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# DOCUMENT de RECHERCHE

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Affect Coordination Issues in a  
Experimental Stag Hunt Game? »

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# Does environmental connotation affect coordination issues in an experimental stag hunt game?\*

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## Abstract

We introduce illustration identifying environmental degradation or improvement into a 2x2 coordination game with two pareto-ranked equilibria. Theoretical as well as experimental investigations do not give a clear cut about which equilibrium players should coordinate on in this kind of game. Our contribution focuses on the environmental nature of the information provided through illustration, and its effects on possible pro-environmental behaviour. The experiment considers: a one-shot stag hunt game, a repeated stag hunt game (without and with illustration), a simple portfolio choice to analyze risk aversion and a questionnaire to capture the subjects' sensitivity to environmental concerns. Results show that environmental connotation has an influence in terms of strategy choice, and the positive or negative nature of the environmental connotation positively or negatively affects the frequency of players' choices. In particular, our analysis suggests that environmental negative signals impact more on players' behaviour over a repeated session than positive signals. Our findings have some important consequences in terms of public policies. Incentives based on sensitization campaigns for environmental issues can be a valid alternative to economic instruments for environmental management.

Keywords: Experimental economics, stag hunt game, pro-environmental behavior

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# 1 Introduction

The social perception of environmental problems has evolved crucially over the last half century. From an economic viewpoint, since the work by [Boulding \(1966\)](#) and [Hardin \(1968\)](#), the vision of natural resources has moved from an anthropocentric one, considering “homo oeconomicus” as a rational profit-taker using natural resources to maximize utility, to an integrated one, where environmental equilibria are the basis for sustainable growth. The latter vision, synthesized in the paradigm of ecological economics ([Daly 1977](#), [Costanza 1991](#)) assigns the same relevance to economic and ecological dynamics, underlying their respective interdependencies and interconnections. The respect of these interconnections is the basic condition for achieving sustainable development ([Brundtland 1987](#)). In terms of the economic analysis of human behaviour related to environmental problems, the standard economic model has evolved towards a Meta model ([Lynne 1999](#)) through the introduction of new elements such as ethical, sociological and psychological considerations. In this new model, personal interest based on a selfish-hedonistic behaviour and ethical/shared interest based on sympathy-empathy for the other members of society are internalized into an integrated own-interest ([Czap et al. 2012](#)). This new representation of human behaviour, which for certain aspects, is in line with the concepts of limited or procedural rationality of behavioural economics ([Simon 1982](#)), encompasses innovative ideas compared with mainstream neoclassical economics, such as social norms ([Lewis 1969](#), [Sugden 1986](#), [Ostrom 2000](#)), “warm glow” ([Andreoni 1989, 1990](#)), altruism ([Andreoni & Miller 2002](#)) or reciprocity ([Falk & Fischbacher 2006](#), [Gächter & Hermann 2009](#)). According to [Schwartz \(1970, 1973, 1977\)](#) the activation of personally held norms influences pro-social behaviour when two pre-conditions co-exist: awareness of consequences and ascription to responsibility. Pro-environmental behaviour (i.e. recycling of waste, green consumption, donations to environmental associations, etc.) is a form of pro-social behaviour that consists mainly in contributing to a public good, creating a positive externality or refraining from creating a negative one ([Marciano & Roussel 2014](#)).

Following these concepts, the economic behaviour in terms of natural resource management, approach to pollution problems, natural resource use, and public good contribution, can prove to be significantly different from that one prescribed by the standard economic theory. To explain this behaviour, [Nyborg et al. \(2006\)](#) proposed a model of green consumers based on concepts such as moral motivation and individual responsibility. Consumers choose environmentally friendly behaviour not only on the basis of their own perception, but also in accordances with the share of the population around them that they believe chose pro-environmental behaviour. [Laury & Taylor \(2008\)](#) showed the role of the components “warm glow” and altruism for the contribution to a public good. [Czap et al. \(2012\)](#) used a contextualized experiment representing upstream and downstream farmers who may use more or less polluting agricultural techniques to test the subjects’ empathy and sympathy. [Michel-Guillou & Moser \(2006\)](#) discussed the dynamics of the adoption by Fench farmers of environmental friendly cultural practices in terms of social representations. More precisely, the main motivation for the adoption of less polluting techniques seems to be the need for farmers to improve and defend the social image of their profession. On the other hand, the adoption of less polluting techniques seems to lie behind an increased perception of and greater commitment to environmental protection. [Grolleau et al. \(2012\)](#) showed that when individuals exhibit positional, pro-social or conformist preferences, which are endogenous, the outcomes in terms of private provision of public goods can differ significantly from traditional neo-classical predictions.

Experimental economics (EE) plays a fundamental role in exploring these behaviours and particularly in testing standard theories when compared to real life. The largely accepted “mantra” in EE is represented by the absence of context (or abstraction) of laboratory conditions ([Czap et al. 2012](#)) in order to allow as much control as possible of the studied parameters. Conversely,

several authors (Laury & Taylor 2008, Farolfi et al. 2014) recently called for introduction of contextual elements in EE protocols in order to improve their external validity, but also to allow subjects to make visible in their behaviour those variables of the above-mentioned meta-economic model. According to Michel-Guillou & Moser (2006) those variables depend on awareness of the context and cannot be made explicit in an abstract situation. Laury & Taylor (2008) demonstrated experimentally that an abstract protocol has less ability than a contextualized one to predict subjects' contributions to a naturally occurring public good. Farolfi et al. (2014) proposed an analytical framework for studying the influence of context on players' behaviour composed of four elements: repetition (R), illustration (I), communication (C) and experience (E). The authors confirmed through the RICE framework the hypotheses put forward by Faravelli (2007) and Loewenstein (1999) that context provides players with indicators enabling them to behave in accordance with a common representation of that context. According to Cooper & Kagel (2003), when learning processes are allowed, a "weak" contextual effect would also allow behaviors to converge more quickly toward theoretical predictions.

