

Prospect-Theory's Diminishing Sensitivity versus Economic's Intrinsic Utility of Money: How the Introduction of the Euro Can Be Used to Disentangle the Two Empirically

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ABSTRACT. The introduction of the Euro gave a unique opportunity to empirically disentangle two components in the utility of money. The first is intrinsic value, a normative component that is central in economics. The second is numerical sensitivity, a descriptive component that is central in prospect theory and that underlies the money illusion. We measured relative risk aversion in Belgium before and after the introduction of the Euro, and could consider effects of changes in intrinsic value while keeping numbers constant, and effects of changes in numbers while keeping intrinsic value constant. Increasing intrinsic value led to a significant increase of relative risk aversion, but changes in numbers did not have significant effects.(JEL D81, E40)

KEYWORDS: utility, currency change, prospect theory, psychology of money, money illusion, relative risk aversion

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I. Introduction

The classical economic assumption of diminishing marginal utility is based on a natural intuition: the first dollar is spent on the most useful thing, the second on the second-most useful thing; etc. Each new dollar brings less extra utility than the one before. Under expected utility, risk aversion results.

Prospect theory (Kahneman & Tversky 1979) makes different assumptions, based on the psychological principle of diminishing sensitivity. People are more sensitive to changes near their status quo than to changes remote from the status quo. For gains, this principle leads to the same implication as the classical economic assumption, with concave utility and a change from \$10 into \$20 having more impact than a change from \$110 into \$120. For losses, however, the principle implies a pattern opposite to the classical economic assumption, with convex utility and a change from $-\$10$ into $-\$20$ having more, and not less, impact than a change from $-\$110$ to $-\$120$. If diminishing sensitivity were the only principle guiding the perception of money, utility for losses would exactly mirror utility for gains. More generally, decisions for losses would mirror decisions for gains, and, for instance, an equivalence between a sure gain $\$X$ and a lottery L over gains would lead to the mirrored equivalence between the sure loss $-\$X$ and the lottery $-L$ over losses. This assumption, the reflection effect, was indeed put forward in original prospect theory.

How can the classical economic predictions and those of prospect theory be so diametrically opposed to each other for losses? The explanation is that they concern different components. The economic prediction concerns the intrinsic goodness of money, and ways in which money improves the purchasing power and well-being of a consumer. Prospect theory concerns the general perception of quantity, as observed in many domains in psychology. The former concept depends on final wealth, the latter on changes with respect to a perceived reference point. Kahneman's (2003a,b) discussion of the value function of money in prospect theory, indeed, concerned general psychological perceptions, and not the intrinsic value that is typical of money and that distinguishes money from other quantities. Thaler (1985) also explained prospect theory's value function through psychological perception: "... captures the basic psychophysics of quantity. The difference between \$10 and \$20 seems greater than the difference between \$110 and \$120, irrespective of the signs of the amounts in question" (p. 201).

The perception of the utility of money that we observe empirically will depend both on general numerical perception and on intrinsic value (Fennema & van Assen 1999; Myagkov & Plott 1997; Shafir, Diamond, & Tversky 1997). The numerical component depends on the nominal value of money, irrespective of what the actual value of money is, and for the intrinsic-value component it is the other way around. For gains, both components enhance concavity, making concavity too pronounced from a normative perspective (Rabin 2000). For losses the two components have opposite effects, leading to utility close to linear.² For outcomes near ruin the intrinsic value of money becomes so salient that it will dominate psychological perception, yielding concave utility again (Kahneman 2003, p. 705). Intrinsic value can also become more salient in market situations and after learning (Myagkov & Plott 1997, Result 4 and Conjectures 2 and 3).

The separation of the two components is important because intrinsic value is normatively relevant, but numerical perception and, in general, reference-dependence, do not seem to be. When prescribing decisions or making policy recommendations we would like to filter out numerical perception (Bleichrodt, Doctor, & Stolk 2003; Fennema & van Assen 1999; Myagkov & Plott 1997). When analyzing observations and communicating risks we should obviously reckon with numerical perception.

