ASSIGNMENT VERSUS CHOICE IN PRISONER'S DILEMMA EXPERIMENTS*

by

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Abstract

We experimentally compare behavior in a repeated prisoner's dilemma (PD) game when players can choose between two different representations of the same PD, to behavior when players are assigned to play a specific game. We find that cooperation rates are up to 60% higher in the games that were chosen. These findings are consistent with the robust evidence of the psychology literature for non-strategic contexts that choice increases motivation, trust, and increases performance. Given that in many contexts agents choose the strategic situation they get involved in, assigning participants to experiments may affect the external validity of some experimental findings.

Keywords: Assignment, Choice, Sorting, Prisoner's Dilemma, Framing

JEL-Classification: H41, C90, C91

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I.- INTRODUCTION

The present study is concerned with the methodological question of the external validity of experimental research based on the assignment of participants to experimental games or decision situations. Experimental findings may systematically misrepresent field outcomes if assigning participants to experiments has an impact on the decisions made by the participants in the experiment and if such an assignment does not occur in the field.

We experimentally analyze to what extent the very possibility of choosing the game one is about to participate in, may have an important effect on behavior and outcomes. To that end, we design an experiment based on a prisoner's dilemma (PD) game. We conduct five different treatments, divided into two *categories*: the *assignment* treatments and the *choice* treatments. In the three assignment treatments, participants play an externally imposed version of a PD game. The three versions of the PD game are different representations of exactly the same game. That is, they have the same number of players, the same action space, the same information structure, the same payoffs, and the same Nash equilibrium. In the two choice treatments, participants can choose the version of the PD game they want to play from a binary set.

The experiment is related to the economic literature on freedom of choice. According to Sen (1988, 290), "one reason why freedom [of choice] may be important is that 'choosing' may itself be an important functioning ... if all alternatives except the chosen one were to become unavailable, the chosen alternatives will not, of course, change, but the extent of freedom would be diminished, and if the freedom to choose is of intrinsic importance, then there would be a corresponding reduction of the person's advantage".[1] In our context, this is to say that, aside from the particulars of a game, *it matters whether the game is assigned, or if it is chosen from a set of games.* Whereas the literature on freedom of choice is concerned with an effect on utility, we are interested in a potential behavioral impact of choice.

Such a behavioral impact of choice has been studied in the psychology literature in non-strategic contexts for several decades. The availability of choice is typically understood as a form of decision control, i.e. the possibility to decide about a forthcoming event that can involve choice among a set of alternatives or the regulation of an event's timing and duration. Several empirical studies support the notion that people who have choice experience "more intrinsic motivation, greater interest, less pressure and tension, more creativity, more cognitive flexibility, better conceptual learning, a more positive emotional tone, higher self-esteem, more trust, greater persistence of behavior change, and a better physical and psychological health" (Deci and Ryan 1987, 1024). In a classic experiment exposing two groups to a recording of loud, unpredictable noises, Glass and Singer (1972) found strong choice effects. Whereas participants in one group had no choice but to listen to the recording, participants in the other group could choose to stop the tape at any time by flipping a switch. These participants were told, however, that the experimenters would prefer that they not stop the tape, and most subjects honoured this preference. Following exposure to the noise, participants with access to the control switch made almost 60 percent fewer errors than participants helplessly exposed to the noise on a proofreading task and made more than four times as many attempts to solve a difficult puzzle.[2]

[1] There is a literature that axiomatizes this line of thought (see Bossert, Pattanaik, and XU 1994, or Pattanaik and Xu 2000).

[2] Similarly Elffers and Hessing (1997) found evidence that offering taxpayers a choice between full itemized deduction and a comparable overall standard deduction enhances tax compliance. In a classic experiment on learned

Related to our experiment are also some recent studies demonstrating the effect a *random* assignment of participants has on outcomes in experimental games in contrast to situations where participants have the option to *self-select*. These studies aim at separating participants by types and are based on the notion that in many field situations that are scrutinized in the laboratory, people have the possibility of avoiding the situation they are confronted with in the experiment. Screening mechanisms used to select employees, customers and insurers are examples of situations where self-selection and/or sorting are essential features of the strategic environment.

Charness (2000) for instance exogenously separated subjects on the basis of performance in a dictator game prior to playing a bargaining game. Bohnet and Kübler (2005) attempt to sort out conditional cooperators and egoists by giving the possibility to bid for participation in a PD game with higher out of equilibrium payoffs than the status quo PD game in an auction. Lazear, Malmendier, and Weber (2005) design an experimental dictator game with an outside option to separate between players. Eriksson and Villeval (2004) (see also Königstein and Villeval (2005)) experimentally study a labor market where workers can choose the incentive scheme according to which they are paid. They show that high skill workers separate from low skill workers by choosing performance pay firms.[3]

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helplessness Seligman (1974) found that loss of choice (control) is experienced as aversive and has detrimental effects on people's emotions, motivation and cognition.