In this paper, we focus on illustration. We introduce basic connotations identifying environmental degradation or improvement into a 2x2 coordination game with two pareto-ranked equilibria, one risk-dominant and the other payoff-dominant. This class of coordination games is called the "stag hunt game". Our hypothesis is that environmental connotation may affect issues in situations with strategic interactions, either by moving away from the Nash equilibrium or by selecting a particular equilibrium in the case of multiplicity. The structure of the stag hunt game is of particular interest for this purpose<sup>1</sup>. This game admits several Nash equilibria, and theoretical as well as experimental investigations do not give a clear cut on which equilibrium players should coordinate. Moreover, some papers deal with the effect of labels placed on strategies in this class of games, as for example Dugar & Shahriar (2012). The authors attach strong labels to the payoff-dominant strategy and manipulate the strength of the labels attached to the risk-dominant strategy. They find that the label attached to the alternative strategy does matter. Labels act as a key to determine a focal point into the game and as such facilitate players' coordination (Schelling 1960, Metha et al. 1994a,b). To our mind, an environmental connotation is not a simple key for coordinating, it is rather a label that makes sense and refers to an intrinsic motivation that may guide a pro-social behavior.

We show that environmental connotation influences significantly subjects' behaviour, but that this influence is constrained by the nature of the stag hunt game. In particular, our analysis shows that environmental negative signals impact more on players' behaviour over a repeated session than positive signals. This result is consistent with the findings of previous work dealing with subjects' appraisal of environmental values and with experimental tests of the influence of rewards and punishments on subjects' behaviour. From a policy implication point of view, this outcome is relevant as it suggests the use of warning campaigns for the protection of the environment as effective tools to sensitize society. In terms of the dynamics observed, the main result is the fact that choices of strategies are made basically during the first repetitions of interactions. This fact has policy implications, as it shows that players coordinate themselves relatively soon and then maintain the equilibrium reached until the end of the game with few exceptions. Policies based on the sensitization of consumers through information and awareness-raising campaigns would again find in these outcomes some interesting suggestions, as they would show that these campaigns modify consumers' behavior quickly and in a steady way.

The paper is composed of the following sections. Section 2 describes the experimental design and our conjectures. Section 3 presents the results of our investigation, while section 4 discusses

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<sup>1</sup>We could also have used a prisoner's dilemma game or a public good game, but these games have a different structure: they introduce a social dilemma; a conflict between the unique Nash equilibrium and a Pareto optimal issue. The study of a prisoner's dilemma game is a possible extension of this work.

them and indicates policy implications.

## 2 Experimental design and conjectures

### Experimental design

We consider a symmetric stag hunt game. Under its normal form, this game can be represented as in table 1. With the conditions that  $a > c \geq d > b$  and  $d - b > a - c$  this game admits two pure-strategy Nash equilibria,  $XX$  and  $YY$  and one mixed-strategy equilibrium where strategy  $X$  is chosen with probability  $p = \frac{d-b}{a-b+d-c}$ . Furthermore,  $XX$  is payoff dominant and  $YY$  is risk dominant (Harsanyi & Selten 1988). The payoff-dominance notion is obvious, since  $a > d$ . Risk-dominance is more complicated.  $YY$  is said to be risk-dominant because adopting this strategy is less risky than adopting  $X$ . Indeed  $X$  has to be chosen by the opponent with a high probability ( $p > 0.5$ ) to have an expected payoff equal to that of  $Y$ .

		Player B	
		X	Y
Player A	X	$a, a$	$b, c$
	Y	$c, b$	$d, d$

Table 1: A symmetric stag hunt game, with  $a > c \geq d > b$  and  $d - b > a - c$

The parameters used for the experiment are  $a = 10$ ,  $b = 5$ ,  $c = 9.25$  and  $d = 8$ , as reported in table 2. The game is based on game 2 of Dubois et al. (2012), with payoffs divided by 4<sup>2</sup>. In order to test for the effects of environmental connotations on strategy choices and coordination issues, we ran five treatments (table 3): a baseline without connotation, two treatments where one option has a “positive” environmental connotation (treatments  $XEP$  and  $YEP$ ) and two treatments where one option has a “negative” environmental connotation ( $XEN$  and  $YEN$ ).

		Player B	
		X	Y
Player A	X	10, 10	5, 9.25
	Y	9.25, 5	8, 8

Table 2: The game experimented

The environmental connotations are very simple and generic in order to be easily understandable and to avoid a strong personal interpretation. Indeed our objective is to analyze the effects of a “pro” or “neutral” (“anti”) environmental connotation in coordination problems, not to lead the subject to rely on his/her own experience or imagination, which would result in a lost of control in the experiment. What we call connotation in our protocol is a short sentence added at the end of the instructions. The sentence with a positive environmental connotation on option  $X$  ( $Y$  in treatment  $YEP$ ) is the following: “ $X$  preserves the environment”. The negative one is “ $X$  degrades the environment”.

The experiment took place in the experimental laboratory of Montpellier (LAMETA-LEEM)

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<sup>2</sup>We divided values by 4 in order to avoid the use of a conversion rate. The payoffs in the matrix are euros.

		Illustrated option	
		X	Y
Environmental illustration	$\emptyset$	Baseline	
	-	$XEN$	$YEN$
	+	$XEP$	$YEP$

Table 3: The treatments

in July and September 2014. A total of 178 subjects participated in the computerized<sup>3</sup> experiment, including some students from various disciplines of the University of Montpellier<sup>4</sup>. The experiment is divided into four parts: a one-shot stag hunt game, a repeated stag hunt game, a simple portfolio choice and a questionnaire to capture the subjects’ sensitivity to environmental concerns (the New Environmental Paradigm – NEP – scale).

In the general instructions<sup>5</sup> the subjects are informed that: i) the experiment is composed of three independent parts and a questionnaire; ii) the instructions of each part are given only when the previous part is finished and iii) payments are based on only one of the three parts randomly drawn.

Let us now detail the content of each part. In the first part randomly formed pairs of players, play the stag hunt game reported in table 2 in one-shot. In the instructions of part 2, the subjects are informed that they are to stay with the same partner as in part 1. In the second part the subjects participate in the same game repeated for 20 periods. In part 3 the subjects participate in a simple real-money portfolio choice designed to capture their sensitivity to risky decisions (Gneezy & Potters 1997, Beaud & Willinger 2015). The subjects then answer the NEP scale questionnaire (Dunlap & Van Liere 1978). The NEP scale aims to measure public pro-environmental orientation. The NEP focuses on beliefs about humanity’s ability to upset the balance of nature, the existence of limits to growth for human societies, and humanity’s right to rule over the rest of nature. The questionnaire was slightly completed and classified by Dunlap et al. (2000) trying to capture the ideas of “ecological consciousness” and “anthropocentrism versus ecocentrism”.

### Conjectures

The experiment is designed to test the following conjectures about the expected effect on players’ decisions of an environmentally connotated strategy.