Numerical perception has been studied in psychology (Galanter & Pliner 1974; Atkinson 1988, Part I of Vol. I) and in medicine (Zorzi, Priftis, & Umiltà 2002). It played a role in many economic studies, concerning payments in artificial currencies instead of money (Barron & Erev 2003; Forsythe, Palfrey, & Plott 1982; Harris 1991; Harrison 1994; Jonas et al. 2002; Plott & Sunder 1982), payments in probabilities instead of money (Allen 1987; Anscombe & Aumann 1963; Davis & Holt 1993; Loomes 1998; Roth & Malouf 1979; Selten, Sadrieh, & Abbink 1999), the money

² More concave utility for gains than convex utility for losses was found by Abdellaoui (2000, p. 1506), Abdellaoui, Vossman, & Weber (2003), Currim & Sarin (1989, p. 30), Davies & Satchell (2003), Fennema & van Assen (1999), Galanter & Pliner (1974, Power 0.45 for gains, 0.39 for losses), Laury & Holt (2000), and Loehman (1998). In line with this, there was more pronounced risk aversion for gains than risk seeking for losses in Battalio, Kagel, & Jiranyakul (1990, p. 32), Battalio, Kagel, & MacDonald (1985), Budescu & Weiss (1987, p. 193), Camerer (1989, Table 5), González-Vallejo, Reid, & Schiltz (2003, Table 2), Harless & Camerer (1994 p. 1281), Hershey & Schoemaker (1980, Table 3 and p. 409), Kühberger, Schulte-Mecklenbeck, & Perner (1999, pp. 216-217), Lopes & Oden (1999), Schneider & Lopes (1986), Smith et al. (2002, Figure 2), Wakker, Timmermans, & Machielse (2003), Weber & Bottom (1989, Exhibit 8). Unclear or balanced findings were obtained by Hogarth & Einhorn (1990, Tables 2 and 4), Kahneman & Tversky (1979), and Tversky & Kahneman (1992). An opposite finding, of more convex utility for losses than for gains, was obtained by Fishburn &

illusion (Fehr & Tyran 2001; Shafir, Diamond & Tversky 1997), and other topics (Huber, Ariely, & Fischer 2001).

An empirical separation of numerical perception and intrinsic value is usually hard to obtain, because both factors covary with money. Some insights can be obtained if we compare different countries with different currencies. Such comparisons are, however, distorted by cultural and economic differences. Comparisons across time, with the value of money changed by inflation, can also give insights, but are distorted by other changes over time. Payments expressed in different artificial units can also be used but are not natural, and will encourage subjects to make mental conversions to their natural currency. Changes of currency in a country provide a good, but rare, opportunity to empirically separate the two factors while avoiding the distortions just mentioned. Such an opportunity arose in Europe in 2002 through the introduction of the Euro. We used this opportunity for an experimental study carried out in Belgium.

We chose Belgium from the 11 European countries that introduced the Euro in 2002 for the following reasons. First, Belgium's conversion rate, BF40 for €1, is round, so that round numbers before the conversion can correspond to round numbers after. Sonnemans (2003) found that differences in rounding affected investment behavior in the Netherlands. We wanted to avoid such distorting effects on behavior. Second and most important, the conversion rate in Belgium is considerable, contrary to the reasonably round conversion rate of 1.96 in Germany for instance, so that there is room for considerable numerical effects (Marques 1999). Third, the other European countries with round and considerable conversion rates, Portugal and Italy, are farther remote from our own location than Belgium.

By relating amounts BF x to amounts € x , for various x , we could observe the effects of intrinsic value while keeping numerical perception constant. Similarly, by relating amounts BF x to amounts € $x/40$, we could observe the effects of numerical perception while keeping intrinsic value constant. Further details of the plan of our study are discussed in Section 4.

