université angers

13, allée François Mitterrand
BP 13633
49100 ANGERS Cedex 01
Tél. : +33 (0) 2 41 96 21 06

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A simple test of the sustainable development hypothesis

Serge Blondel
GRANEM, Université d'Angers

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Mots-clés : Jeu expérimental, Préférences sociales, Développement durable.
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Résumé : Nous introduisons un nouveau jeu expérimental où chaque joueur d'une session *N* reçoit 4 € et en transmets X_N (entre 0 et 4) à un joueur de la session suivante. X_N est alors multiplié par deux avant d'être donné au joueur suivant. Ainsi, le gain est $2X_{N-1}+4-X_N$. Les gens sont plus altruistes quand ceux de la session précédente le sont. Ce résultat est accentué pour les étudiants et atténué pour les mangers. La plupart des comportements sont cohérents avec le développement durable. Le premier joueur est essentiel car il va conditionner les comportements à venir: c'est un challenge pour les décideurs publics.

Abstract: We introduce a new experimental game where each player of a session *N* receives €4 and transmits X_N (between 0 and 4) to a player of the next session. X_N is then multiplied by two before being given to the next player. Hence, the gain is $2X_{N-1}+4-X_N$. People are more altruistic when others from the previous session behave in the same way. This result is accentuated for students and attenuated for managers. Most of the behaviors are consistent with the sustainable development hypothesis. The player to make the first move is essential because it will condition future behavior: this is a challenge for policy makers.

Serge Blondel *
Faculté de Droit, Economie et Gestion
Université d'Angers
serge.blondel@univ-angers.fr

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1. Introduction

As it has been underlined by Arrow and al. (2004), sustainable development (SD) consists of choosing a sustainable mode of growth so that future growth is not penalized by successive growth periods. In other words, the principle of SD requires that consumption opportunities of future generations should be at least at the same level as consumption today. Hence, if the subject's behaviour is guided by SD hypothesis, the level of consumption chosen will follow this constraint. However, in reality SD is not obvious because economic agents do not necessarily behave in this way. The consumers or producers seem more and more concerned by SD but how do they *really* behave? This question is crucial because SD is the result of economic decisions, but the debate is complex for two reasons. First of all, a common attitude is to formulate promises which are not credible: consumers and producers are in favor of SD, but have more consideration for their own economic interest when making decisions. Secondly, the consequences for the future generation are determined by a problem of common pool resources.

So, how could we evaluate the real commitment to SD, without being limited to good intentions? Experimental economics is the appropriate tool for measuring the real motivation of agents. Although the stakes are low in a laboratory, the observed decisions reflect the real behavior of agents: "an increase in the amount at stake had no or only small effects on subject's behavior" (Fehr, 2009, p. 219-220). Hence, SD could be studied with experimental methods, as most popular themes: risk attitudes, cooperation, bargaining… Surprisingly, amongst the growing applications of experimental economics (see the handbooks of Kagel and Roth, 1995, or Plott and Smith, 2008), there is not yet an application focusing on SD. Fischer et al. (2004) had studied the behaviour of generations in an experimental situation but each generation did not know the decision of the previous generation and the game was complex since there was also a problem of common pool resources. However, the "parallelism precept" applies to SD because, as Smith (1982) said, "Propositions about the behavior of individuals (…) that have been tested in laboratory microeconomics also apply to non laboratory microeconomics where similar *ceteris paribus* conditions hold" (p. 936).

A new experimental game is introduced here, called SD game. In this game, each subject is between a subject from the previous generation and another one from the following generation. This is a simple test of SD hypothesis since each subject has to choose the sum transmitted, knowing the sum given by the player of the previous generation. To our knowledge, this is the first study to report a test focusing only on SD behaviour, without other behaviours, as cooperation. If a player is a pure money maximizer, he or she will give

nothing to the next sessions and keep everything. SD hypothesis is verified if the sum chosen is at least equal to the sum transmitted by the previous player.

Although this game is suggested for testing SD hypothesis, it has some common points with classical games in experimental economics. A player in this game could be seen as a "dictator", but, in the dictator game, the player has not received anything from another player. The SD game could also be compared to the public goods game, since there is a dilemma between individual and collective interest, or lastly to the trust game, since one player sends an investment to another, but there is no return in the SD game.

After describing the SD game, we will specify the experimental design, present the results, analyze the theoretical implications, and finally evaluate if the subjects are guided by the principle of the SD.