**Conjecture 1** *An environmental connotation attached to a strategy affects players’ choices of that strategy*

This is our main conjecture. Several papers have shown that a “pro-environmental” behaviour exists that leads people to take decisions inconsistent with pure maximizing concerns, such as waste recycling, green consumption or donations to environmental associations (Marciano & Roussel 2014). For Schwartz (1970, 1973, 1977) and Stern et al. (1993, 1999) pro-environmental behaviour belongs to the class of pro-social behaviours with the specificity that it also concerns nonhuman species.

<sup>3</sup>The computer program is based on LE2M, the software dedicated to experimental economics developed in Montpellier by Dubois, D. and Rousselle, J.M.

<sup>4</sup>The organization of the experimental sessions as well as the subjects’ database is managed by ORSEE (Greiner 2004).

<sup>5</sup>Instructions are available from the authors on request.

**Conjecture 2** *A positive (resp. negative) environmental connotation attached to a strategy increases (resp. decreases) the frequency of choice of that strategy compared to the baseline*

We assume that, in general, the players have a pro-environmental behaviour or at least they are neutral.

**Conjecture 3** *A negative environmental connotation has a stronger effect than a positive one*

Some experimental results have shown that people are more sensitive to loss than to gains with respect to climate and environmental issues (Newman et al. 2012) and to punishments than to rewards (Bravo & Squazzoni 2013). Applied to our context, these findings may imply that a negative connotation has a stronger impact than a positive one.

**Conjecture 4** *Repetition has no additional effect with respect to environmental connotation*

The repeated game is built such that players are not incentivized to influence their partner decision (partner matching and only one randomly selected period is paid). Additionally, we believe that the players have a some kind of myopic behavior with respect to information. Therefore, strategic considerations might quickly replace the environmental considerations. In other words we do not expect environmental connotations to affect the dynamic of the repeated game.

## 3 Results

### 3.1 One-shot game

[INSERT FIGURE 1 HERE]

Figure 1 shows the distribution of the average frequency of  $X$  in each treatment. The frequency of the  $X$  choice in the baseline treatment is 67.00%. This frequency is very close to the 68.75% observed by Dubois et al. (2012) in the first period of their game 2 which differs only in that payoffs are multiplied by four<sup>6</sup>.

The average frequencies of  $X$  in treatments  $XEP$  and  $YEN$ , at 71.00% and 64.00% respectively, are not statistically different compared to the baseline treatment (Mann Whitney two-sided test<sup>7</sup>, p-value=0.884 and 0.806). The averages between these two treatments do not differ either (MW p-value=0.663). However, there is a strong effect towards a less frequent choice of  $X$  when the environmental connotation encourages to move away from it: the  $X$  strategy frequency falls to 36% in treatment  $XEN$  and to 31% in  $YEP$ , which is a significant difference compared to the baseline<sup>8</sup> (MW p-value=0.024 and 0.008 respectively).

The observations in the one-shot game show that the environmental connotation has an influence in terms of strategy choice. However, this choice is constrained by the nature of the stag hunt game. A statistically significant reduction in the choice of  $X$  with respect to the baseline treatment is observable when this strategy is described as degrading the environment. On the other hand, no statistically significant increase in the choice of  $X$  is observed when this

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<sup>6</sup>In particular the two games share the same mixed strategy equilibrium ( $p=0.8$ ) and the same “relative riskiness” ratio ( $RR = 0.25$ ). The relative riskiness of the safe strategy relative to the risky one is defined by the ratio of their expected payoff ranges:  $RR = \frac{|c-d|}{a-b}$ . A Mann Whitney two-sided test confirms that there is no significant difference between the observed frequency of  $X$  in both games (p-value=0.751).

<sup>7</sup>Hereafter MW. Since the independent data in our experiment is the group, all the statistical tests are based on this unit of observation.

<sup>8</sup>As well as to treatments  $XEP$  and  $YEN$ .

strategy is presented as able to preserve the environment. Actually, that connotation go against the game's structure in terms of guiding players' choices. When the connotation pushes players to a choice that goes in the same direction as the strategies' basin of attraction, then the players follow it. Conversely, when the connotation pushes players in a direction contrary to the basin of attraction, then its influence is statistically not significant. The analysis of the data therefore partially confirms conjectures 1 and 2 while conjecture 3 is not verified.

## 3.2 Repeated game

[INSERT FIGURE 2 HERE]

Figure 2 shows the distribution of the average frequency of  $X$  in each treatment. The choice of  $X$  is significantly lower in  $XEN$  and  $YEP$  compared to the baseline (MW,  $XEN$  vs Baseline p-value=0.010,  $YEP$  vs Baseline p-value=0.012). Introducing a positive connotation for  $X$  is not sufficient to increase the choice of this strategy compared to the baseline ( $XEP$  vs Baseline p-value=0.986). Conversely, a negative connotation for  $Y$  strongly affects the decisions, as the frequency with which  $X$  is chosen approaches 100%, which is significantly higher than in the baseline and  $XEP$  treatments (MW p-value=0.062 and 0.042 respectively)<sup>9</sup>.

In the baseline treatment and in both treatments with the positively oriented environmental connotation ( $XEP$  and  $YEP$ ) the average frequency of  $X$  stays virtually around the same level as in the one-shot game: 68.00% in the baseline, 70.00% in  $XEP$  and 28.00% in  $YEP$ . Conversely in both treatments with the negative environmental connotation the frequencies of the payoff dominant strategy  $X$  are more extreme: a choice of  $X$  that reaches 92.00% in  $YEN$  and falls to 21.00% in  $XEN$ . These two values are significantly different from those observed in the one-shot decision (Wilcoxon two-sided test: p-value=0.033 for  $XEN$  and p-value=0.006 for  $YEN$ ).

[INSERT FIGURE 3 HERE]

Figure 3 gives the average frequency of  $X$  in the one-shot game and the evolution of  $X$  in the repeated game for each treatment. As the pairs remain unchanged between the one-shot and the repeated game and throughout the latter the first periods of play are the most important part of the coordination game. For three out of five treatments (Baseline,  $XEP$  and  $YEP$ ) there is almost no difference between the one-shot decision and the decision at the beginning of the repeated game. Conversely for the two treatments with the negative environmental connotation ( $XEN$  and  $YEN$ ), a strong dynamic occurs in the very first repetitions. In  $XEN$  the frequency of  $X$  in the one-shot, 36%, falls to 22% in period 3. The change in the  $YEN$  treatment is even more pronounced, from 64% in the one-shot to 86% in period 2 and 94% in period 6. After period 6, in each game the dynamic is quite stable. As mentioned above this is a consequence of the partner matching we chose in the experiment.

