Rationality and drug use: An experimental approach

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Serge Blondel
University of Angers

Youenn Lohéac
Rennes School of Business

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Rational Decision of Drug Users: An Experimental Approach*

Serge Blondel [a,b], Youenn Lohéac [a] and Stéphane Rinaudo [a]

Abstract

To explain rationally the demand of narcotics, Becker and Murphy (1988) assume that drug addicts have higher discount rates than others. Orphanides and Zervos (1995) extended it to risky decisions. These models of rational addiction maintain the standard assumption about rationality under risk and time.

The aim of the paper is to compare behavior towards risk and future of drug users (DU) and non-drug users. We conducted an experimental investigation over two populations with a real monetary incentive system.

We observe that DU are not less rational than others in the sense of standard theories, under risk and time. The hypothesis that DU have higher discount rates (Becker and Murphy, 1988) is not validated. However, we observe that they are more risk seeking.

JEL Classification*: C91, D81, D91, I10*

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[a] TEAM (CNRS and Université Paris I)
Maison des Sciences Economiques
106-112, Boulevard de l'Hôpital F-75647 Paris Cedex 13 - France
Tel. (33) 1 44 07 82 51 - loheac@univ-paris1.fr - rinaudo@univ-paris1.fr

[b] National Institute of Horticulture
2, rue Le Nôtre F-49045 Angers Cedex - France

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Tel. (33) 2 41 22 55 00 - sblondel@angers.inra.fr

1. Introduction

Generally, drug user (DU) behavior is considered to be irrational because the consumption generates an increasing need of the product and amounts devoted to this are increasing with quantity consuming previously. A major competitor of any theory that views addiction as irrational behavior is the rational addiction theory (Becker and Murphy, 1988; Orphanides and Zervos, 1995). According to this theory, addicts exhibit an individually optimal behavior: the model of Becker and Murphy is in a certain world and Orphanides and Zervos have extended it to uncertainty. Thus, DU are conscious of risk which their consumption can generate, but this consciousness can be concealed by the present and painful need to consume an addictive product. These new theories take place in the area of myopia and intertemporal decisions, but in the area of risk taking behavior we do not know if DU are similar or not to others. Their need to have more money for buying drugs may conduct them to choose behaviors which lead them to earn money quickly, that is not without risk.

To explain rationally the demand of narcotics bringing about addiction, Becker and Murphy's theory of rational addiction (1988) assumes that individuals are rational. They are forward-looking and make consumption choices which are temporally consistent: they anticipate the possible future negative consequences of their choices, and their strong depreciation of the future leads them to consume. These individuals choose intentionally to enter in addiction, this choice being optimal among the alternatives they face. The theory predicts that those who have a high discount rate are more likely to become addicts; but the discount function remains exponential, which assures the dynamic consistency of choices.

When an individual decides to consume an amount of drug today he often does not foresee continuing consuming in the future, and he thinks he can enjoy occasional use of the product. But the drug addicts who are able to respect this kind of commitment are few. Their choices are temporally inconsistent meaning they revise past decisions for present consumption. The particular shape of the discount function is likely to be the root of this time inconsistency of choices. The discount function is perhaps more concave than the exponential one for a drug addict: the discount function is possibly hyperbolic as suggest Ainslie (1992), or Loewenstein and Prelec (1992). This approach allows the start of drug use to be explained, which is not the wish of the individual but a result of his myopia.

The aim of the paper is to compare the risky and intertemporal decisions of DU and non-drug user (NDU) persons. We test various basic hypotheses, from H1 to H4. Since consuming drugs is a risky behavior, H4 is an intuitive hypothesis

- **H1**: DU are EU-maximizers (Orphanides and Zervos, 1995);
- **H2**: Time decisions of DU are consistent (Becker and Murphy, 1988; Orphanides and Zervos, 1995);
- **H3**: DU have higher discount rates (Becker and Murphy, 1988);
- **H4**: DU are less risk averse.

For this, we have collected experimental data on two populations:

- A DU group currently following a course of methadone substitution treatment.
- A control population with similar income features.

Both under risk and time, we conclude that DU are not less rational than others. They are more risk-seeking than others but they have not higher discount rates. We show also that the discount functions of the DU are not more concave than those in the control population, and that they do not depreciate the future more.

The rest of the paper proceeds as follows. In section 2, we will consider the standard theories of choice, namely expected utility (EU) and time preference theories. The experimental design will be presented in section 3. We describe the behavior of DU and NDU subjects and then we test the assumptions above in sections 4 (risk) and 5 (time). The last section concludes.

2. The theories of rational decision

The criteria of decision are presented first under risk and second under time.