2. The sustainable development game

2.1. The rules of the game

[Insert Figure 1 here]

Figure 1 presents the SD game. A session *N* is between a previous session $N-1$ and a next session $N+1$. The first session had some simulated decisions from the "previous session" and the last session transmits to no one, but subjects (of the first and last session) were not aware of this. Each player of a session *N* receives 4€ and transmits X_N ($X_N \leq 4$) to a player of the session $N+1$. X_N is then multiplied by two before being given to the next player. Since the game is the same for each session, each subject, in session *N*, wins a gain G_N equal to $2X_{N-1}+4-X_N$.

There is no reciprocity with the players of sessions $N-1$ and $N+1$. The anonymity is total between players. If all players are pure money maximizers, the prediction is straightforward: they will give nothing to the next sessions and keep the €4. Hence, everybody earns €4, although it was possible to earn more. For example if €4 is always transmitted, everybody earns €8.

Proposition 1. In a session *N*, a pure money maximizer will keep all, i.e. $X_N = 0$.

2.2. Common points with well-known games

The SD game has some common features with various well-known games developed in experimental economics. From a general point of view, there is a dilemma between individual and social interest in all these games. More precisely, the SD game is linked with the following games:

- Dictator game. This game is a modification of the ultimatum game (Güth et al. 1982), where a player 1 offers to share a sum of money with the player 2, the later accepting or rejecting it. If both players are moneys maximizers, and at perfect equilibrium, player 1 only gives a small amount to player 2 which is then accepted. Results have shown that player 1 keeps about 60% and player 2 rejects an offer of less than 30%. In the dictator game (Forsythe et al., 1994), player 2 must accept the choice of player 1: the game checks if the player 1 behaves altruistically. The answer is no: most player 1's keep everything. If you consider that player 1 simulates one generation and player 2 the following generation, the dictator game could be related to SD, since the first generation could keep most of the resources and the following generation could not prevent this from occurring.
- Trust game. In this game, both players have the same sum of money. Player 1 sends a part of his sum to the player 2, and this amount is then multiplied by 3 for the benefit of player 2. The player 2 then sends in return what he or she wants to player 1. Under money maximization, at the perfect equilibrium, player 1 keeps everything because player 2 will return nothing. In the Berg et al. (1995) first study, players 1 sent about half of their endowment and players 2 sent back in return about one third of what they received. So, player 1's get back approximately their initial endowment while the player 2's multiply by 2 their initial sum. The common point with the SD game is that player 2 is a "dictator" and can return what he or she wants, after having received an investment.
- Public goods game. In the public goods games, there is a social dilemma. Players must allocate their endowment between two accounts, one private and one public. The private one is simply keeping the money whilst the public investment is greatly increased, and then divided equally between all the players. Hence, everyone's earnings will be maximized if everybody cooperates and contributes their entire endowment to the public account. However, under individual money maximization and at equilibrium, each subject contributes nothing to the group account. In fact, on

average, people contribute between 40 and 60% (see Leylard, 1995). The common point with SD is that self-interest goes against collective interest.

Figure 2 summarizes the common points with the well-known experimental games. Amongst all the situations in these games, the player with the situation closer from the SD game is the player 2 in the trust game, receiving an investment and returning a free amount of money.

[Insert Figure 2 here]

2.3. Some examples of behavior

Consider three cases, where the first gift is 0, 2 or €4. If each player simply replicates the previous decision, we will have the accumulation of wealth as described in figure 3.There are various development paths for the growth of global wealth, depending on the first decision.

[Insert Figure 3 here]

Over 10 sessions the accumulated wealth will be very different: from €40 to €80. Clearly, one development path, the higher one, maximizes the welfare. Now compare this development path with the case where the agent of the fifth session, for example, keeps all the money and so the development path becomes the lower one, as described in figure 4. Clearly, this agent breaks the SD path, and wins €12 instead of €8 as the previous players: this immediate reward leads to a lower wealth in the long run with only €4 for the next players. The accumulated wealth will be €68 instead of 80. An individual's decision will have high consequences for future agents.