[3] Besides this literature, see for example the experimental studies by Niederle and Vesterlund (2005) in the context of occupational gender differences, Cadsby, Song, and Tapon (2004), Eriksson, Teyssier, and Villeval (2005), and Dohmen and Falk (2006) in the context of worker-self-selection and productivity. Although not directly concerned with sorting, Orbell and Dawes (1993) provided participants in a one shot PD game the choice of not playing the game. Hauk (2003) provided an outside option in a repeated PD game context. Cox et al. (2001) analyze endogenous entry and exit in common value auctions.

Of some relevance to the present work, is also the literature on group membership. In a classic experiment Tajfel (1970) allowed participants to identify with a group based either on the preference for a painting by Kandinsky or Klee or the tendency to over or underestimate the number of dots displayed on a screen prior to allocating money between one in-group member and one out-group member.[4] The effects of group membership and what is necessary to trigger such effects has recently been systematically analyzed by Charness, Rigotti, and Rustichini (2006) in the context of a battle of the sexes and PD game.

Finally, our paper relates to an emerging literature that criticizes the standard methodology used in experimental economics in light of the possible lack of external validity with respect to some experimental results obtained (see, notably, List and Levitt (2005) and references therein, Lazear, Malmendier, and Weber (2005) and Harrison, Lau and Rutström (2005)).

In contrast to the literature on self-selection/sorting and group membership, we analyze to what extent experimental deviations from actual situations due to the assignment of participants is based exclusively on the possibility of self-selection or sorting, or whether choice has an important behavioral effect in itself. The present paper extends the results obtained in the experimental psychology literature on control and choice by analyzing whether choice effects are also found in strategic environments, rendering them of particular interest to economic environments. Based on the idea that choice either via active modification of the strategic environment[5] or by passive self-selection into a particular strategic environment may be an

[4] See also Tajfel, Billig, Bundy, and Flament (1971), Yamagishi, Jin, and Kiyonari (1999) and Yamagishi and Kiyonari (2000).
[5] See the literature on self-governance, for instance Ostrom (1990) or Scott (1998).

important property of many empirical problems studied using experimental methods, we are interested in separating a choice effect from sorting or self-selection effects.

We analyze the behavioral importance of the possibility of choosing the game to be played in a scenario where the differences between the alternatives available are kept to a minimum. We conjecture that a behavioral effect when players are given the possibility of choosing between two games that in standard game theoretic terms are equivalent, and differ only in the presentation of the game, may be even more pronounced if differences between games are more substantial, and for instance allow self-selection and sorting.

The experimental results clearly indicate that the mere fact that participants can choose the game they want to play has a statistically significant impact on behavior. Cooperation rates are higher when players can choose the game they want to play as compared to when players are assigned to the game. The increase in cooperation rates is in some cases even 60%. As an immediate consequence, the current laboratory practice of assigning participants to experimental games may, even absent the possibility of sorting, provide biased results. This finding adds an additional reason why experimental results cannot directly be extrapolated to the field.

The organization of the rest of the paper is as follows. The next section introduces the three versions of the PD that are used in this paper, Section 3 contains the experimental procedure, Section 4 reports the experimental results and Section 5 concludes.

II.- THE GAMES

1.- THE PRISONER'S DILEMMA GAME

Table 1 presents a typical 2-player matrix game in normal form. This game is a PD if and only if, the following conditions are met: $a > b > c > d$ and $2b > a + d > 2c$.

Table 1: General 2×2 prisoner's dilemma game in normal form (PD).

	Cooperate	**Defect**
Cooperate	(b,b)	(d,a)
Defect	(a,d)	(c,c)

Note: The first element of the payoff vectors refer to the row player.
In the experiment a=400, b=300, c=100 and d=0

It is well known that both players playing defection is the unique Nash equilibrium of the one-shot prisoner's dilemma game. Applying the logic of backward induction, Luce and Raiffa (1957) showed that the unique Nash equilibrium outcome in the finitely repeated prisoner's dilemma game under perfect information is again the one in which both players defect in every single period. In fact, the unique subgame-perfect equilibrium is both players defecting in all periods (see, e.g., Binmore 1992).

The experimental analysis of the prisoner's dilemma involves over hundred experiments mainly in Psychology, Economics, Biology and Political Science. It has been shown that behavior is sensitive to subtle changes in the experimental conditions. Factors like repetition, experience, information, relative payoffs, monetary incentives, fixed or random opponents and framing, play an important role in the experimental behavior.[6]

In this paper we will analyze a prisoner's dilemma game repeated over 20 periods with a fixed opponent under perfect information. Earlier experimental studies with *assigned* treatments show that average cooperation levels start relatively high, between 40%-60%, and then gradually decline through time. We will see that our experimental results conform to this general pattern.