2.1. Rational decision under risk: Expected utility theory

The EU criterion will be presented in the framework of a binary choice defined in table 1. The utility function *u(y)* being strictly increasing, we set up:

$$u(y_1) = 1; u(y_2) = x; u(y_3) = 0; 0 < x < 1$$

Here we restrict our analysis to actions, that is to say to the lotteries presented in a “states-of-nature-format”. We are in the framework of a binary choice between an action R (the most risky) and an action S. There are 3 outcomes with $y_1 > y_2 > y_3$ and four states of the world with associated probabilities $p_1 ? p_2 ? p_3 ? p_4 ? 1$ and $p_1 ? 0, p_2 ? 0, p_3 ? 0, p_4 ? 0$. Table 1 presents the choice:

Table 1. The risky choice problem

State	**1**	**2**	**3**	**4**
Probability	p_1	p_2	p_3	p_4
S	y_2	y_2	y_2	y_3
R	y_1	y_2	y_3	y_3

States 2 and 4 are the common consequences to both actions. According to EU, the choice is entirely determined by the utility function. *S* is chosen if:

$$?p_1 ? p_3 ?x ? p_1 \tag{1}$$

The announced prices $?$ of S and R are, according with EU:

$$\begin{aligned} &?_S ? u^{?1}??p_1 ? p_2 ? p_3 ?x? \\ &?_R ? u^{?1}?p_1 ? p_2 x? \end{aligned} \tag{2}$$

Where $u^{?1}$ is the reverse function of *u*. Obviously, the equations (1) and (2) lead to:

$$?_S ? ?_R ? \quad S \square R \tag{3}$$

EU criterion implies that the lottery chosen will necessarily have a higher announced price.

2.2. Rational decision under time

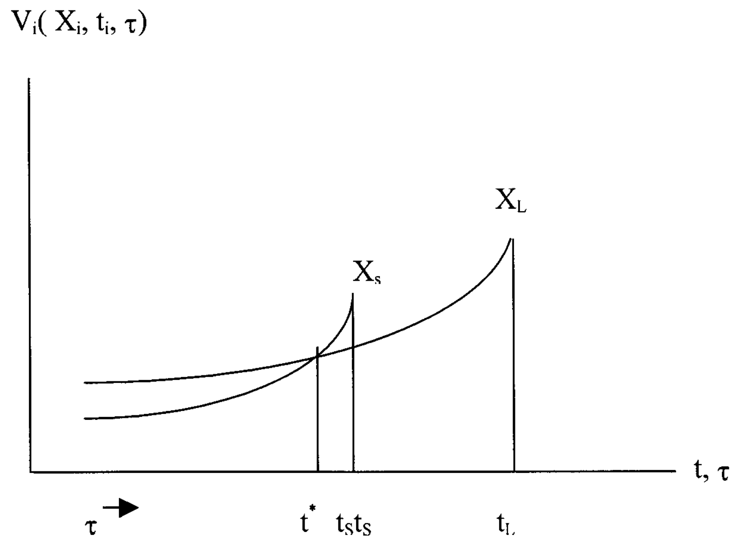
a) The rational addiction model

The rational addiction model of Becker and Murphy (1988) is a rational habit formation model. The addict individual has a consistent, forward looking, and optimal behavior. He is aware of the deterministic habit formative aspect of his drug consumption, and is also able to make the trade-off between present benefits and future costs. The authors show that the individual decides according to the full price of his consumption which take account of the updated costs of the future consumption of the product, costs generated by habits. And the more he depreciates the future, the lower is the full price. Therefore the hypothesis of a strong time preference allow the authors to explain the entrance in addiction as a rational optimal choice.

Moreover, Orphanidès and Zervos (1998) and Becker and Mulligan (1994) show that the use of drug leads to a fall of the discount factor.

b) Hyperbolic discounting

According to George Ainslie, drug addict's behavior can be explained almost only by a time preference broadly biased toward the present. This means a tendency to increase the valorization of a satisfaction as it draws near, and then to always allow oneself to be tempted by near satisfactions. This search for immediate pleasure leads the drug addict to consume his favorite product(s) as soon as the opportunity comes his way, even when he had not planned it. Formally this preference reversal may be due to a hyperbolic discount function which unlike the exponential discount function does not assure the stability of choices in time. The next figure, usually called Ainslie diagram illustrates this mechanism:



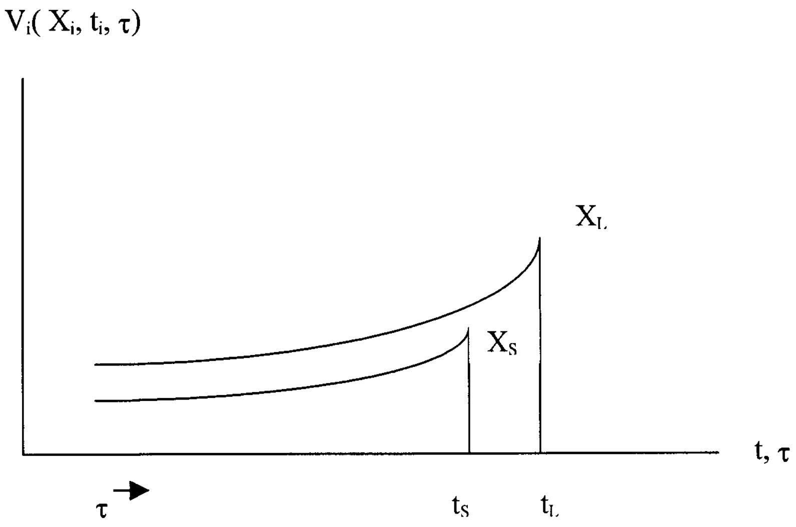
Preference reversal due to hyperbolic discounting

? is the present moment, X_S is a small gain which will be available at the moment t_S, and X_L is a large gain which will be available at the moment t_L ($t_S < t_L$).