[Insert Figure 4 here]

2.4. Test of SD hypothesis

The previous examples show that each player has the possibility to maximize future wealth, but with an individual sacrifice. Do the subjects support SD? The SD hypothesis is verified for the player of the session N if the subject of the next session has at least the same opportunities as the subject of the previous session N. Formally, it leads to $Max\{G_{N+1}\} \geq Max\{G_N\}$, that is to say $2X_N + 4 \geq 2X_{N-1} + 4$ or $X_N \geq X_{N-1}$. A subject in the session N verifies the SD hypothesis if he or she transmits at least the amount transmitted in the previous session.

Proposition 2. In a session *N*, a player following the SD hypothesis will give at least the sum transmitted by the previous player, i.e. $X_N \geq X_{N-1}$.

[Insert Figure 5 here]

Figure 5 summarizes the possible behaviors of a player. Note that if the previous player has kept everything $(X_{N-1} = 0)$, there is no test of the SD hypothesis.

3. The experimental design

We took advantage of an experiment conducted by our colleagues in marketing. The timing of their design (approximately 35-45 minutes) allowed us time to use their experimental population for our experiment. There was just one question in our experimental design and it took about 5 minutes, including explanations.

[Insert Figure 6 here]

The sample of 175 subjects (see Figure 6) was representative of the French population and includes some information on their profile. They were recruited in Angers, a medium sized French town. 55.4% of the population were female and the distribution (in %) of the ages was as follows: 15.4, 18.9, 10.9, 25.7 and 29.1, respectively for younger than 25, 25-34, 35-44, 45-54 and older than 54. Concerning the social status, 22.3% were managers, 31.4% were non-managers in a firm, 24% were retired, 12% were students and 10.9% were unemployed.

[Insert Figure 7 here]

The question was presented in few minutes and the subjects wrote their decisions on a piece of paper. The question is shown in figure 7. The explanation only focused on the game itself, nothing was said about SD. If a subject had a question, he or she was able to switch on a light and the experimentalist would come over to give the explanations required. The 175 decisions were collected from between 7 and 17 subjects in each of the 15 sessions. All the sessions were conducted in April 2009, in the ESA (*Ecole supérieure d'agriculture*) sensory analysis laboratory, at Angers. The anonymity was total, since the transfers between the sessions were reported by the experimentalists. The amount of money was received in cash. The subjects earned between 2 and €11, and €5.73 on average. In addition, subjects received, for their participation in the marketing experiment, €7.5 worth of coupons that could be used in a supermarket.

We collected results over 15 sessions, but the number of subjects was variable from one session to another. Hence, some decisions were not transmitted to the next session, but to the following one. Twice, there were not enough players in the previous session for the subjects in the next session, so the experimentalists simulated a donation of €3 for each supplement player. In order to begin the experiment, the first decisions were simulated and the decisions of the subjects in the last session had no consequences. The 15 simulated values, with an average of €1.43, were (number of times): 0.5 (2), 1 (4), 1.5 (4), 2 (4), 2.5 (1).

4. Results

[Insert Table 1 here]

Table 1 summarizes the various decisions obtained. On average, the subjects transmitted €1.71, knowing that they received €1.72. The gift is correlated at 55.3% to the gift of the previous generation. In figure 8, bubbles (proportional to the number of observations) represent this high positive correlation ($t = 15.78 >> 3.29$, at 0.1% risk).

[Insert Figure 8 here]

The more the subject received, the more they gave. When the previous generations did not send more than €1, 98.6% of the players did not send more than €2; reversely, when the sum sent was at least €3, 87.5% gave at least €2. Very few subjects (2.9%) have maximized their gains and given nothing: 3 out of 6 who received nothing and 2 out of the 169 remaining subjects. The usual assumption that individuals act in their own self interest is strongly rejected by our data.

We observe that 46.9 % of the subjects have sent exactly the same amount given in the previous session. The study could be contested on the grounds that the correlation could be due to the subjects simply reproducing the previous decision, if they did not really know what to do. However, the correlation remains significant even without these 94 subjects, or in other words only with the subjects choosing $X_N \neq X_{N-1}$ ($t = 9.78 >> 3.29$, at 0.1%).

Our data allows a comparison of the differences between subjects'genders summarized in Figure 9. It can be observed that behaviors are very different for the 38 managers and the 27 younger people (or students). Whilst managers received slightly more (€1.63 instead of €1.59), they gave €0.6 less (€1.33 against €1.93). Reversely, students gave significantly more than they received.