The introduction of the euro spurred many studies into the psychology of money and of currency changes. Currency changes generate linguistic changes and,

Kochenberger (1979, p. 511). Cohen, Jaffray, & Said (1987, Table 3) and Levin, Irwin & Hart (2003) found more risk seeking for losses than risk aversion for gains.

obviously, changes of coins and notes. Numerical perception seems to be affected neither by the former (Brysbaert, Fias, & Noël 1998) nor by the latter (Foltz, Poltrock, & Potts 1984; Noël & Serron 1997). Other psychological effects may be generated by positive or negative attitudes towards loss of the national identity, a currency change and the corresponding arithmetic requirements, a domestic versus a joint currency, fear for nickle in the 1- and 2-Euro coins, etc.³ Phenomena of these kinds clearly affect absolute levels of perceived utility, but have no clear effect on the curvature of utility as relevant to relative risk aversion (RRA). We, therefore, took RRA as the dependent variable in our experiment, and nominal value and intrinsic value as independent variables. The classical economic assumption is that RRA is increasing (Arrow 1971 p. 97; Jevons 1889, pp. 172-173), and many empirical studies have confirmed this.⁴ In particular, Holt & Laury (2002) confirmed the assumption for high real incentives. It seems plausible that these increases are not only due to increased intrinsic values, but also due to a perception of increased numbers. Fetherstonhaugh et al. (1997) and Quattrone & Tversky (1988, p. 727, the "ratio-difference principle") suggested such an effect of numerical perception.

We measured the RRA of 88 subjects in December 2001, shortly before the introduction of the Euro, and did the same for 93 subjects in May 2002, when people had started getting accustomed to the Euro. In this manner, we could distinguish between changes in risk attitude and concave utility that were generated by intrinsic value and changes generated by numerical perception. Our hypothesis is that increases in numerical perception and in intrinsic value both enhance RRA. We investigated which of these effects was larger.

II. The Experiment

Procedure. The treatments with BF payments were carried out on two different days in December 2001, just before the introduction of the Euro. The treatments with

³ Bornemann (1976), Bruner & Goodman 1947, Furnham & Argyle (1998), Gamble et al. (2002), Jonas, Greitemeyer, Frey, & Schulz-Hardt (2002), Marques (1999), Meier-Pesti & Kirchler (2003), Müller-Peters 1998, Mussweiler & Englich (2003), Nestle, Speidel, & Speidel 2002, Pepermans, Burgoyne, & Müller-Peters (1998).

⁴ Baron (1997), Binswanger (1981), Guiso & Paiella (2000), Harrison et al. (2003), Kachelmeier & Shehata (1992), Rapoport, Anatol (1984). The opposite, decreasing RRA, has also been found, especially near ruin, by Cohn et al. (1975), Friend & Blume (1975), and Ogaki & Zhang (2001).

€payments were carried out on two different days in May 2002, four months after the introduction of the Euro. The design was between-subjects.

Two experimenters asked students in the meeting area of the University of Diepenbeek whether they were willing to participate in a 10 minutes experiment. If students agreed to participate, they received a booklet with one page of instructions, seven pages with one choice task on each page, and a final page asking for demographics and giving information on how to contact us. Participants were asked to work quietly and individually. The stimuli and the procedure were tested in a pilot study of $n=45$ subjects.

Stimuli. Each subject made seven choices between a lottery and a sure amount of money, such as between

- a lottery yielding BF 600 with probability $15/20$ and nothing otherwise,
- or
- a sure amount of BF 400.

Figure 1 depicts, in reduced form, examples of the choice tasks presented to the participants for each of the four treatments. The basic treatment was with low amounts of Belgium francs (*LBF*), as in Fig. 1a. The second treatment, in Fig. 1b, is discussed later. Fig. 1c depicts the third treatment (*L€*), with all amounts of Belgium francs in Fig. 1a replaced by Euro-amounts of equal intrinsic value. It means that all numbers of Fig. 1a were divided by 40. Fig. 1d depicts the fourth treatment (*H€*), with all amounts of Belgium francs in Fig. 1a replaced by the same numbers of Euros, yielding 40 times higher intrinsic values. The second treatment (*HBF*), in Fig. 1b, replaced all €amounts of the fourth treatment by BF-amounts of the same value, resulting in quantities of Belgium francs 40 times bigger than in the basic *LBF* treatment.

Figure 1a. Low BF treatment.

 Lottery:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Prob- ability	$\frac{15}{20}$	$\frac{5}{20}$
Gain	BF600	0

 Sure Amount : BF400

Figure 1b. High BF treatment.