To summarize, two main differences are observed in the repeated game with respect to the one-shot. In  $YEN$  the choice of strategy  $X$  is significantly higher than in the baseline. In  $XEN$  the frequency of  $X$ , which was already significantly lower in the one-shot compared to the baseline, becomes even lower. As a consequence, conjectures 1 and 2 are confirmed in  $XEN$ ,  $YEP$  and  $YEN$  but not in  $XEP$ , where conjecture 3 is confirmed and conjecture 4 is rejected.

[INSERT FIGURE 4 HERE]

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<sup>9</sup>More precisely, the frequency is 97% if we exclude the group which clearly stand out from the other with a very low frequency of  $X$  choice (2%). With this group the p-values are 0.117 and 0.090 respectively.



Figure 4 shows the changes in coordination rate, corresponding to the frequency with which the two players choose the same strategy. We observe firstly that there is no difference between treatments in either the one-shot (67%, 61%, 53%, 61% and 61%) or the repeated game (95%, 91%, 95%, 96% and 92%). Environmental connotation therefore affects the equilibrium towards which pairs converge but not their success in coordinating. Secondly, we find that the coordination rate strongly increases at the beginning of the repeated game (first five periods) and then remains quite stable until the end of the repetitions, whatever the treatment. The environmental connotation does not affect the dynamics of coordination either.

### 3.3 The New Environmental Paradigm (NEP) scale and investment in the portfolio choice

The (revisited) NEP scale (Dunlap et al. 2000) is a test that captures the sensitivity of the subject to environmental concerns. The questionnaire contains a set of 15 items. The eight odd-numbered items refer to a pro-ecological behaviour and the seven even-numbered ones to a disagreement with the pro-ecological world view. Moreover, the items were classified according to the following five central ideas: (i) the reality of limits to growth (questions 1, 6, and 11), (ii) antianthropocentrism (questions 2, 7, and 12), (iii) the fragility of nature's balance (questions 3, 8, and 13), (iv) rejection of exemptionalism (questions 4, 9, and 14), and (v) the possibility of an ecocrisis (questions 5, 10, and 15). The participants in the experiment answered the 15 questions, which we carefully translated into french. Figure 5 shows the distribution of the NEP coefficients.

[INSERT FIGURE 5 HERE]

The observed coefficients are in accordance with the literature in this field (Dunlap et al. 2000, Kotchen & Reiling 2000). The average value for the NEP coefficient is 55.4 compared to 54.8 and 54.1 for the NEP coefficients estimated during the contingent valuation of two different endangered species (Kotchen & Reiling 2000).

[INSERT FIGURE 6 HERE]

In order to capture the sensitivity of the subjects to risky decisions, they also participated in a portfolio choice game. More precisely, the participants have an initial endowment of 10 euros and have to decide its allocation between a safe asset (return rate equal to 1) and a risky one where the rate of return is  $\tilde{k} = (0, 1/2; 3, 1/2)$ , i.e. with a probability 1/2 that they lose the amount invested and with a probability 1/2 that they get back three times their investment. Figure 6 shows the distribution of the amount invested in the risky option. On average the subjects invested 4.24 euros in the risky option, and the third quartile corresponds to an investment of 6 euros, which means that most of the subjects are rather risk-averse, as usually observed in economic experiments (Holt & Laury 2002).

[INSERT FIGURE 7 HERE]

As depicted in figure 7 and confirmed by a Pearson's correlation test, there is no link between the subjects' environmental concerns and their sensitivity to risk ( $\rho = -0.065$ , p-value=0.386). In order to test for the existence of a relationship between the subjects' profile in these two dimensions and their choice in the coordination game we group subjects according to their coefficient in the NEP scale and to the amount they invested in the portfolio choice. In the former dimension we split subjects depending on whether their NEP coefficient is strictly lower

than the median of the observed coefficients ( $N_L$ ) or not ( $N_H$ ). We applied the same rule for the risk dimension, i.e.  $I_L$  if the subject invested strictly less than the median of the observations and  $I_H$  otherwise. Combining the two criteria, the subjects are therefore classified according to four profiles:  $N_L I_L$ ,  $N_L I_H$ ,  $N_H I_L$  and  $N_H I_H$ . We put forward the following conjectures.

**Conjecture 5**  $I_L$  (resp.  $I_H$ ) subjects more frequently choose the risk-dominant (resp. payoff-dominant) strategy

We wanted to test the relationship between the subject’s risk-aversion and his/her choice in a game with a risky strategy. This has been tested by [Eckel & Wilson \(2004\)](#) in the trust game where the usual conjecture is that greater risk aversion leads to less trust. Some authors, on the contrary, find that trustfulness is not correlated with sensitivity to risk. We are aware of the paper by [Buyukboyaci \(2014\)](#), which observe that, in the stag hunt game, a subject’s propensity to choose the risky action does not depend on his/her own risk attitude but rather on his/her opponent’s risk attitude. However, due to the specific protocol used by the author in her experiment we still believe that our conjecture is testable in our case.

**Conjecture 6**  $N_H$  subjects are more sensitive to environmental connotation

We restrict the conjecture to the  $N_H$  type since it would be false to consider that the  $N_L$  type is anti-environment.

[INSERT FIGURE 8 HERE]

Figure 8 shows for each treatment the average frequency of the  $X$  choice depending on the profiles, in the one-shot game and in the repeated game. Some observations are in line with the conjectures but some are not. Let us start with those that are.

In treatment  $XEP$  the data are very consistent with our conjectures. On average, the subjects with the highest coefficient in the NEP scale,  $N_H$  type, more frequently choose  $X$  than  $N_L$ . Moreover, in both classes, the subjects who invested more in the portfolio choice (type  $I_H$ ), choose  $X$  more frequently than the others (type  $I_L$ ). More precisely, the average frequencies of  $X$  in the repeated game are as follows:  $N_L I_L$ : 55.00%,  $N_L I_H$ : 66.67%,  $N_H I_L$ : 72.27% and  $N_H I_H$ : 73.46%. In treatment  $YEN$ , type  $N_H I_H$  chooses  $X$  at a frequency of 97.86%, followed by type  $N_L I_H$  with a frequency of 95.71%. As for the other two types of subject,  $N_L I_L$  and  $N_H I_L$ , the latter chooses  $X$  with a higher frequency (92.50%) than the former (83.13%).