[Insert Figure 9 here]

We conducted a multivariate regression where X_N was explained by X_{N-1}, sex and various social status. The ages are not in the regression because they are correlated to the social status for retired people and students. The social status "Employed" is the reference for the regression. It shows that the effect on X_N is:

- positive ($p < .0001$) for X_{N-1};
- negative ($p < .05$) for managers.

[Insert Table 2 here]

Detailed results are in the table 2. A small effect on results can be seen from gender and students. Women overall did not seem to be more generous than men, unlike the findings of other studies. Many studies have focused on the differences in the economic decisions between men and women (see the survey of Eckel and Grossman, 2008) where women appear more altruistic in the case of the dictator game, but not in the other games where there is a strategic dimension. In the SD game, each subject is a "dictator" but also a player to make the first move for players in the next sessions. Hence, women do not appear more altruistic.

The strong influence of X_{N-1} is the most significant result. The more money received, the more is given and inversely, which is a normal real life behavior. If a friend invites you for a dinner, you will invite him in return, and your friendly relation continues. However, a relationship could cease if one partner was to stop reciprocating with similar invites. Our result is intuitive, but it raises a question: Which model could explain this behavior?

5. Analysis of the preferences

There are various ways of analyzing how preferences are formed. First, economists have developed social preferences models, where the utility of a player depends on his or her own profit, but also on the profit of the other players (see Fehr, 2009, for a survey). Second, some behavioral economists have focused on the framing of decision. Last, the SD hypothesis of this paper will be tested.

5.1. Social preferences

A black box exists here for the application of these models which are usually applied to games where all players know the profit of the other players. In the SD game, each player

knows his or her own gain but does not know exactly how much the sender and the recipient gain in the end. Moreover, the second limit is that there is no reciprocity. Hence it is impossible to apply the two prominent models of social preferences, the inequity aversion model of Fehr and Schmidt (1999) and the fairness model of Rabin (1993).

Consider first the inequity aversion model. In figure 1, we do not know exactly the previous (session $N-1$) and next (session $N+1$) gains, since X_{N-2} and X_{N+1} are unknown. If we assume that the inequity appears through the only possible comparison, between X_N and X_{N-1}, there will be a feeling of envy (if $X_N > X_{N-1}$) or guilty (if $X_N < X_{N-1}$). Since $X_N > X_{N-1}$ is reducing the individual gain and the equity, this is a dominated strategy. 26.3% of the subjects, who gave more than they received, are inconsistent with this model: this is not significantly different from the proportion of subjects giving less than the amount they received (27.4%). This is a limit of this model for explaining the SD game results. The model explains 74.7% of decisions, but also predicts a significantly lower number of people giving more than they received ($X_N > X_{N-1}$) than the reversed case ($X_N < X_{N-1}$): this is not the observed behavior in this case. Moreover, this model is inconsistent with some behaviors compatible with the SD hypothesis (see Figure 5).

To apply the fairness model, the essential emotion assumed is reciprocity. People are willing to sacrifice their own gain to help those who have been kind or to punish those who have been unkind. But how could we know here if a player has been kind or not? For example, consider the case where the previous player has sent €2: if her or his previous player has transmitted no more than €2, this is kind, otherwise this unkind. Since we do not know the value of X_{N-2}, it is impossible to apply the fairness model.

5.2. Framing effects

It is well known from the works of Richard Thaler and other behavioral economists or psychologists that a decision can be strongly influenced by framing effects. *Nudge* (Thaler and Sunstein, 2008) discusses how public and private organizations can help people make better choices in their daily lives concerning the environment, as well as other topics like money and health, and how we can be framed into making better decisions to save the planet and ourselves. More precisely, in chapter 12 “Saving the planet”, they argue that a simple return of information could be a nudge to follow SD behaviours.

Our result suggests that people are willing to support SD, but that it requires that the previous generations have themselves supported SD. In other words, the return of

information on a SD behavior will motivate similar behaviors. People are reluctant to initiate SD, if it has not been supported previously: hence, the public decision-makers have to be the first mover and initiate SD.

5.3. SD hypothesis

Amongst the remaining 169 subjects receiving more than 0, 121 (71.6%) made decision consistent with SD. This rate is significantly greater than 50¨% ($t = 6.23$, $p < .001$). More precisely, 48 (28.4%) transmitted less than the previous player, 78 (46.2%) replicated the previous decision, and 43 transmitted more. Amongst the players consistent with SD hypothesis, 64.5% maintained exactly the possibility of gain for the following session wile the remaining ones supported future development.