$V_i(X_i ,t_i ,?)$ is the utility obtained from X_i at time t_i viewed from the time ? < t_i . $i = S, L$.

Before t^* X_L is preferred to X_S, however, after t^* this is the discounted utility of X_S which dominates. The choices are temporally inconsistent.

For an individual with temporally consistent choices the Ainslie diagram has the following shape:



Temporally consistent preferences with exponential discounting

If the large gain X_L is preferred at a given moment, then it is preferred at any other moment, likewise for X_S.

3. The experimental design

3.1. Subjects and recruitment

The subjects were 34 DU (we excluded one of them because he did not answer at all games) and 28 NDU persons. The experiment was carried out with the permission and very helpful cooperation of the methadone center staff (for DU subjects) to whom we are most grateful.

The methadone center staff (doctor, nurses and social workers) recruited 35 DU persons. Methadone is a substitute of heroin. This product is included in global taking charge of DU, which is included in expanded context of risk reduction policy. This product is active during from 24 to 36 hours; it is prescribed by a specialized doctor on addictions and must be taken only at the methadone center. In this last one, all individuals are heroin addicts: one part includes polydrug addicts (heroin and cocaine in association) and most of them consume other drugs (cannabis, alcohol, medicines, amphetamine, LSD, crack-cocaine, ecstasy, etc[1]). Concerning age, this population is in the superior part of the scale of DU ages (see table 2). However, note that DU career is made of periods of weak consumption, even of abstinence and of periods of relapse. Drugs

[1] Note that most of them are tobacco smokers.

consumption is neither constant nor continually increasing like it's showing in most recent models (Orphanides and Zervos, 1995, 1998). These individuals are often unemployed. Unemployment benefit, social benefits and RMI (minimum guaranteed income) are the most widespread incomes. The fact that their consumption career is already long explains their situations on the labor market.

Table 2. Individual characteristics

	Mean (standard deviation)	
	DU (34 subjects)	**NDU (28 subjects)**
Age in years	35 (5.8)	39 (10.4)
Oldness in consumption	16 (6.2)	-
Income in francs	2952 (1879)	2987 (2485)
Rate of unemployment	76.47%	70.37%
Percentage of men [a]	62.86%	100%

[a] Significantly different between both populations at 1%. [b] Significantly different between both populations at 5%.

Since we compare DU and NDU populations, we researched people who have the same characteristics of income and age for a control of parameters. Therefore, we put a recruitment poster (proposition to participate at experiment with monetary gains) in a social action center of Paris (accommodation, restaurant, health care and integration), in a training center (*Relais des carrières*) and in a familial benefit center (*Caisse d'Allocation Familiale*). Interested individuals called us at the phone number indicated on the poster: we answered to their interrogations and gave the hour and the place of the experiment to them. Most of the NDU subjects came from the social action center. The situation of most of them was relatively precarious: some were homeless and others lived in hotel bedroom. Just as DU, their incomes were often RMI, unemployment benefit or handicapped adult benefit; some did not have declared any income. Their qualification levels were relatively heterogeneous. After discussion with these individuals, they were not shocked to be compared with DU concerning their way of life. After a comparison test between these two populations on their age and income, we can't reject hypothesis of a non-difference.

3.2. Sessions

Four sessions were conducted with DU subjects at a methadone center (Emergence Espace-Tolbiac, Paris) while two sessions with NDU subjects were conducted at the University of Paris 1 (Tolbiac). Each session took in average one hour. Note that DU subjects took their methadone before coming at the session.

Experiment was presented as a part of an INSERM (French National Institute of Health and Medical Research) project. Afterwards, we distributed the first questionnaire in alternating risky games and intertemporal games since we did not want that neighbors cheat between them. Finally, each individual played one risky game and one intertemporal game and, if it was necessary, made his own drawing lots as it was specify in the incentive system. Each individual received his gain in cash, signed a receipt and left the room.

3.3. Questionnaire

We undertook two experiments, a risky decision experiment (20 decisions: 15 choices and 5 evaluations) and an intertemporal experiment (20 decisions: 12 choices and 8 evaluations). Each subject received a first questionnaire with 7 pages of instructions and hypothetical gambles, and one after the other two questionnaires including each 20 pages with one gamble by page. The order of the 20 gambles and the order of the choices within each pair were randomly determined. It was emphasized that there were no right or wrong decisions.

In the first questionnaire, subjects answer at socio-demographic questions: age, sex, income, etc. DU subjects had specified their starting date in consumption and the nature of drugs they consume. Then, game rules and incentive systems are explained. We conduct first hypothetical games of each type of game in order to assist the comprehension. Moreover questions must be easily comprehensible. Thus, games are presented in a visual way.