 Lottery:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Prob- ability	$\frac{15}{20}$	$\frac{5}{20}$
Gain	BF24000	0

 Sure Amount : BF16000

Figure 1c. Low €treatment.

 Lottery:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Prob- ability	$\frac{15}{20}$	$\frac{5}{20}$
Gain	€15	0

 Sure Amount : €10

Figure 1d. High €treatment.

 Lottery:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Prob- ability	$\frac{15}{20}$	$\frac{5}{20}$
Gain	€600	0

 Sure Amount : €400

Figure 1. Examples of our stimuli.

Table 1 in the results section gives a complete description of the probabilities and outcomes in the seven choice questions. The first two tasks served as learning exercises, to test for extreme risk attitudes and to discourage choices for certainty or for risk without inspecting the probabilities and outcomes. The order of the five experimental tasks was counterbalanced. The questionnaire was in Flamish.⁵ An English translation is available in the Appendix.

Implementation of real incentives. Paying each participant according to one or more of their choices would have been too expensive, given the high stakes that could not be avoided in the high-payment treatment. We, therefore, developed a random incentive system in the following manner.

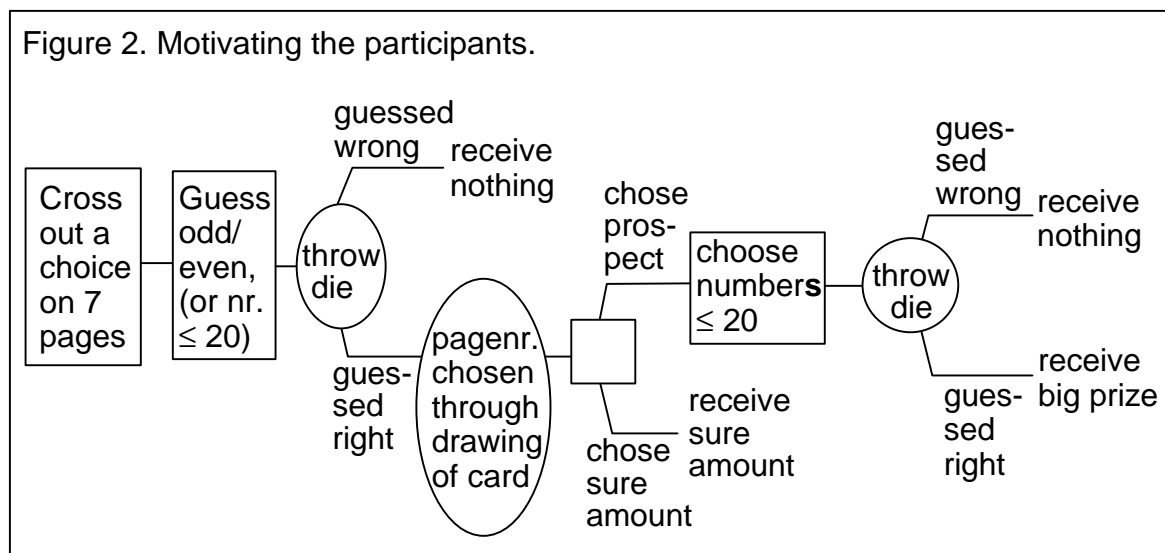


Figure 2 depicts our system for implementing real incentives. The low-treatment subjects had a $\frac{1}{2}$ chance, and the high-treatment subjects a $\frac{1}{20}$ chance, to play one of their choices for real.

After the subjects had filled out the seven pages with choices, the LBF and L€ groups guessed odd or even, and the HBF and H€ groups guessed one number between 1 and 20. They next threw a 20-sided die. If the resulting number did not agree with the prediction, the game was over and no money was paid. In the other case, the subjects drew one card at random from seven numbered card. This number

⁵ Thanks to Myriam Welkenhuysen for correcting the Flamish language.