6. Conclusion

We have proposed and tested a new experimental game, reproducing in a lab the sustainable development (SD). The usual assumption that individuals act in their own self interest is strongly rejected by our data. People are more altruistic when others from the previous session behave in the same way. This result is accentuated for students and attenuated for managers, partly consistent with social preferences models.

The message of this experiment is clear. People are willing to support SD, but it requires that the previous players have themselves supported SD. In other words, people are reluctant to initiate SD, if it has not been supported previously. This could be compared to the problem of the strong development of emerging countries and pollution. Why must they choose SD when most developed countries have not taken into account SD principals before?

It seems like an illusion to hope that people will initiate SD. In our experiment only 27% of people clearly support SD (increasing what they give to the next generation), but this is equivalent to the 26% diminishing the sum transmitted. So, SD requires a real incentive. The first person to make a decision in the game is essential because their action will condition all future behaviors. This is a challenge for policy makers: The behavior of the past generation must be valued. Instead of feeling guilty, policies must communicate on the positive actions undertaken: “look at your quality of life: you must transmit at least the same to the next generation”. The SD game results predict that this positive message will incite people to be consistent with SD.

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Tables

Table 1 The 175 decisions

	X_N							
X_{N-1}	0	0.5	1	1.5	2	2.5	3	4
0	3		1		2			
0.5		4	3		3			
1	3	4	32	1	17		1	
1.5		1	4	1	2		1	
2	1	2	16	1	30	3	3	6
2.5			1		2	2	1	
3			1	1	4		3	2
4			1		5		1	6

Table 2 Multivariate regression explaining X ($N = 175$)

	Estimations		
	Coefficient	Standard error	P-value
Xn-1	0.5470	0.0642	<.0001
Male	0.175	0.1229	0.1562
Manager	-0.3538	0.1693	0.0381
Retired	0.1487	0.1653	0.3695
Student	0.2828	0.2043	0.1682
No job	0.0030	0.2119	0.9886
Constant	0.5231	0.2178	0.0174
R^2	0.3563		