3.3.1. Incentive systems

We have an incentive system for two reasons: subjects are incited to be attentive and the opportunity costs (time passed to answer) must be paid. To our knowledge, this is the first experimental study of Du behavior with *real* payments.

The following procedure is the same for both part of the experiment. Subject's task was to choose one option (indifference could not be expressed) or to indicate their prices for one option. To increase the realism of the choices and motivate the subjects, one of the 20 decisions was randomly selected at the conclusion of the experiment and played for real money. The effectiveness of this incentive method relies to the "isolation effect" (Kahneman and Tversky, 1979), the finding that subjects evaluate each decision in isolation instead of evaluating their 20 decisions as subparts of one large joint gamble. Thus, each subject drew himself one option in a bag containing 20 identical counters taken each a name's game. The rules of the payment are described in the sub-sections 3.3.1 (risky part) and 3.3.2 (temporal part).

In the case of a pricing decision, subjects drew themselves a card from a deck of 100 cards marked 1 to 100[2]. If the number drawn, say X, was superior or equal to the price written by the subjects, they received X; otherwise, they are paid in function of the nature of the option, risky or temporal, that they own. Becker, DeGroot and Marshal (1964) have first introduced this preference-elicitation mechanism[3].

3.3.1. Risky decision part

The risky decision questionnaire includes 15 lottery choices and 5 lottery evaluations. In lottery choices, two lotteries are presented and the subject chooses his preferred one. [Appendix reports one sample of choice, named Stockholm.] In lottery evaluations, one lottery is presented and the subject writes the minimum selling price he wishes to receive rather than to "take the risk of playing the lottery". [Appendix reports one sample of evaluation, named Caracas.]

In the case of pairwise choice, the gamble that they had chosen in that pair would be played by selecting themselves a card from a deck of 100 cards marked 1 to 100. The number written on that card would determine the outcome which they would receive, depending on their choice of gamble. The procedure is the same if the preference-elicitation mechanism has led us to be in possession of the lottery.

In this part of the experiment, a participant can earn from nothing to F.400. The subjects earned in average F.89.3. Tables 3 and 4 present the main results.

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[2] Except if the expected value of the lottery is greater than 100 where the subjects drew themselves a card from a deck of 200 cards marked 1 to 200.

[3] The Becker-DeGroot-Marshak mechanism can be shown to be incentive-compatible. The intuition is straightforward. It is not in the individual's interest to overstate true willing to accept (WTA): if the random value falls between the true WTA and the announced WTA, the individual has foregone a benefit. It is also not in an individual's interest to understate true WTA: if the random value is greater than the state value but less than true value, the individual will required to play the game even thought he would accept random value. Thus, in evaluation games, we indicates: "If you don't state your true value but a strategic value, you will be losing if random value falls between true value and strategic value".

Table 3. The 15 binary risky choices

Question number	Lottery		Percent of R	
	S	R	DU	NDU
		E(S) = E(R)		
01	(90; 1)	(300; 0.3)	38.24 [b]	14.29
02	(90; 0.5)	(300; 0.15)	47.06 [a]	17.86
03	(100; 0.9)	(300; 0.3)	32.24	17.86
04	(60; 1)	(120; 0.5)	47.06 [b]	25
05	(120; 1)	(60; 0.5 , 180; 0.5)	41.18	35.71
12	(20; 1)	(200; 0.1)	58.82	42.86
13	(20; 1)	(400; 0.05)	61.76 [b]	35.71
14	(40; 1)	(400; 0.1)	52.94	42.86
15	(80; 1)	(400; 0.2)	38.23	25
		E(S) < E(R)		
06	(150; 1)	(200; 0.8)	47.06	35.71
07	(150; 0.5)	(200; 0.4)	58.82	53.57
08	(150; 0.25)	(200; 0.2)	64.71	50
09	(150; 0.65)	(150; 0.4 , 200; 0.2)	50	42.86
10	(150; 1)	(150; 0.75 , 200; 0.2)	35.29	50
11	((150; 1); 0.25)	((200; 0.8); 0.25)	32.35	28.57
All*			48.11	34.95

[a] Significantly greater in the DU sample at 1%. [b] Significantly greater in the DU sample at 5%. * Except the question number 11.

Table 4. The 5 pricing questions

Question number	Lottery	Average price (in francs)	
	R	DU	NDU
16	(300; 0.3)	147.83	142.82
17	(100; 0.9)	84	79.82
18	(120; 0.5)	70.11	71.82
19	(200; 0.8)	123.29	142.64
20	(200; 0.4)	106.47	109.25
All		104.07	109.22

3.3.2. Intertemporal decision part

The experience includes two series of questions. One concerns choices between two dated gains [Appendix reports one sample of choice, named ???], the other one evaluations at given dates of future gains: individuals were asked to state how much they are ready to receive at a given date to give up a gain at a later date [Appendix reports one sample of evaluation, named Beaumarchais].

In the choice questions, the subject was remunerated in function of his choice, i.e. a set gain at a given date. The procedure is the same if the preference-elicitation mechanism has led us to be in possession of a temporal option.