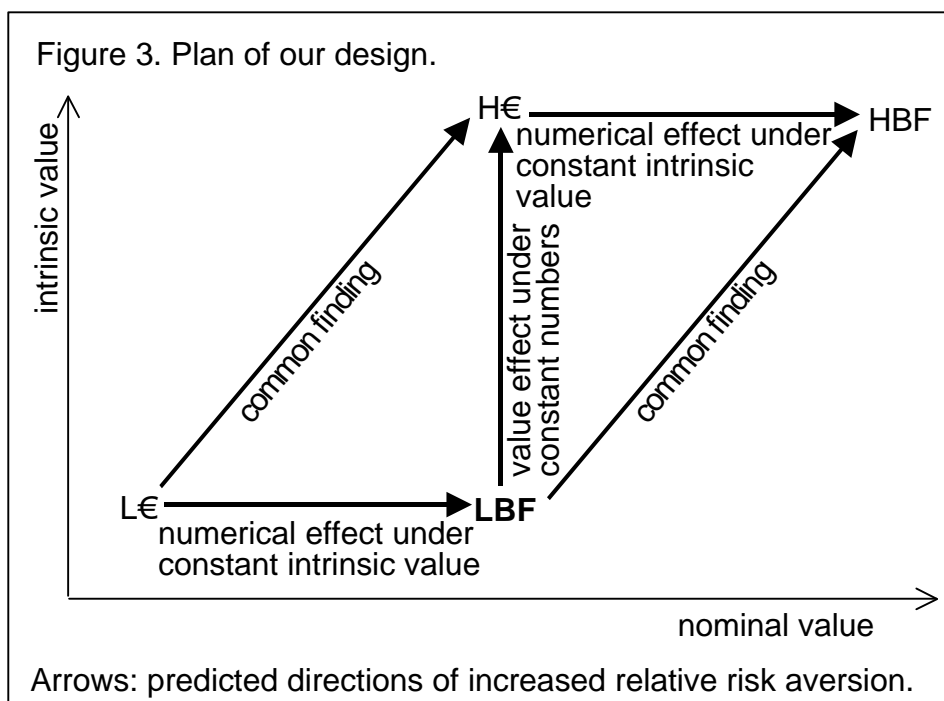
determined which of their seven choices made during the experiment was played out for real. If they had chosen the risky option in the choice selected, the probabilities were again generated by the subjects throwing a 20-sided die, where the numbers yielding the prize also had been chosen by the subjects before throwing the die.

Subjects. N = 181 subjects participated in the four treatments, n = 43 in LBF, n = 45 in HBF, n = 48 in L€ and n = 45 in H€. All participants were students from various departments of the University of Diepenbeek. As many were male as female, and they were of age between 17 and 24. Except 3, all were Flamish. Subjects were not permitted to participate more than once.

Analysis. As degree of RRA of each subject we took the number of safe choices excluding the two learning tasks. The four different treatments were compared through independent-samples *t*-tests and through 2 by 2 analysis of variance with number of safe choices as dependent variable and intrinsic value (high-low payment) and nominal value (Euro-BF) as independent factors.

III. Discussion of the Plan of Our Design

Figure 3 illustrates our design.



We compared the RRA in the four treatments. Diagonal comparisons constitute direct tests of RRA, and have been frequently conducted in the literature. *Constant RRA* means that risk attitude remains the same if all outcomes are multiplied by a common positive factor. It implies no changes along the diagonals in Figure 3. The common finding is increasing RRA, with more safe choices at the top of the diagonal arrows than at their bottom. Our hypothesis is that both horizontal and vertical moves in the direction of the arrows generate increases in RRA. In classical economic texts, where horizontal moves were considered irrelevant, it was common to explain the observed increases in RRA through vertical moves. Horizontal increases of RRA were suggested by Baron (1997), Quattrone & Tversky (1988, p. 727, the "ratio-difference principle"), and Fetherstonhaugh et al. (1997).

Horizontal comparisons between different intrinsic values while keeping the numbers constant, and vertical comparisons between different nominal values while keeping the intrinsic values constant, usually cannot be observed. We could make such observations, which is the new contribution of this paper.

IV. Results

Table 1 gives descriptive statistics. Questions 4 and 5 compare a lottery with its expected value and, hence, provide direct tests of risk aversion. Question 4 reveals significant risk aversion ($t_{180} = -9.02$, $p < 0.001$; also $p < 0.01$ for each of the four treatments). Question 5 does not yield significant deviation from risk neutrality (only for the HBF treatment there is significant risk aversion, $t_{43} = 4.98$, $p < 0.001$). We did not find gender effects in risk aversion ($t_{177} = 0.162$, $p = 0.872$).