In the one-shot game of treatment  $YEP$  the choices are consistent with the conjectures. In the repeated game the  $N_L I_H$  type chooses  $X$  with a higher frequency than the other types almost all the time, while the frequency with which type  $N_L I_L$  selects  $X$  is below that of the other types in most periods.  $N_H$  types,  $I_L$  and  $I_H$ , behave in the same way. In other words, in this treatment it seems that the risk-aversion dimension matters for the subjects with low environmental concern but not for the subjects with a higher ones.

Conversely, in treatment  $XEN$  the  $N_H I_L$  type clearly more frequently chooses  $X$  than the other types, contrary to our conjectures. However, for more than half of the repetitions, type  $N_L I_H$  chooses  $X$  with a frequency above types  $N_L I_L$  and  $N_H I_H$ . In the baseline treatment the environmental concern dimension should not matter since no context is introduced into the game. According to conjecture 5  $I_H$  types should select  $X$  more frequently than  $I_L$ ’s. This is not found in our data.

To summarize, in both treatments where the environmental illustration is in favour of the “riskier” payoff-dominant strategy, the subjects’ choices are in accordance with conjectures 5 and 6. This is less evident in the other connotated treatments as well as in the baseline. In terms of conjecture 5, an avenue for further investigation could be to relate strategy choices with ambiguity-aversion

instead of risk-aversion as we have done so far. Ambiguity would seem to refer to the belief dimension about the opponent's choice while risk-aversion is purely linked to the game's probabilities.

## 4 Discussion

This article set out to discover whether basic environmental illustration influences players' economic behaviour. We test hypotheses about this research question through an experiment based on a symmetric stag hunt game. Both one-shot and repeated games were implemented. The one-shot game clearly shows that environmental connotation has an influence in terms of strategy choice, and the positive or negative nature of the environmental connotation positively or negatively affects the frequency of players' choices. However, that modification is constrained by the nature of the stag hunt game. Environmental connotation is therefore influential on the players' behaviour, but it "goes against" the game's structure in terms of guiding players' choices. A further analysis in this direction could consist in testing the same connotations in games with a different structure and less risk of  $X$ , and comparing the results with those observed in the current set-up.

In repeated games, we observe a similar result to that in the one-shot games except when the risk-dominant strategy is environmentally negatively connotated. In the latter condition the choice of the payoff-dominant strategy dramatically increases. This finding suggests that negative environmental signals impact more on players' behaviour than positive signals over a repeated session. This is consistent with previous work dealing with subjects' appraisal of environmental values (Newman et al. 2012) and with experimental tests of the influence of rewards and punishments on subjects' behaviour (Bravo & Squazzoni 2013). According to Shogren et al. (2010), in addition to the fact that willingness to pay (WTP) measures are more accurate than willingness to accept (WTA) measures in terms of subjects' capacity to induce environmental values, WTP for positive values is more consistent with theoretical expectations, while people tend to "overbid" negative environmental values. According to Bravo & Squazzoni (2013), punishment has a stronger effect on cooperation than rewards. This is in line with the idea that the "stick" (here a negative impact on the environment) is more effective than the "carrot" (here a positive impact on the environment) in changing subjects' behaviour. From a policy implication point of view, this outcome is relevant as it suggests the use of warning campaigns for the protection of the environment as effective tools to sensitize society and thereby induce a behavioural change in the direction of either a reduced negative practice or an increased positive one.

As regards the dynamics observed during the repeated games, the main result is the fact that the choices of strategies are made basically during the first repetitions of the game. In other words, due also to the fixed-pair nature of the groups, players coordinate and reach a Nash equilibrium in the very first repetitions and in the majority of cases select the same strategy up to the end of the game. To check for the influence of environmental connotation over time, a further test could be made by introducing it in the middle of the repetitions, and observe whether the strategy on which the players coordinate is modified by the introduction of environmental connotation. Policies based on consumer sensitization through information and awareness-raising campaigns would again find in these outcomes some interesting suggestions, as they would show the speed and stability of consumers' behaviour changes under the influence of environmental campaigns. Further extensions of these experiments will consist in analysing larger groups to avoid the fixed-pair effect and in introducing environmental connotations into the two strategies at the same time as Dugar & Shahriar (2012) did in their experiment, to observe the possible facilitation of coordination through the introduction of illustration.

Results from the NEP scale test tally with the literature in this field ([Dunlap et al. 2000](#), [Kotchen & Reiling 2000](#)) and the effect of environmental connotations on strategy choice is partially in line with the NEP findings. Similarly, the investment portfolio test partially explains the attitude of players with regard to the risk observed in the game. An avenue for further investigation in this field could be to relate strategy choices to ambiguity aversion rather than to risk aversion, with ambiguity referring to the belief dimension about the opponent's choice, while risk aversion is purely linked to the game's probabilities.

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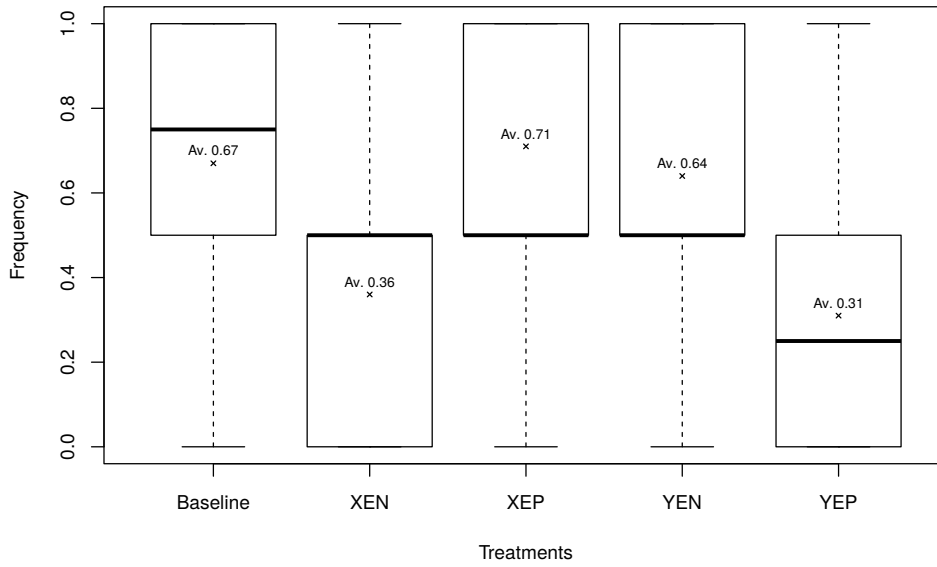