Figures

Figure 1 The decision in a session N

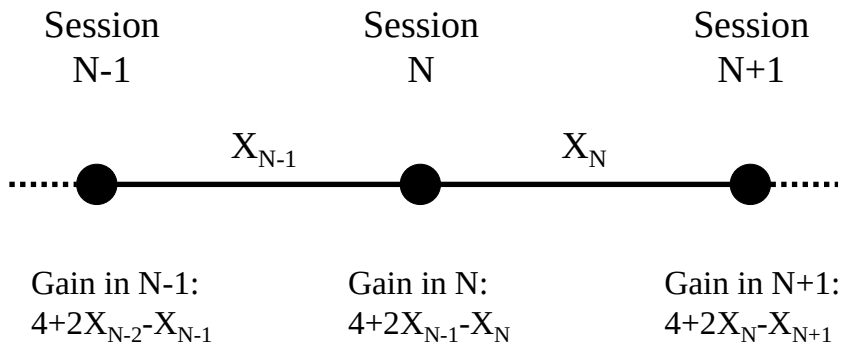


Figure 2 Common points between SD game and usual games

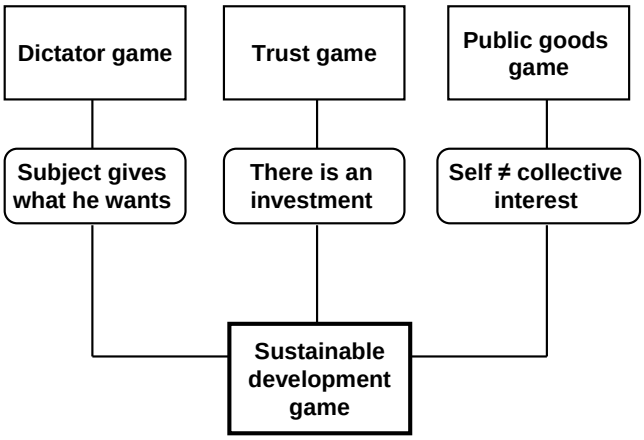


Figure 3 Three different development paths

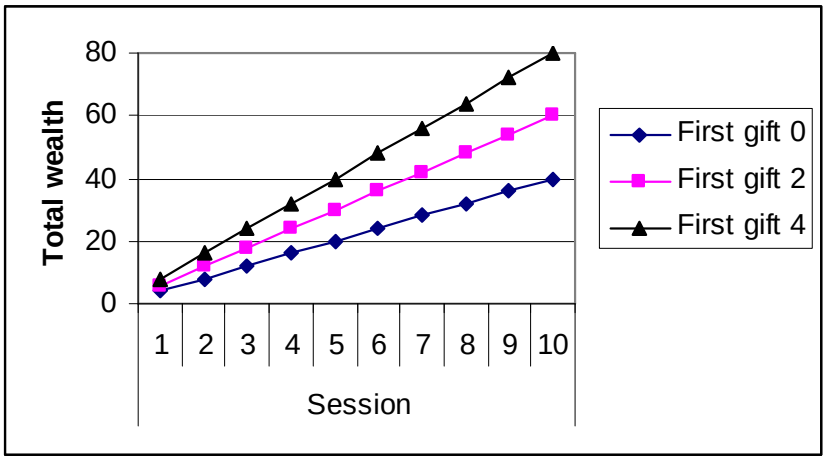


Figure 4 Two different development paths

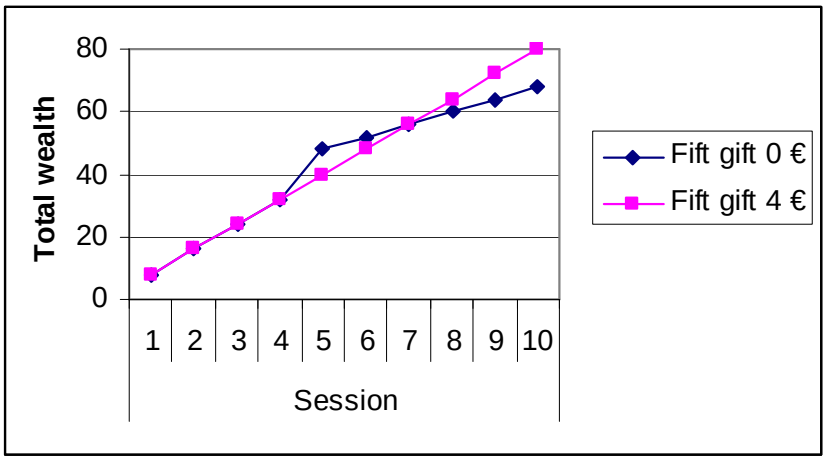


Figure 5 Possible behaviors of a player

$X_N = 0$:
Pure money maximizer

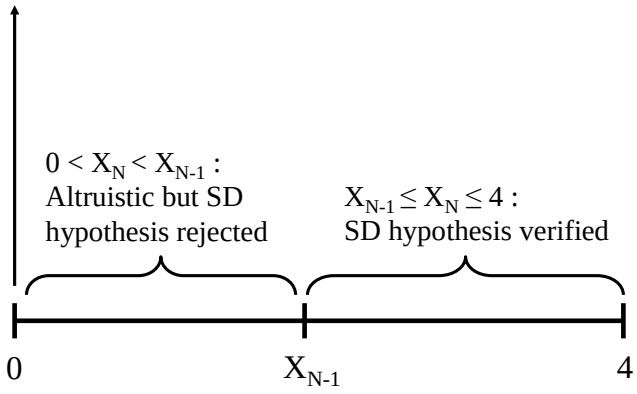


Figure 6 The 175 subjects

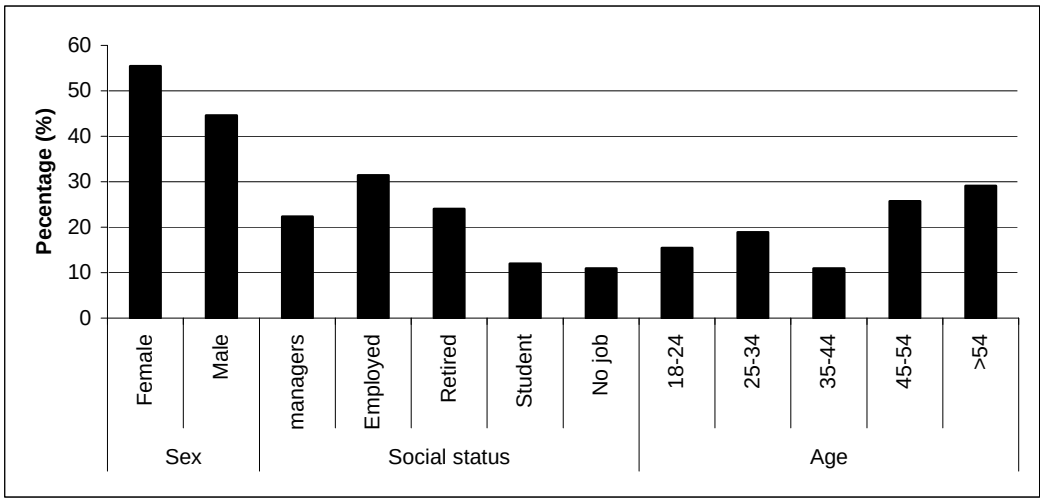


Figure 7 The question (translated from French)

Choice of the sum B

In this game, you will receive, as for all participants:

→ €4 ;

→ and a sum A (no more than €4) transmitted by a participant of the previous session, to which is added the same sum A by the organizer : thus you will receive A twice ;