On the whole, the questions seem to have been well understood, and the financial incentive should have reinforced the attention o the subjects: the gain varied between F. 50 and F. 110. The subjects earn in average F. 91.5.

We keep attention to the methodological discussion. For the evaluation questions, an implicit substitution rate was calculated by the mean of the formula:

$r \; ? \; \frac{x_L}{x_S} \; ? \; 1$ where x_L represents the future set gain.

and x_S represents the estimation of x_L at a given date.

The substitution rates are calculated for each individual and each evaluation question. The mean values for each group are presented in the table 5.

Table 5. Substitution rates computed with the pricing questions

N°	t_0	(x,t)	Substitution rate *r*			
			DU		NDU	
1	0	(110,1)	0.352 (0.790)		0.329 (0.435)	
2	0	(110,5)	0.329 (0.545)		0.454 (0.649)	
3	0	(110,9)	0.320 (0.377)		0.268 (0.414)	
4	0	(60,2)	0.432 (0.49)	**0.182 (0.18)**	0.294 (0.43)	**0.125 (0.17)**
5	6	(60,8)	0.395 (0.40)	**0.171 (0.15)**	0.316 (0.34)	**0.138 (0.14)**
6	0	(75,4)	0.587 (0.85)	**0.102 (0.12)**	0.477 (0.63)	**0.088 (0.1)**
7	4	(75,8)	0.416 (0.46)	**0.082 (0.08)**	0.424 (0.48)	**0.086 (0.08)**

Notes:
The pair (x, t) denotes the option of receiving F. *x*, *t* weeks from now, and *y* denotes the cash payment at the nearer date t_0. The substitution rate *r* is then $r \; ? \; \frac{y}{x} \; ? \; 1$ For example, someone who is indifferent between (80,0) and (110, 1) has a substitution rate *r* equal to $\frac{110}{80} \; ? \; 1 \; ? \; 0.375$
Standard errors in brackets.
Numbers in bold represent the equivalent substitution rate over one week when the gap between choices in the questions is greater than one week.

In rational addiction theory, Becker & Murphy consider pure time preferences, whereas the substitution rates obtained here are only approximations to them. The substitution rate for an individual is a function of his pure time preference and of other factors likely to influence the substitution of his consumption between periods, such as risk, consumption levels in the considered periods, or possible liquidity constraints. Therefore the differences between estimated substitution rates might be due to differences between pure time preferences, but also to differences between other factors. Then by controlling the income variable with the choice of samples, we hope to neutralize the differences between groups due to liquidity constraints, although we do not control the wealth variable for the DU[4]. There was about no risk about future payments for the drug-addict population: an envelope with the name of the person enclosing the future gain in cash was sealed before the respondent and given over to the administration of the center, to be handed over to the respondent at the date mentioned on the envelope. The cost of this transaction is itself assumed to be nil, as the individual goes to the center everyday to follow his treatment course. Regarding NDU, the risk of future non-payment was evaluated by an individual by the trust he granted to the experimenters: a meeting was fixed at the welfare center during which the subject received his due sum. The transaction cost is here again assumed to be low enough, the subjects going almost everyday to the welfare center.

Likewise, the answers to the choice questions are susceptible to be influenced by risk and liquidity constraint considerations which could lead to false conclusions regarding hyperbolic discount functions. Conversely, a hyperbolic discount function may be hidden by the stability of choices between the different repetitions, due to an inappropriate calibration of times or stakes for the revelation of the individual's myopia. The answers in percentages for the different modalities are indicated in table II of section IV.

[4] We implicitly assume that the individuals of the NDU population do not possess any wealth.

Table 6. Percentage of individuals choosing the sum closest in time
(100, 4) □ (110, 5) means the subject choose (100, 4).

	Percentage of choice	
	DU	NDU
Sample size	34	28
100□(110,1)	65.5	78.5
(100,4)□(110,5)	48.5	64.5
(100,8)□(110,9)	37	53.5
50□(60,2)	63	75
(50,6)□(60,8)	57	53.5
60□(75,4)	54.5	68
(60,4)□(75,8)	48.5	57

The object of these questions is to observe whether one of these populations has a greater tendency to reverse his choices when we repeat these choices, keeping the fixed amount of gains and the fixed time between these gains but by envisaging them at different dates. The percentages of individuals always sticking to the same choice, and of those who reverse their choices just once and in the sense near small gain to larger further away gain are given in table 9 of section 5.

4. The results under risk

4.1. Risk aversion

After this analyze game by game, we aggregate the games to create indicators of risk attitude towards risky games. We have nine lottery choices (Games 1 to 5 and 12 to 15) where both options have the same expected value. c_i is equal to 1 if the subject chooses *R* in the game *i*, 0 elsewhere. Thus we generate a choice indicator of risk (CIR).

$$CIR = \frac{1}{9}\left(\sum_{i=1}^{5} c_i + \sum_{i=12}^{15} c_i\right), \quad 0 \leq CIR \leq 1 \tag{4}$$

The risk aversion decreases when CIR increases. In the same way, we generate a pricing indicator of risk (PIR) with the five lottery prices (see table 4). $?_i$ is equal to 1 if the subject evaluates the lottery at a price greater than the expected value (risk seeking) in the game *i*, 0.5 if the price is just equal to the expected value and 0 elsewhere (risk averse).

$$PIR ? \frac{1}{5}\sum_{i?16}^{20} ?_i, \quad 0 ? PIR ? 1 \tag{5}$$

Note also that CIR (PIR) indicates the percentage of risk seeking in the context of choice (pricing). Table 4 compares both populations with these indicators. According to CIR, DA take significantly more risk than NDA (significant at 5%). However, this difference exists with CIR, but does not exist with PIR. Moreover, PIR does not indicate any difference between both groups.