2.- THE DECOMPOSED PRISONER'S DILEMMA GAME

Evans and Crumbaugh (1966a, 1966b), and Pruitt (1967) independently proposed the decomposed prisoner's dilemma game. Consider the game depicted in table 2. The game is played as follows: Both players face the same matrix. Each player must choose between actions *Cooperate* or *Defect*.[7] Each choice provides a payoff to the player in the *self* column, and a payoff to the other player in the *other* column. Hence, if for example player 1 chooses *C* and player 2 chooses *D*, then player 1 gets w + z, while player 2 gets y + x.

The game in table 2 is a decomposed form of the PD game introduced earlier (Table 1) if and only if the following conditions hold: $a = x + y$, $b = w + x$, $c = y + z$ and $d = w + z$. Substituting these into the conditions that define the PD game, the following conditions must be satisfied for the DPD game: $y > w$, $x > z$, and $w + x > y + z$. These inequalities impose constraints on the PD, namely that $b + c = a + d$. As a result only certain PDs are decomposable.[8]

Table 2: Schematic representation of a 2×2 PD game in decomposed form (DPD).

	Self	**Other**
Cooperate	(w)	(x)
Defect	(y)	(z)

[6] Good overviews of the experimental literature are found in Lave (1965), Rapoport and Chammah (1966), Roth & Murnigham (1978), Roth (1988), and Kagel and Roth (1995).
[7] In all the experimental games we used labels A and B, instead.
[8] Not all PDs are decomposable but a decomposable PD can be decomposed into an infinite number of DPDs. The conditions for decomposing a PD game are also referred to as seperability conditions (Hamburger, 1969).

Since the initial research by Evans and Crumbaugh (1966a, 1966b), Crumbaugh and Evans (1967), and Pruitt (1967) there have been a series of studies, mainly conducted in the 1970ies, that analyzed different decompositions of the PD game. In particular, the studies by Pruitt (1970, 1981), Guyer, Fox, and Hamburger (1973), Tognoli (1975), Pincus and Bixenstine (1977), Komorita (1987), and Beckenkamp, Hennig-Schmidt, and Maier-Rigaud (2006) analyzed the effects of different decompositions on cooperation rates in prisoner's dilemma games.[9] These studies largely revealed that the type of decomposition has a significant impact on cooperation rates. While some decompositions elicited less cooperation than the normal form game, others showed a substantial increase in cooperative behavior. The generally accepted hypothesis for this finding is that different decompositions arouse different motives in the players. Based on the type of decomposition, decomposed games are either referred to as *take-some* or *give-some* games, where take-some games evoke lower and give-some games higher levels of cooperation than the normal form game. Typically, in a give-some decomposition payoffs in the "self" column are lower than payoffs in the "other" column, and vice versa for the take-some decomposition. According to the psychological literature, give-some games evoke a higher level of cooperation because they provide an opportunity to signal a willingness to cooperate at some cost to self, and thus elicit trust and mutual cooperation. Take-some games in contrast are supposed to heighten the competitive motivation of the players due to their punishment aspect inflicted on the other player in case of defection.

Table 3: 2×2 prisoner's dilemma game in give-some decomposition.

	Self	**Other**
Cooperate	(0)	(300)
Defect	(100)	(0)

[9] Decomposed PD games are also discussed in Selten (1978) and Selten (1998).

Table 4: 2×2 prisoner's dilemma game in take-some decomposition.

	self	Other
Cooperate	(150)	(150)
Defect	(250)	(-150)

We evaluate the behavioral consequences of a choice of game in both settings. The two decompositions of the standard prisoner's dilemma game presented in table 1 that will be analyzed experimentally are shown in tables 3 (give-some) and 4 (take-some). Note that both decompositions add up to the same parent game presented in table 1.

III.- EXPERIMENTAL DESIGN

The experiments were conducted at the Experimental Economics Laboratory at the University of Bonn using a program based on the z-Tree software developed by Fischbacher (1999). At the beginning of each session participants were randomly assigned to one of the 18 computer terminals. Before the session started, participants first had to read the instructions (see Appendix A), and then had to answer test questions to check if they understood the game they were about to participate in. The experiment was started only once all participants had correctly answered all test questions. We run two treatment conditions: *assignment* (~C) and *choice* (C). In the *assignment* condition participants were told the game they were going to participate in, while in the *choice* condition participants were informed about the two games they could subsequently choose from. In the *assignment* condition we conducted three different treatments; one implementing the prisoner's dilemma in normal form of table 1 (~Cn), and the other two implementing the decomposed prisoner's dilemma games of tables 3 and 4 (~Cg and ~Ct). In the *choice* condition, two different treatments were conducted. In the first treatment coded as Cng participants could choose between the normal form and the give-some decomposition of the prisoner's dilemma game. In the second treatment coded as Cnt participants could choose between the normal form and the take-some decomposition of the prisoner's dilemma game.