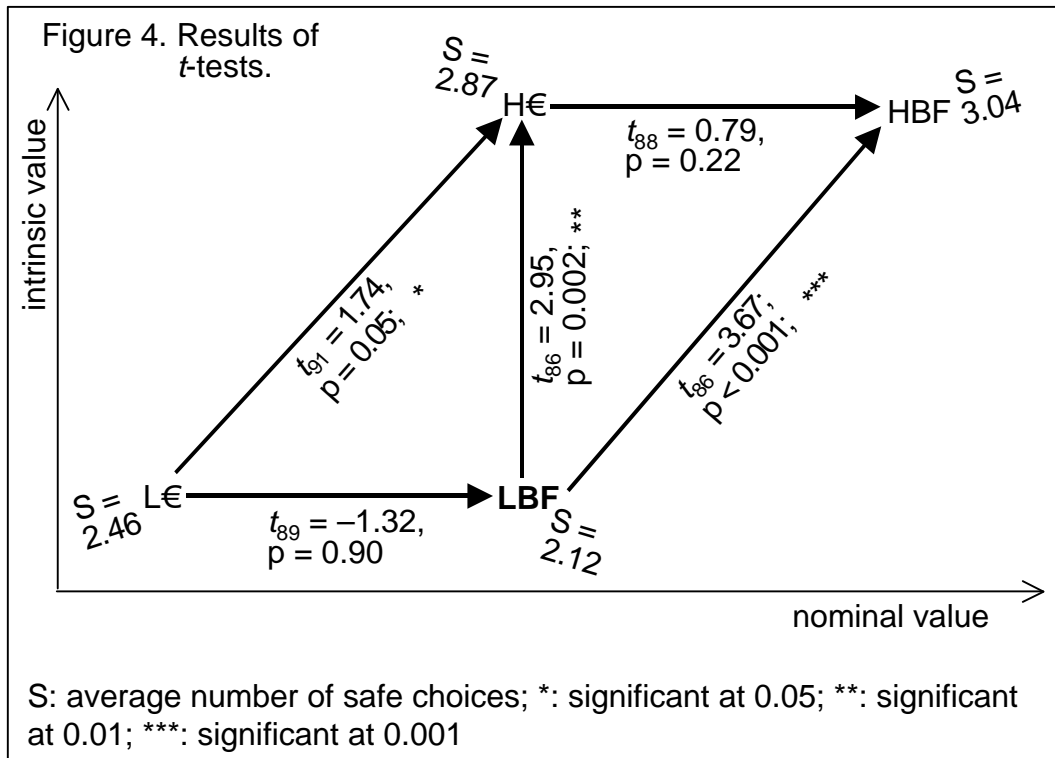
TABLE 1. PERCENTAGES OF SAFE CHOICES

#	LBF			HBF			L€			H€		
	risky BF	safe BF	% safe	risky BF	safe BF	%S	risky €	safe €	%S	risky €	safe €	%S
1	.50:300	20	14%	.50:12000	800	09%	.50:7.5	0.5	13%	.50:300	20	16%
2	.05:220	200	100%	.05:8800	8000	100%	.05:5.5	5	100%	.05:220	200	98%
3	.05:2000	120	60%	.05:80000	4800	69%	.05:50	3	65%	.05:2000	120	62%
4	.25:800	200	70%	.25:32000	8000	82%	.25:20	5	73%	.25:800	200	87%
5	.50:200	100	42%	.50:8000	4000	80%	.50:05	2.5	46%	.50:200	100	58%
6	.75:600	400	30%	.75:24000	16000	51%	.75:15	10	40%	.75:600	400	53%
7	.95:200	160	09%	.95:8000	6400	20%	.95:05	4	23%	.95:200	160	27%
Total			46%			59%			51%			57%

In the LBF treatment, the first choice was between BF 20 for sure (safe BF) and the lottery yielding BF 300 with probability 0.50 and nothing otherwise (risky BF). 14% chose the safe option (% safe); etc.