Table 7. Indicators of risk: CIR and PIR

	Average index (standard deviation)		Test (t) between level index and neutrality		Test (t) between DU and NDU
	DU	**NDU** [d]	**DU**	**NDU**	
CIR	0.451 (0.232)	0.286 (0.271)	-0.9004	-4.1810 [a]	-2.2033 [b]
PIR	0.534 (0.251)	0.493 (0.344)	0.8087	-0.1098	-0.5336
Test PIR *vs* CIR	-1.0994	-2.4654 [b]			

[a] Significantly different between both populations at 1%.
[b] Significantly different between both populations at 5%.
[c] Significantly different between both indicators at 1%.
[d] Significantly different between both indicators at 5%.

Another way to study both indicators is to compare them. According to the previous experimental results in the literature (Lichtenstein and Slovic, 1971; Grether and Plott, 1979), the evaluation context stimulates the risk seeking of the subjects. Indeed, they focus on the higher outcome when they have to evaluate the price of the lottery: this is the compatibility effect (Lichtenstein and Slovic, 1971) between the question asked (a price) and the characteristics of the lottery. Thus it is interesting to compare CIR with PIR. We find a significant difference for NDA, but not for DA (although PIR is greater than CIR on average). Since PIR is greater than CIR, our results are consistent with the compatibility effect.

4.2. Common patterns

Some common patterns are observed, some are not. Question 1, with a majority of people choosing *S*, illustrates the certainty effect but this effect is not significant for the questions 6 and 10.

In the sense of EU, the questions 1 and 2 (from 6 to 10) are identical: the questions deduct themselves, one from another, by multiplying the probabilities by a common ratio, or by subtracting a common consequence from both lotteries. For example, to multiply the probabilities of gain of both lotteries from question 6 by 0.5, leads back to question 7; to multiply again the probabilities of gain by the same ratio leads back to question 8. By dividing the probabilities of gain by 4, the choice is reversed between the questions 6 and 8: this is one version of the Allais paradox, the common ratio effect. However, this effect is not observed over the questions 1 and 2. Observe too that to add 0.75 from the probability of obtaining F. 150 conducts from the question 8 to the question 10. We do not observe a common consequence effect: the second version of the Allais paradox is not significant.

The questions 8 and 11 put in evidence the isolation effect (Kahneman and Tversky, 1979). Both questions are statistically equivalent but the subjects consider question 11 as if they are already in the state of the world (probability 25) where their choice will have an impact on the final outcome. This isolation effect leads to a higher risk aversion in the question 11 (around 30 choosing *R*) than in the question 8 (around two times more choosing *R*).

According with EU and most of the non-EU (except CC theory), the preference between two risky options can be given under choice or under evaluation indifferently. Hence, when we rely choice questions with evaluation questions, four cases are possible, including two of them consistent with EU. Questions 3, 16 and 17 put in evidence the classical version of the preference reversal phenomenon (Lichtenstein and Slovic, 1971; Lindman, 1971; Grether and Plott, 1979) with one choice and *two* evaluations: the most usual answer is to choose *S* (question 3) and to evaluate *R* at a higher price than *S*. Three other pairs of questions (1-16, 4-18 and 6-19) put in evidence a stronger version of the preference reversal phenomenon with one choice and *one* evaluation (see Blondel and Lévy-Garboua, 1999). Table 7 indicates the profiles of decisions under choice and evaluation. Note that we don't observe a higher rate of preference reversal under the classical version (questions 3, 16 and 17) than under the "one evaluation" version (questions 1 and 16). This result confirms the generality of preference reversal between choice and evaluation procedures of revelation of preference. It also confirms the failure of the implicit assumption of invariance of the procedure of preference revelation (Lichtenstein and Slovic, 1971).

4.3. Risky decisions and expected utility

We first identify the profiles of decisions consistent with EU and test this theory (section 4.3.1). An example will illustrate the necessity for our method of test in section 5.1.

Table 7. Profiles of decisions and EU

Games	**Rate of consistent profiles**	**Observed**	
		DU	**NDU**
	Profiles under choices		
1-2	2 (50)	73.53 [a]	75 [a]
6-10	2 (6.25)	25.71 [a]	28.57 [a]
	Profiles under choice and pricing		
3, 16, 17	2 (50)	38.24	28.57
1, 16 [c]	2 (50)	43.65	25
4, 18	2 (50)	52.94	50
6, 19	2 (50)	48.53	57.14

[a] Superior to the rate of consistent profiles, significant at 1%. [b] Superior to the rate of consistent profiles, significant at 5%.