Figure 1: Distribution of the average frequency of  $X$  in the one-shot game

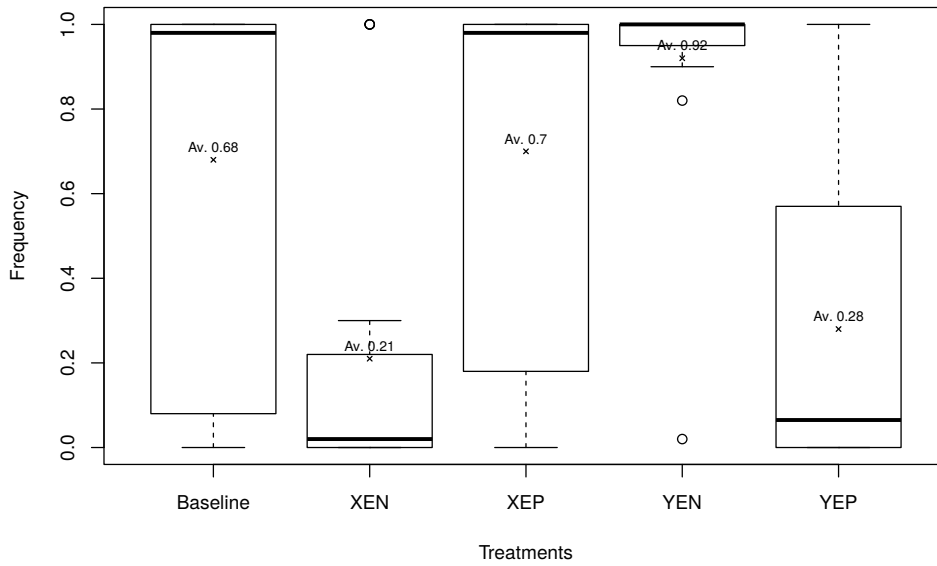


Figure 2: Distribution of the average frequency of  $X$  in the repeated game



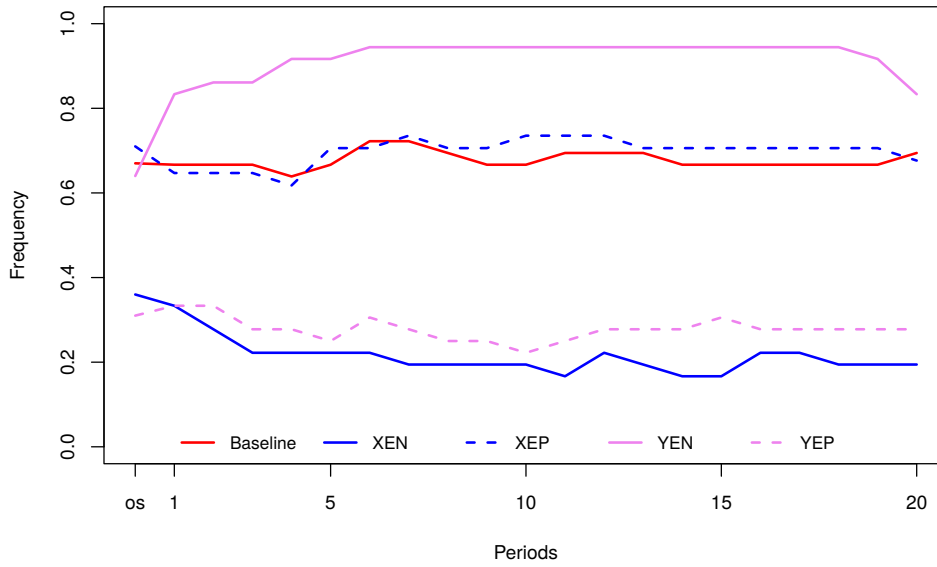


Figure 3: Evolution of the frequency of strategy  $X$  in the repeated game

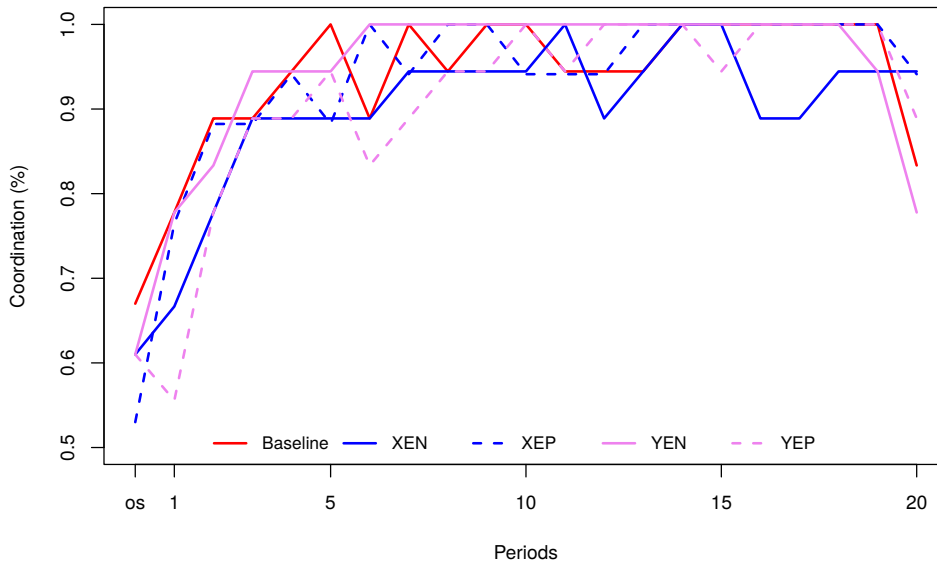


Figure 4: Evolution of the coordination rate, in the one-shot and repeated game

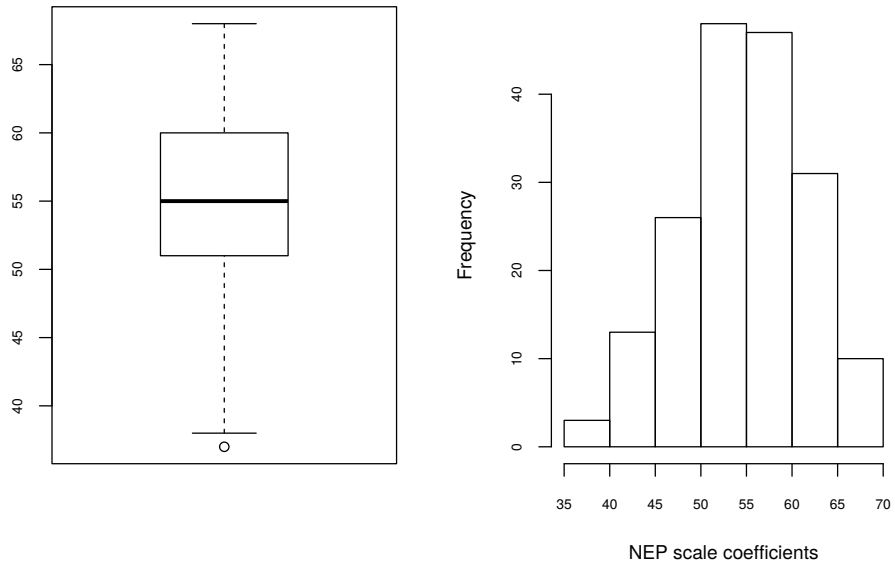


Figure 5: Distribution of the NEP scale coefficients

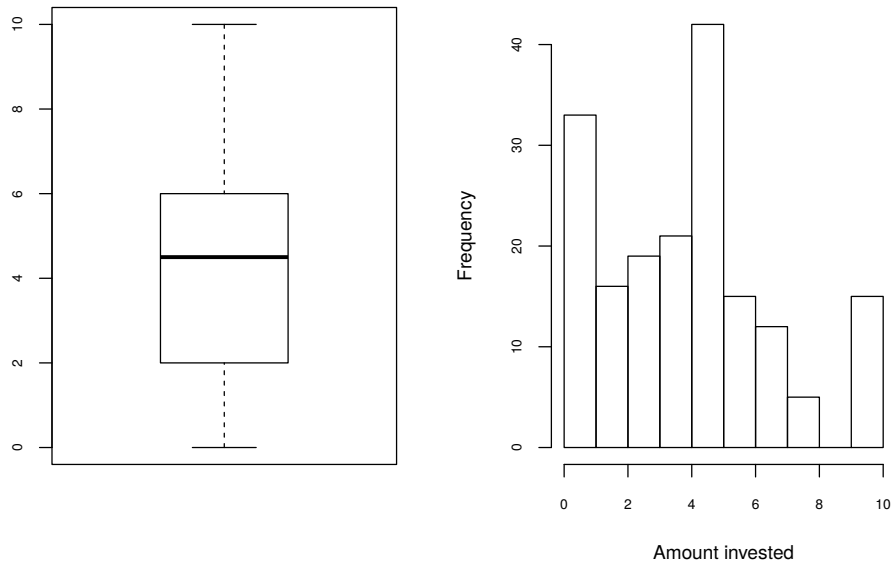


Figure 6: Distribution of the amount invested in the risky option of the portfolio choice problem

