first wins the game.

You see the first round of the game on the right.
Earnings:
Half of the people in this room who win the most games get **10 Euro**, the other half gets nothing. In case

of a tie each tied person gets **4 Euro**.

If there is anything that you do not understand, please raise your hand. An experimenter will then come to you and answer your question.

The choices that you and the other people make, and the corresponding results, will not be communicated to you until the end of the whole experiment.

D Screenshots

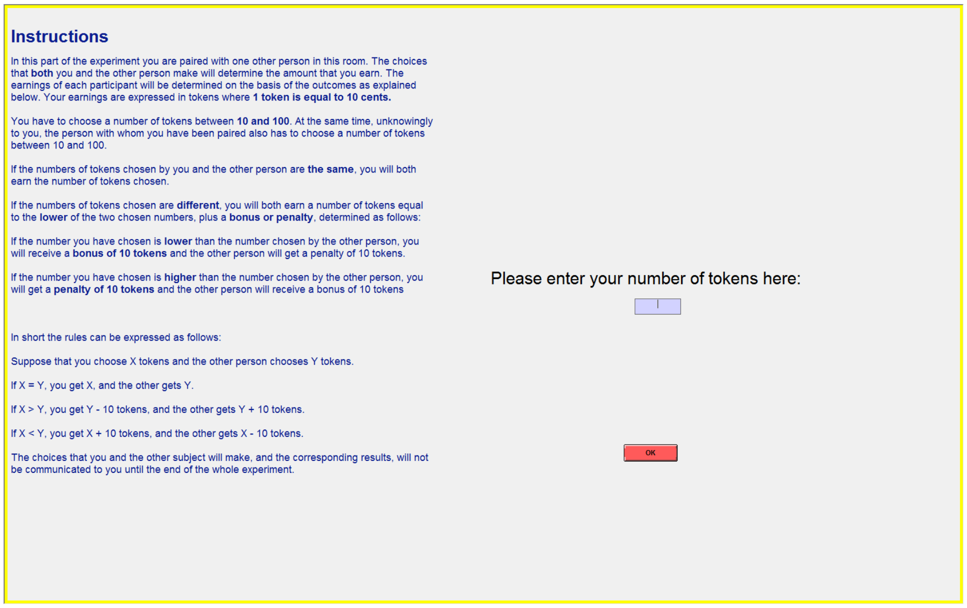

Figure 11: Screenshot of Traveler's Dilemma.

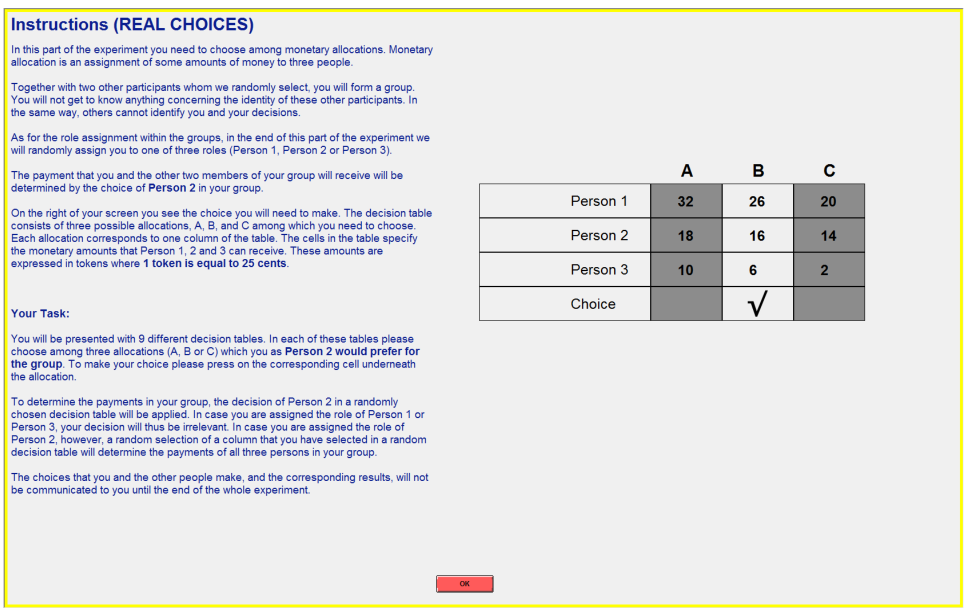

Figure 12: Screenshot of a Dictator game.

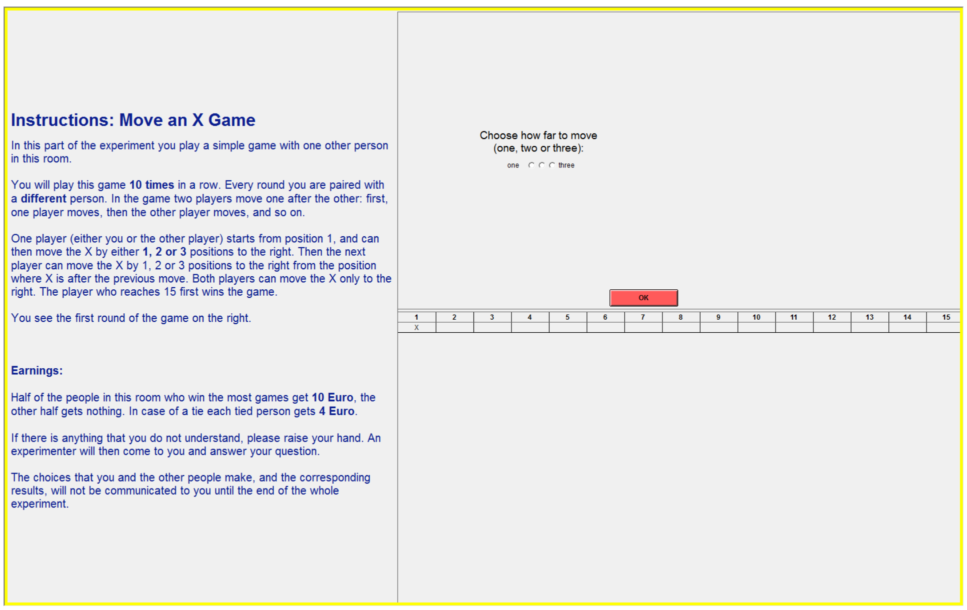

Figure 13: Screenshot of Race to 15 game.