All treatments where participants were assigned to play a specific game are coded by ~C, that is, ~Cn for the normal form, ~Cg for the give-some decomposition and ~Ct for the take-some decomposition of the prisoner's dilemma. The treatments where participants had the possibility to choose the game they wanted to play are coded by C, where the following letters indicate the two choice options i.e. treatment Cng allows participants to choose between the normal form and the give-some game, and treatment Cnt allows participants to choose between the normal form and the take-some game. Table 5 summarizes the experimental treatments, and gives information on the number of groups, i.e. the number of independent observations in each treatment.

Table 5: Experimental treatments and number of groups conducted in each treatment.

Treatment	Game	Number of groups
~Cn	No choice, **n**ormal form	9
~Cg	No choice, **g**ive-some decomposition	9
~Ct	No choice, **t**ake-some decomposition	9
Cng	Choice between **n**ormal form and **g**ive-some decomposition	17*
Cnt	Choice between **n**ormal form and **t**ake-some decomposition	18

* In the choice treatments players were grouped randomly after they had chosen the game they wanted to play. In this case the amount of players who chose a particular game was not even, so that one player from each group was randomly drawn to be excluded.

In all treatments participants played against the same opponent for 20 periods. In the *choice* treatments participants played against a player who chose the same game. All this information was common knowledge.

A total of 126 students, mainly law or economics students, took part in the experiment. The experiment took 45 minutes on average. Taler (the experimental currency) were transformed into Euro at the exchange rate of 1000 Taler = 2€. Average payoffs were 9.92€.

IV.- RESULTS

We now analyze the central hypothesis of this paper. That is, if allowing participants to choose the game from a binary set of games with identical game theoretic properties, as opposed to assigning them to the game, has a behavioral impact.

Table 6 gives information on the games chosen by players in the choice treatments. Participants generally preferred the normal form as opposed to the decomposed prisoner's dilemma.

Table 6: Number of groups choosing the PD and the DPD in the choice treatments.

Treatment	Groups choosing the PD	Groups choosing the DPD
Cng	14	3 (give-some)
Cnt	13	5 (take-some)

Note that there is no clear mechanism to separate players by types of preferences. For example, it has been shown in the literature (and replicated here) that the give-some representation evokes more cooperative behavior. Then, cooperators may choose the give-some decomposition over the normal form. Egoists, however, may anticipate this behavior and go for the give-some decomposition too, and therefore cooperators would think it twice before going for the give-some decomposition. Hence, in contrast to the sorting literature mentioned above, it is not clear for cooperators how to sort out from egoists, and for egoists how to match cooperators in this study. In fact, if sorting were present in our data, some games in the *choice* treatments would exhibit higher cooperation rates *and others* should show lower cooperation rates. We will immediately see, however, that this is *not* the case. As a result our experiment allows the separation of a choice effect from other factors such as sorting that have been found to influence experimental findings based on a *random* assignment of participants.

An alternative explanation of the findings could in principle be due to in-group effects as analyzed in the minimal group literature mentioned above. In line with recent findings by Charness, Rigotti, and Rustichini (2006) who find that "purely minimal group identification is insufficient" to find group membership effects in their PD and battle of the sexes experiment, this explanation is unlikely to be capable of explaining the significant treatment effects we observed.

We compare behavior exhibited in the assigned normal form game (treatment ~Cn) with the behavior of those players that chose the normal form game in the *choice* treatments (Cng:n and Cnt:n). Analogously we contrast behavior in the two versions of the assigned decomposed games (treatments ~Cg and ~Ct) to the behavior of those players that chose the corresponding decomposed prisoner's dilemma game in the *choice* treatments (Cng:g and Cnt:t).

Figures 1, 2, 3, and 4 plot the time series of the average cooperation rates in treatments ~Cn and Cng:n, ~Cn and Cnt:n, ~Cg and Cng:g, and finally ~Ct and Cnt:t. Table 7 reports the average cooperation rates.