4.3.1. An example

Consider the pairs of decisions of all the subjects (DU and NDU) over question 1 and 2. Four cases, *SS*, *RR*, *SR* and *RS*, are possible. The percentage of observed decisions are 56.45 (*SS*), 17.74 (*RR*), 16.13 (*SR*) and 9.68 (*RS*). A statistical test validates EU since 74.19 is significantly greater than 50 (no theory: an equal repartition between the different cases).

4.3.2. Test of EU theory (questions 1-2, 6-10 and preference reversal)

Table 7 describes the specific profiles of decisions consistent with EU.

4.2.1. Choice questions (1-2 and 6-10)

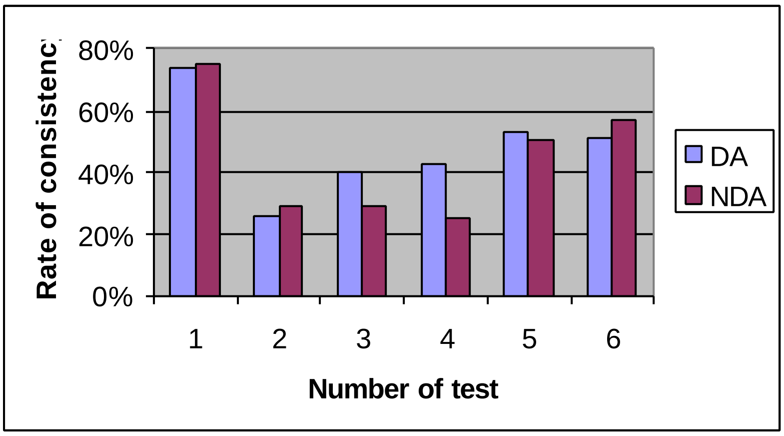
Four tests (two populations and two sets of questions) indicate that EU has a significant power of explanation. We don't observe any significant difference between DU and NDU.

4.2.2. Preference reversal questions

Eight tests (two populations and four sets of questions) indicate that EU has not a significant power of explanation when the context of decision is changed. None of these tests validate EU, whatever is the population and the set of question. We don't observe any significant difference between DU and NDU.

Figure 1 illustrates the similitude between the behavior of DU and NDU, whatever is the task of questions (tests 1 and 2 correspond to the choice questions and the following ones correspond to the preference reversal questions).

Figure 1. Rates of consistency with EU for DU and NDU populations



5. The results under time

The hypothesis of the equality of substitution rate distributions between the two samples (see table 5) is tested using a Mann-Whitney test on the ranks'sum for each evaluation question. This can not be rejected for any question. However, we may note that the difference is almost significant for the evaluation question of the equivalent in 8 weeks of 110 FF in 9 weeks, and the one of the equivalent today of 60 FF in 2 weeks, with respective observed significance levels of 16 and of 11.

The design of the evaluation and choice questions allows us to observe whether preference reversals (PR) occur. An individual is said to reverse his preference if he chooses the sum closest in time and evaluates the other sum higher.

Table 8. Percentage of individuals choosing the sum closest in time.

Percentage of individuals evaluating the sum closest in time higher than the other sum.

Percentage of Preference Reversal (PR).

$E^{t}_{(x,t_L)}$ denotes the equivalent at the date t of the sum latest in time: (x, t_L).

$E_{(x,t_L)}$ denotes the equivalent today of the sum latest in time: (x, t_L).

	DU	NDU
Sample size	34	28
100 □ (110, 1)		
100 ? $E_{(110,1)}$	65.5	78.5
PR: 100 □ (110, 1) and $E_{(110,1)}$? 100	41	39
	14.7	17.8
(100, 4) □ (110, 5)	48.5	64.5
100 ? $E^{4}_{(110,5)}$	47	42.8
PR: (100,4) □ (110, 5) and $E^{4}_{(110,5)}$? 100	6	3.5
(100, 8) □ (110, 9)	37	53.5
100 ? $E^{8}_{(110,9)}$	44	39.2
PR: (100, 8) □ (110, 9) and $E^{8}_{(110,9)}$? 100	6	3.5
50 □ (60, 2)	63	75
50 ? $E_{(60,2)}$	32	28.5
PR: 50 □ (60, 2) and $E_{(60,2)}$? 50	20	17.8
(50, 6) □ (60, 8)	57	53.5
50 ? $E^{6}_{(60,8)}$	41	28.5
PR: (50, 6) □ (60, 8) and $E^{6}_{(60,8)}$? 50	5.7	7
60 □ (75, 4)		
60 ? $E_{(75,4)}$	54,5	68
PR: 60 □ (75, 4) and $E_{(75,4)}$? 60	41	39.2
	20	17.8
(60, 4) □ (75, 8)	48,5	57
60 ? $E^{4}_{(75,8)}$	41	42.8
PR: (60, 4) □ (75, 8) and $E^{4}_{(75,8)}$? 60	14.7	14.2

The drug-addict sample does not exhibit any greater tendency for choice-reversal than the control sample:

The equality hypothesis of proportions of subjects reversing their choices between the both populations has been tested with the help of a homogeneity ?^{2} test for each choice question. None of these differences are significant.