Figure 4 depicts the results of *t*-tests, with the learning questions (choice # 1 and 2 in Table 1) excluded. Including them would not change any of the conclusions. All reported significance probabilities are one-tailed. The value-effects are in the predicted direction and are significant one-tailed. The numerical effects are not significant.

Analysis of variance gave the same conclusions, with a highly significant effect of intrinsic value ($F(1,180) = 15.04, p < .001$), a nonsignificant effect of nominal value ($F(1,180) = .23, p = .63$), and a nonsignificant interaction ($F(1,180) = 2.28, p = .13$). The absence of numerical effects suggests that there was no difference in RRA between BF outcomes and €outcomes.



V. Discussion

We discuss a number of limitations to our study. First, we would have preferred a within-subjects design, but this was not possible due to practical limitations.

Second, the procedure for implementing real incentives could not be entirely identical for the two treatments. The average gain over the seven choice tasks was about €5 (BF200) for the low-stimuli treatments and €200 Euro (BF8000) for the high-stimuli treatments. Such large differences in payment between treatments could, obviously, not be avoided in view of the conversion factor of 40. Because of budgetary considerations, we could not pay all amounts for real in the high-payment treatments. We, therefore, introduced the 1/20 chance of playing one choice for real in the high-payment treatments. The resulting expected gain of €10 per participant for 10 minutes time is still favorable. In order to have the procedures for the low- and high-payment treatments as similar as possible, we introduced a 1/2 chance to play one choice for real in the low-payment treatments. It could not be 1/20 because then the payments would be too low and subjects would not be sufficiently motivated (Smith 1982). For the low-payment treatment, the expected gain was €2.5

A third problem concerns the timing of the experiment. It is, in general, desirable to observe different treatments as much as possible in similar situations. No significant historical changes should take place between the measurements, inflation should be as small as possible, etc. For these reasons it was desirable to have our measurements before and after the introduction of the Euro as close to each other as possible. It was also desirable, however, that subjects were maximally familiar with the unit of payment used, and considered it as “their” currency. We wanted to minimize subjects converting Euros into francs (or vice versa) during the experiment. For this reason, it was desirable to perform our measurement of the Euro treatments long after the introduction in January 2001. The actual timing of our experiment was a compromise between the two, conflicting, desiderata.

Fortunately for our experiment, no major historical changes took place between December 2001 and May 2002. Only usual random factors due to differences such as winter versus spring, middle of the academic year versus end thereof, and a five-months increase in age, remained. Four months is obviously not enough to get completely used to a new currency and to forget about the old one. Our population, young academic adults, can be expected to be among the fastest to get adapted though. Indeed, the percentage of support for the Euro was higher among students (78% while grouped with self-employed people) than among other groups (European Commission 2002, p. 76; Mussweiler & Englich 2003). In April 2002, 80% of the Belgians indicated that they felt comfortable using the Euro (European Commission 2002, p. 79). In this, and several other respects, Belgium was among the most supportive countries for the Euro. This was confirmed in EOS Gallup Europe (2002). To the extent that subjects converted Euros back into francs before deciding, our study loses statistical power but not validity.

VI. Conclusion

The observed utility functions for money consist of a normatively relevant component based on intrinsic value, and a normatively irrelevant component reflecting the general perception of numbers. In general, measurements of utility cannot separate these two components. A change of currency in a country gives an opportunity to separate the two components after all, while avoiding a number of biases.

We carried out an empirical study in Belgium at the introduction of the Euro in 2001, measuring the relative risk aversion of subjects. Changes of nominal value did not have significant effects, but changes of intrinsic value did. This finding is positive for the economic, normatively oriented view on utility. We hope that future conversions of currencies, such as in future extensions of the European union, will be used to further investigate the questions addressed in this paper.

Appendix. The Instructions, Translated into English

For each of the four treatments, the instruction were more or less the same, and only one sentence differed between the low- and the high-stimuli treatments. The instructions for the low-stimuli treatments are given hereafter, with the deviating sentence for the high-stimuli treatments given in square brackets.