Figure 1: Time series of average cooperation rates in ~Cn and Cng:n

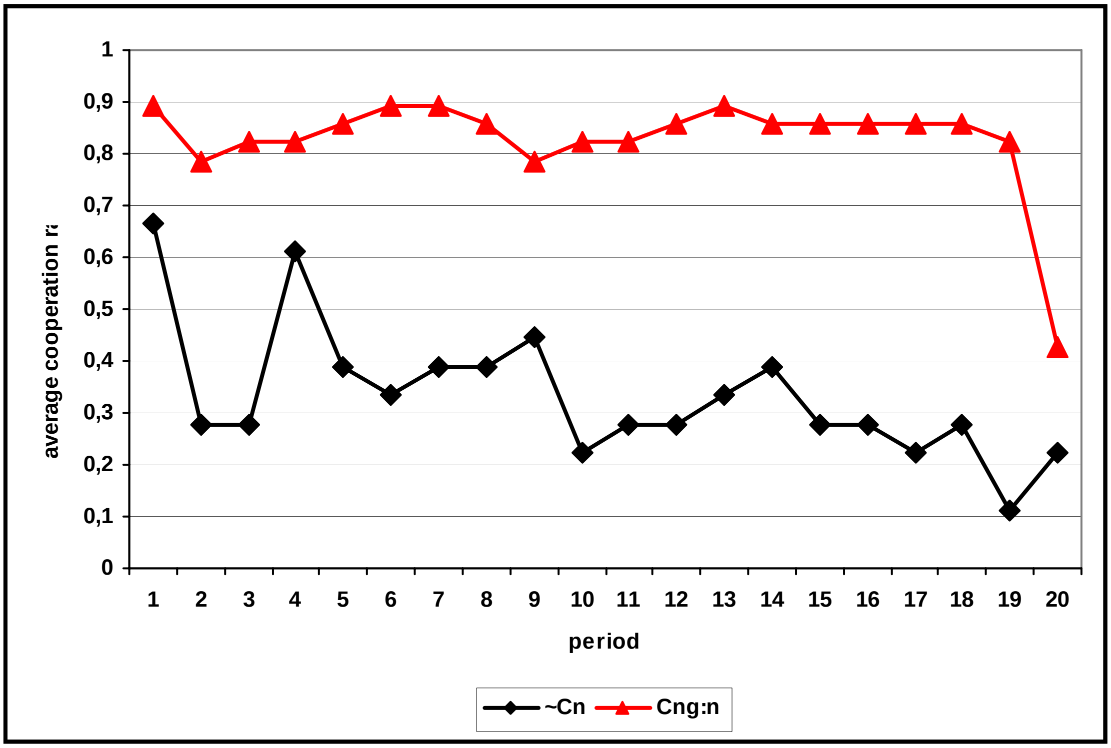


Figure 2: Time series of average cooperation rates in ~Cn and Cnt:n