→ Minus a sum B (no more than €4) that you transmit to a participant of the following session, to which is added the same sum B by the organizer: thus this next participant will receive B twice.

A participant of the previous session has transmitted to you:

A = ☐ € (Organizer) so you have ☐ € (Organizer) (twice A), plus €4.

You transmit to a participant of the following session:

B = ☐ € that will give ☐ € (twice B), plus €4.

Your gain (in €) is thus = 4 + 2A - B = ☐

Number of judge

Name :

Figure 8 The influence of previous session on the decision ($N = 175$)

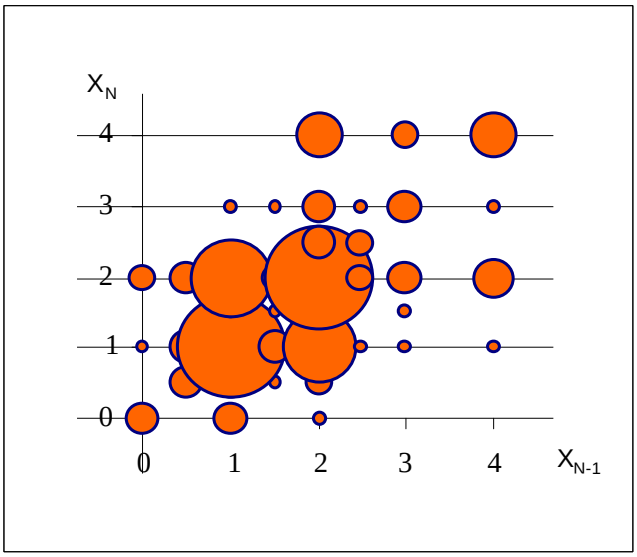
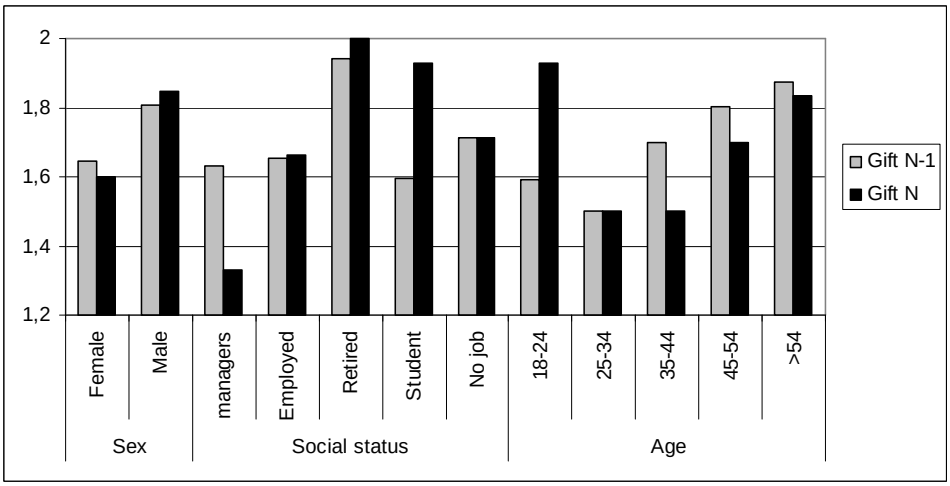


Figure 9 Average gifts, by gender



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