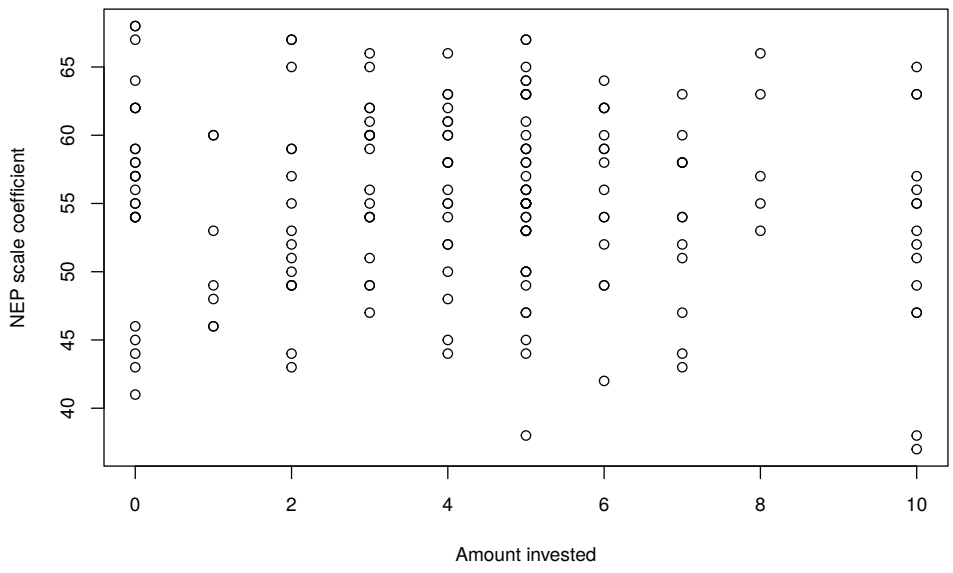


Figure 7: Correlation between NEP scale coefficient and sensitivity to risk

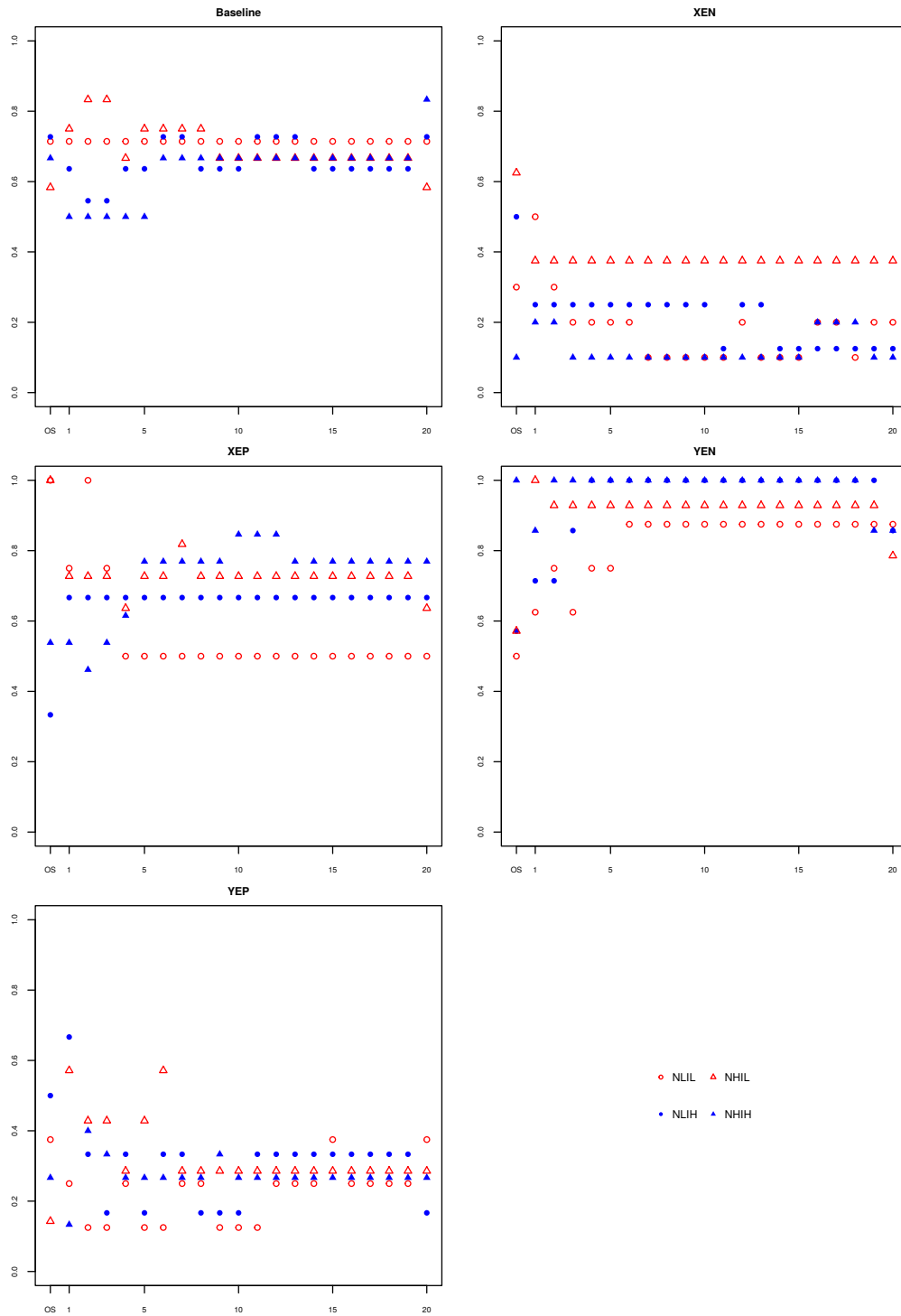


Figure 8: Choices according to NEP and Risk profiles

### **Instructions (translated from french)**

The experiment you are going to participate in is aimed at studying decision making process. We ask you to read carefully the instructions. These instructions will allow you to understand the experiment. After all participants have read the instructions, an experimenter will read them aloud.

From now on, you are requested to stop talking. If you have any questions, please raise your hand and an experimenter will come to answer you personally.

The experiment is composed of three parts and a questionnaire. The attached instructions are those of part 1. The instructions of part 2 will be distributed when part 1 is finished, and the instructions for part 3 will be distributed when part 2 is finished.

Your final payoff for the experiment will be the sum of two out three parts, randomly drawn by the computer.

## Part 1

You have an endowment of 10 euros. You have to decide the amount you invest in a risky option. You can choose any amount (entire number) between 0 and 10, i.e. 0, 1, 2, ..., 9, or 10.

The risky option is a heads or tails game. If heads is drawn, the risky option will give you 3 times the amount invested, while if tails is drawn, you will have 0.

Your final payoff is equal to the number of euros kept plus the payoff of your investment.

Examples:

- (1) You invest 5 euros. Your final payoff will be 20 euros if heads is drawn (5 euros kept + 5 euros invested  $\times$  3) and 5 euros if tails is drawn (5 euros kept + 5 euros invested  $\times$  0).
- (2) You invest 0 euro. Your final payoff will be 10 euros whatever the result of the heads or tails game.
- (3) You invest 10 euros. Your final payoff will be 30 euros if heads is drawn (0 euro kept + 10 euros invested  $\times$  3) and 0 euros if tails is drawn (0 euros kept + 10 euros invested  $\times$  0).

To avoid calculations, the table here below is provided to you. It indicates directly the final payoff in function of the amount invested and the result of the heads or tails game.

Invested amount	Payoff	
	If heads	If tails
0	10	10
1	12	9
2	14	8
3	16	7
4	18	6
5	20	5
6	22	4
7	24	3
8	26	2
9	28	1
10	30	0

## Part 2

At the beginning of the part the server will form pairs randomly. Each pair will remain unchanged until the end of this part. You cannot identify your partner and your partner cannot identify you. To facilitate the reading of the instructions, your partner is called player B.