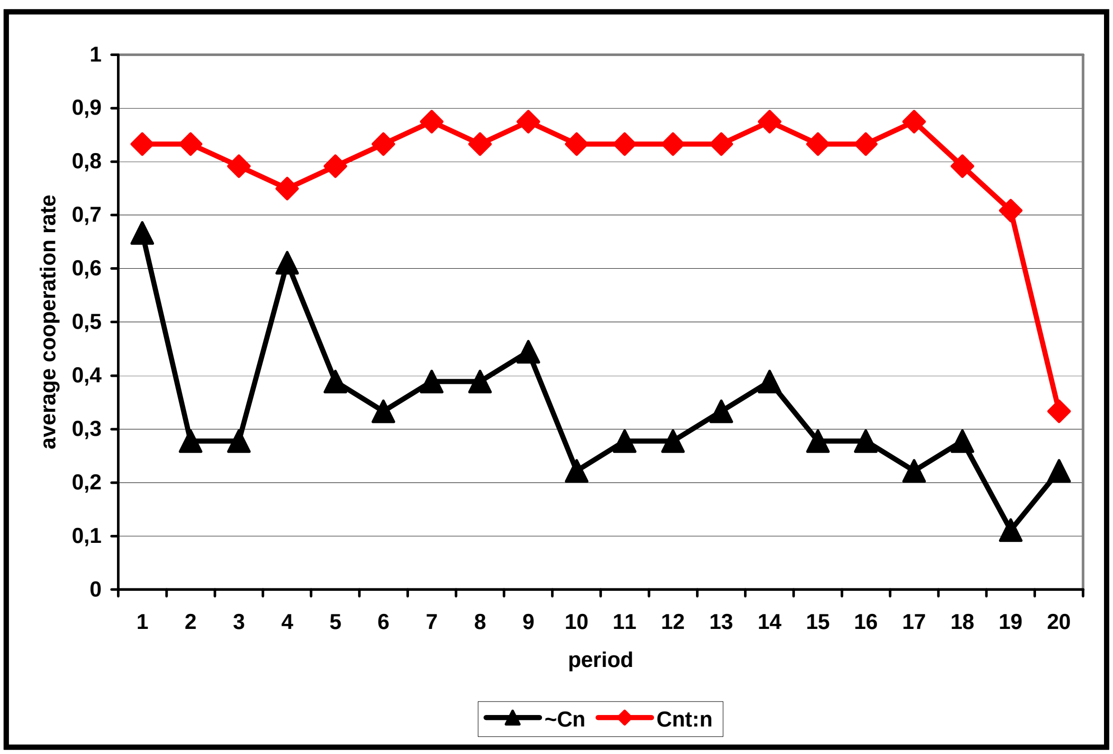


Figure 3: Time series of average cooperation rates in ~Cg and Cng:g

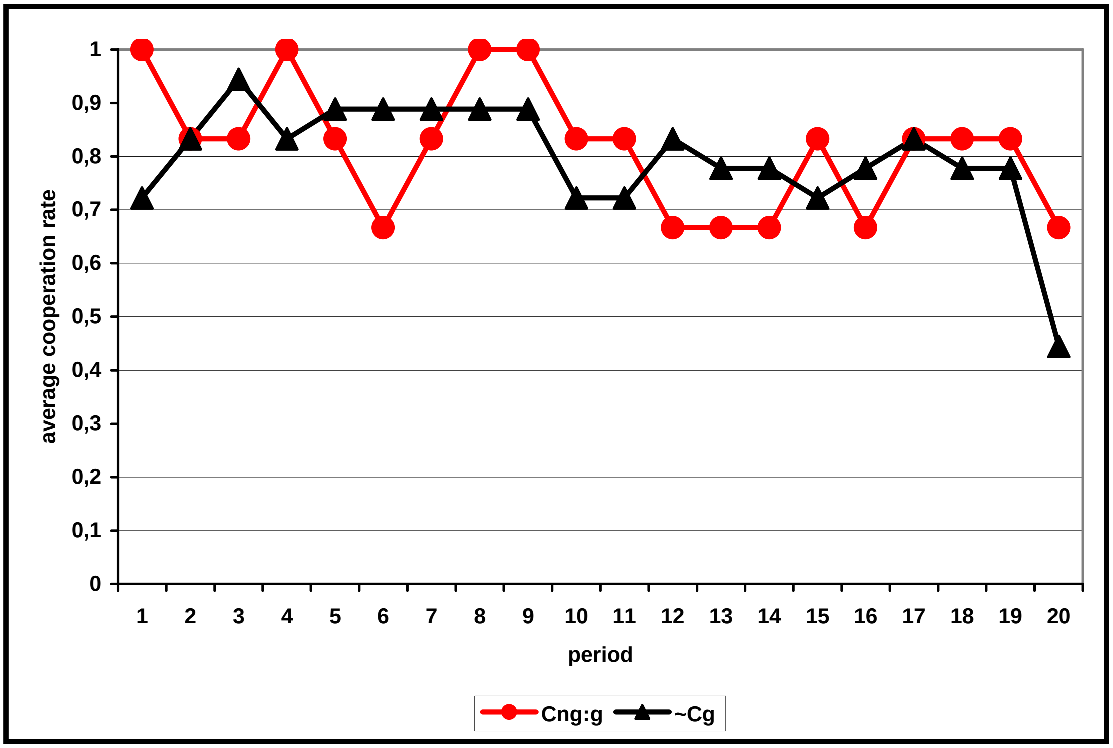
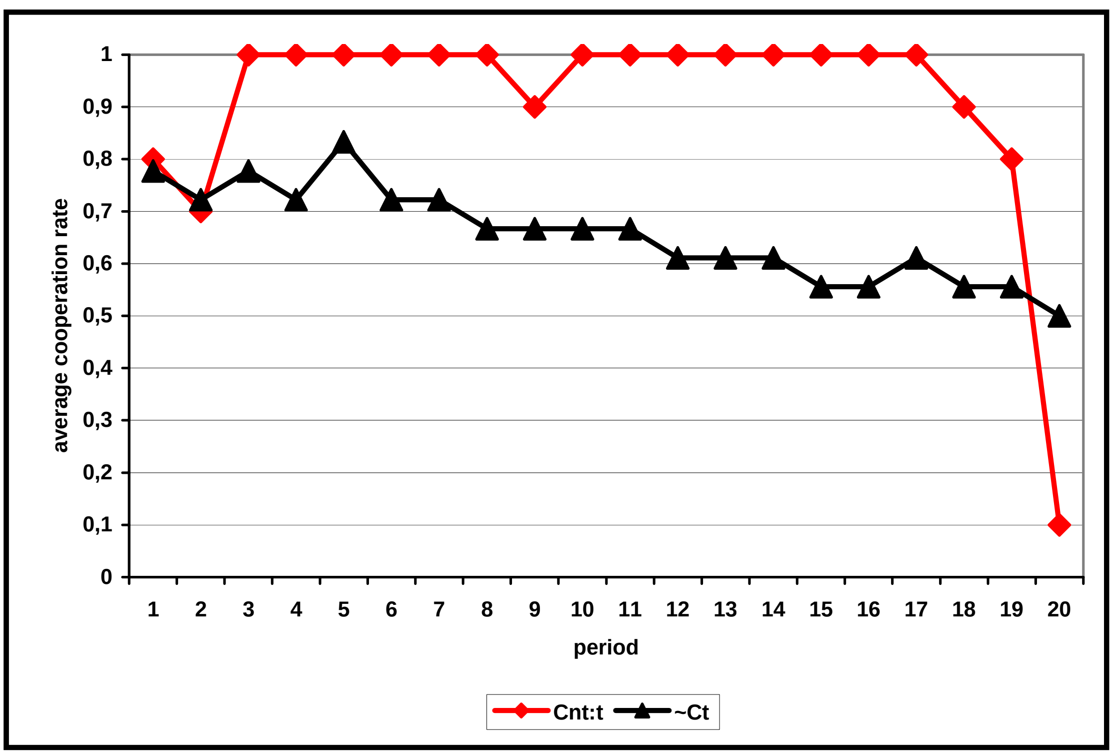