Table 9. Percentages of subjects with constant choices and of subjects reversing their choices just once and in the sense more immediate small gain to more distant larger gain (with hyperbolic discount function).

		DU	NDU
Sample size		35	28
Choice questions between 100 F and 110 F	Percentage of individuals with stable choices on three choices	51,5	71,5
	Percentage of individuals reversing their choices just once on three choices	31,5	25
Choice questions between 50 F and 60 F	Percentage of individuals with stable choices on two choices	83	78,5
	Percentage of individuals reversing their choices on two choices	11,5	21,5
Choice questions between 60 F and 75 F	Percentage of individuals with stable choices on two choices	71,5	75
	Percentage of individuals reversing their choices on two choices	17	18

The rest of the individuals reverse their choices in the sense far large gain to near small gain or reverse several times when the choice is repeated more than twice.

None of the hypotheses tested are validated by the data collected at the time of our experiments. We can suggest several reasons for this.

Our sample of addict users is perhaps not representative of the active drug-addict population. Because this sample is particular, insofar as individuals visit a methadone center[5], then it consists of individuals having taken the decision to give up their addiction.

[5] The methadone is a substitution product of the opiates (opium, morphine, heroin). It must help the opiate addicts to stand a sevrance by sparing them the torments of the physical withdrawal.

The observed discount rates similarity between the two samples can then be explained in two ways.

First, if there exists a high discount rate variability among the drug addict populations in general, it may possibly be that the individuals deciding to attempt to stop their consumption are those with the smallest discount rates, which would be in accordance with Becker & Murphy's theory. Thus there is a selection bias. A recent and similar study by Bretteville-Jensen (1999), conducted on three distinct populations (control, former drug addicts, and active drug addicts), obtains very similar discount rates for the control sample and the former drug addicts sample. On the other hand, the discount rates of the active DU sample are much larger.

Moreover, if we relax the hypothesis of discount rate stability over time, we can imagine, following the example of Masson (1995), that the time preference of addicted respondents has undergone a discontinuous variation during the period preceding the withdrawal decision. An important modification of the discount rate could then explain both the users'quitting decision and the similarity of the observed discount rates of addict users and of non-users. Nevertheless, the hypothesis of a variable discount rate over time does not change the conclusion regarding the determining role of the time preference in the formation of an addiction.

The proportion of choice reversals and of stable choices are very similar for both samples, this can be explained using the same arguments as used to explain the similarity of observed discount rates.

First, if there is significant variability in the discount functions'shapes in the drug addict population, the individuals who decide to quit are possibly those whose discount functions are the least concave, i.e. the least myopic individuals. The closeness of observed choices would then again result from selection bias.

On the other hand, addicted respondents have maybe succeeded in making their discount function less concave (more exponential), hence as they are less myopic, they take the decision to give up consuming. This modification of the discount function from hyperbolic to exponential does not question the possible influence of myopia on drug consumption decisions.

Our control sample presents a rate of time preference just as large as that of the addict users because:

These subjects in social difficulty are maybe more liquidity constrained.

Moreover, the greater uncertainty regarding the payments in the future for this sample involves perhaps a bias toward the present which is not imputable to the pure time preference of the subjects. In addition, these subjects are maybe addicted to a licit or illicit drug.

Last, explaining time preference according to Masson (1995), we note that both samples are in somewhat the same situation with respect to the future. They are both in the process of being helped by outside agencies in term of the management of their day-to-day life It may therefore be difficult for both of them to imagine future projects in an autonomous way.

6. Discussion

If we assume that the subjects are expected utility maximizers, DU are not less rational than others; however, they are more risk seeking. The same conclusion remains true if we assume that the subjects are non-EU maximizers (Blondel and Lohéac, 2000; see Hey and Orme, 1994, for these non-EU theories). Concerning time preference, There is also not a significant difference between DU and NDU. Moreover, the hypothesis that DU have higher discount rates (Becker and Murphy, 1988) is not validated.

The main conclusion – DU are not less rational than others – can be related to the previous studies. Fehr and Zych (1998) induced experimentally addictive preferences and they concluded that addicts consume systematically too much compared to the optimal consumption. However, their study was not focused on DU. Moreover, there were already some empirical foundations for a rational approach of the drug consumption: for example, Grossmann and Chaloupka (1998) have found a negative effect of the price of cocaine, in a paper that applies the rational addiction theory. Our study complements the preceding ones because we study the rationality of DU in a different way.

Our study is limited to an experimental framework but this is a first step in the comparison between the behavior of DU and others. Which policy is appropriated if we want to reduce the drug consumption? In the present debate, this paper is a supplementary argument in favor of a rational approach of the drug consumption. DU have chosen their way of life and they are not more “irrational” than others are. But is a NDU conscious about the risk of addiction before consuming drugs? If DU seems to be rational, he constructs this rationality with his experiment of drugs and life. NDU has not an experiment of addiction and can't know that it is bad, then the most important thing is the information of NDU on risk of addiction.

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