In this part you must choose one of the two proposed options called X and Y respectively. Player B must also choose one of the two options. Your payoff will depend on both your choice and the choice of player B. Reciprocally, the payoff of player B will depend on both choices.

If you choose the option X and player B chooses the option X then your payoff is 10 euros and the payoff of player B is 10 euros.

If you choose the option X and player B chooses the option Y then your payoff is 5 euros and the payoff of player B is 9.25 euros.

If you choose the option Y and player B chooses the option X then your payoff is 9.25 euros and the payoff of player B is 5 euros.

If you choose the option Y and player B chooses the option Y then your payoff is 8 euros and the payoff of player B is 8 euros.

Table 1 below gives you your payoffs as a function of both your choice and the choice of player B. Table 2 gives you player B's payoffs as a function of both your choice and his/her choice.

		Player B chooses	
		<i>Option X</i>	<i>Option Y</i>
You choose	<i>Option X</i>	Your payoff is 10 euros	Your payoff is 5 euros
	<i>Option Y</i>	Your payoff is 9.25 euros	Your payoff is 8 euros

Table 1: Your payoffs as a function of both your choice and the choice of player B.

		Player B chooses	
		<i>Option X</i>	<i>Option Y</i>
You choose	<i>Option X</i>	Player B's payoff is 10 euros	Player B's payoff is 9.25 euros
	<i>Option Y</i>	Player B's payoff is 5 euros	Player B's payoff is 8 euros

Table 2: Player B's payoffs as a function of both your choice and his/her choice.

When making your choice you do not know the choice made by player B. In the same way when player B chooses his/her option he/she does not know your choice. After all the participants have made their choices, a screen of summary

will display. This screen will show you the choice made by B and your payoff for this part.

**Option X preserves the environment.**



### Part 3

The pairs created for the previous part will remain unchanged for this part, so you are still interacting with the same person.

This part is a repetition of 20 periods of the game of the previous part. At each period you and player B must choose an option between the two proposed, option X and option Y. The payoffs are the same as in the previous part. A screen 'history' is available from the decision screen and from the summary screen. This screen recaps under the form of a table the information referring to each past period. This table includes four columns: period, your choice of option, B's choice of option, and your payoff for the period.

As in the previous part, **option X preserves the environment.**

One period out of the 20 will be randomly drawn by the server and your payoff for that period will be your payoff for this part.

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