Figure 4: Time series of average cooperation rates in ~Ct and Cnt:t



Figures 1, 2, and 4, and table 7 clearly show the strong behavioral effect on relative cooperation levels of allowing players to choose the game they want to play.

In the cases where the normal form game was chosen (treatments Cng:n and Cnt:n), the increase in cooperation rates compared to the assigned prisoner's dilemma (treatment ~Cn) is dramatic. In both cases there is an increase of about 60% in the rate of cooperation. The permutation test (Siegel and Castellan, 1988) yields significance levels at .1% and .5% respectively.

Table 7: Average cooperation rates by treatment

	~Cn	~Cg	~Ct	Cng:n	Cng:g	Cnt:n	Cnt:t
Average Cooperation Rates	.33	.80	.66	.83	.82	.88	.91

When analyzing the differences in behavior between the decomposed prisoner's dilemma in the assigned condition (treatments ~Cg and ~Ct) and the decomposed prisoner's dilemma in the *choice* condition (treatments Cng:g and Cnt:t), the effect is not as strong. Clearly, behavior in the decomposed games in the *assignment* conditions (treatments ~Cg and ~Ct) is highly cooperative, rendering it difficult to reach even higher cooperation levels in the *choice* treatments. Furthermore, the statistical tests suffer from the relatively small number of decomposed games chosen by players (see table 6). Nevertheless, cooperation rates in the take-some groups where participants freely choose the game (treatment Cnt:t) are close to 30% higher than in the assigned take-some game (treatment ~Ct). This is a remarkable increase in the cooperation rate, (the permutation test yields a .1258 significance level, one sided). In the case of the give-some game (treatment ~Cg vs. treatment Cng:g) the increase is just 2.2%, clearly not significant.

Table 8: Gains from Cooperation.

Treatment	Aggregate efficiency[10]
~Cn	40,84
~Cg	80,00
~Ct	65,56
Cng:g	81,67
Cng:n	82,68
Cnt:t	91,00
Cnt:n	81,35

Finally, we note that, as expected, framing significantly impacts behavior. Comparing the behavior between the three assigned treatments, it is clear that both decompositions of the prisoner's dilemma have a significant positive impact on cooperation rates (with significance levels of .5% each). In the give-some treatment ~Cg participants achieve cooperation rates that result in roughly 80% of possible profits being extracted – a 100% increase compared to the normal form treatment ~Cn.

V.- CONCLUSION

There exist many economic and non-economic situations where agents make choices that impact the incentive structure they face afterwards. In fact, choice is a fundamental economic reality. Based on this fact and motivated by the findings of the psychological literature on choice in non-strategic settings and the literature on freedom of choice, we conjectured that the very possibility of choosing the game one wants to get involved in may have a significant impact on behavior even absent any possibility of self-selecting, of sorting or of influencing the game.

[10] Efficiency is defined as $(\pi - \min \pi) / (\max \pi - \min \pi)$, where $\min \pi$ and $\max \pi$ stand for the minimal and maximal payoffs respectively.

In our experiment participants playing a PD game cooperate significantly more, even 60% more on average, when they are given the possibility of choosing between the PD game and a different representation of the same PD game, than when they are directly assigned to play that game.

The set of games from which participants could choose contained two different representations of a strategically identical game. Our data shows that despite this narrow difference the change in behavior was dramatic. It can be hypothesized that if the set of games to be chosen from not only consists of games differing with respect to their representations, but also with respect to their strategic character, resulting differences in behavior may even be more substantial.

Our findings indicate that motivational aspects inherent in the design and choice of games, even absent the possibility of sorting, can have a significant impact on outcomes. This confirms one of the basic tenets in psychology, namely that choice and loss of choice have a substantial impact on human behavior. As shown by our results, choice not only has an impact on outcomes in non-strategic environments but also in strategic situations. An immediate consequence for experimental research is to exert caution in extrapolating results to the field. In contrast to the recent literature on sorting that identifies the *random* selection of participants as a potential source of experimental bias, at least in those situations where self-selection is an essential feature in the field, we show that the assignment as such can have an impact irrespective of any possible additional effects due to sorting.[11]

[11] From that perspective it may not be sufficient to allow for sorting by assigning participants to a game based on the performance in a prior one, although such a setting may allow a direct comparison of the impact of sorting versus choice that is outside the scope of the present study.

Appendix: The Written Instructions For Treatment IIab

<u>Note:</u>

- You have 5 minutes to read the instructions. If after reading the instructions you have any question, please contact one of the experimenters. Communication with other participants is not allowed during the experiment.
- After the 5 minutes you will be asked to fill out a test questionnaire about the experiment. Once all participants have correctly answered all questions, the experiment will start.
- After completion of the experiment you will be asked to fill out a computerized questionnaire.
- Please do not leave your seat before you have filled out the questionnaire and your terminal number has been announced.

<u>The experiment:</u>

The experiment is composed of two phases.

In phase I you have the choice between two experimental situations. Both experimental situations have the following in common:

- You play during 20 periods with another person. The decision situation, as well as the other person are identical in each period.
- You have to choose between A and B in each one of the 20 periods.
- The amount of Talers you earn in each period depends on your decision, and the decision of the other person.
- In each period, you will not know the choice of the other person before you have made your own choice.
- After each period you will be given information on: your last decision, the last decision of the other person, the number of Talers you earned in the last period, and the total number of Talers you have earned so far.

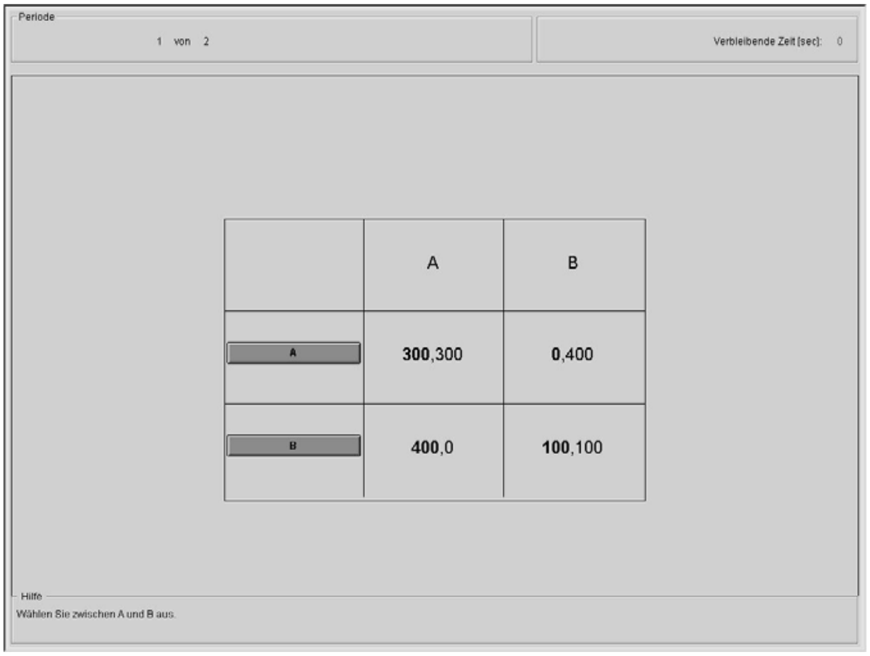
Particular to Decision <u>Situation I</u>:

Every period you will have the opportunity to decide how many Talers you give to yourself and how many Talers you give to the other person by choosing between A and B. The Talers you earn in one period are determined by the amount of Talers you give to yourself plus the amount of Talers the other person gives to you. The other person faces exactly the same decision situation.

- If you choose A you give 0 to yourself and 300 to the other person.

- If you choose B you give 100 to yourself and 0 to the other person.
- If the other person chooses A, he/she gives you 300 and 0 to him/herself.
- If the other person chooses B, he/she gives you 0 and 100 to him/herself.

Particular to Decision Situation II:



- If you choose A and the other person as well, you both get 300.
- If you choose B and the other person as well, you both get 100.
- If you choose A and the other person chooses B, you will get 0 and the other person will get 400.
- If you choose B and the other person chooses A you will get 400 and the other person will get 0.

In Phase II after you have decided what experimental situation you would like to participate in, you will be randomly paired with a participant who choose the same experimental situation.

In case the number of participants who choose a particular experimental situation is odd, a randomly determined participant will have to leave the experiment. This person receives Euro 4.

Payment:

You will be privately paid on the basis of the total Talers accumulated in all the experiment. 1000 Taler equal 2 Euro.

Thank you very much for your participation!

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