Investigation of Opinions about Uncertain Payments

In this investigation, we are interested in opinions of people about uncertain payments. We will present seven choice situations to you. In each you can choose between the certain receipt of an amount of money or the playing of a lottery. When playing the lottery you may win, with a certain probability, an amount of money, and you gain nothing otherwise. You can only gain money, and you will never lose money. There are no right or wrong answers for these questions, and they only concern your own preferences. Your preferences are what we are interested in!

- On each of the following seven pages there is an amount of money that you can gain with certainty and a lottery for money. You are asked each time what you would prefer most: receiving the sure amount of money or playing the lottery. Cross out your preference each time.

It is next determined whether one of your choices will be played for real. For this purpose, you will be asked to guess whether an odd or even number shows up when you throw a 20-sided die. [For this purpose, you will be asked to guess which number will come up when you throw a 20-sided die.]

- If you guessed wrong, the experiment is over and you, unfortunately, did not gain anything. If you guessed right, then one of the choices that you crossed out will be played for real.
- You then draw one of seven numbered cards to determine from which page the choice you made will be played out for real.
- From the selected page you receive the sure amount of money if that is what you crossed out, and we play the lottery if that is what you crossed out.

As said before, there are no right or wrong answers, and we are interested in your own preferences. It is also favorable for yourself to cross out your preferred option at each page. After all, if that page is selected, then we really carry out what you crossed out there.

References

- Abdellaoui, Mohammed (2000), "Parameter-Free Elicitation of Utilities and Probability Weighting Functions," *Management Science* 46, 1497–1512.
- Abdellaoui, Mohammed, Frank Vossman, & Martin Weber (2003), "Choice-Based Elicitation and Decomposition of Decision Weights for Gains and Losses under Uncertainty," GRID, Cachan, France.
- Allen, Franklin (1987), "Discovering Personal Probabilities when Utility Functions are Unknown," *Management Science* 33, 542–544.
- Anscombe, F.J. & Robert J. Aumann (1963), "A Definition of Subjective Probability," *Annals of Mathematical Statistics* 34, 199–205.
- Arrow, Kenneth J. (1971), "*Essays in the Theory of Risk Bearing*." North-Holland, Amsterdam.
- Atkinson, Richard C., Richard J. Herrnstein, Gardner E. Lindzey, & R. Duncan Luce (1988, Eds.), "*Stevens Handbook of Experimental Psychology*." Wiley, New York; 2nd. Ed.
- Baron, Jonathan (1997), "Confusion of Relative and Absolute Risk in Valuation," *Journal of Risk and Uncertainty* 14, 301–309.
- Barron, Greg & Ido Erev (2003), "Small Feedback-Based Decisions and Their Limited Correspondence to Description-Based Decisions," *Journal of Behavioral Decision Making* 16, 215–233.

- Battalio, Raymond C., John H. Kagel, & Komain Jiranyakul (1990), "Testing between Alternative Models of Choice under Uncertainty: Some Initial Results," *Journal of Risk and Uncertainty* 3, 25–50.
- Battalio, Raymond C., John H. Kagel, & Don N. MacDonald (1985), "Animal's Choices over Uncertain Outcomes: Some Initial Experimental Evidence," *American Economic Review* 75, 597–613.
- Binswanger, Hans P. (1981), "Attitudes towards Risk: Theoretical Implications of an Experiment in Rural India," *Economic Journal* 91, 867–890.
- Bleichrodt, Han, Jasan Doctor, & Elly Stolk (2003), "A Nonparametric Elicitation of the Equity-Efficiency Tradeoff in Cost-Utility," iMTA, Erasmus University, Rotterdam, The Netherlands.
- Bornemann, Ernest (1976), *The Psychoanalysis of Money*. Urizen Books, New York.
- Bruner, Jerome S. & Cecile C. Goodman (1947), "Value and Need as Organizing Factors in Perception," *Journal of Abnormal and Social Psychology* 42, 33–44.
- Brybaert, Marc, Wim Fias, & Marie-Pascale Noël (1998), "The Whorfian Hypothesis and Numerical Cognition: Is "Twenty-Four" Processed in the Same Way as "Four-and-Twenty"?", *Cognition* 66, 51–77.
- Budescu, David V. & W. Weiss (1987), "Reflection of Transitive and Intransitive Preferences: A Test of Prospect Theory," *Organizational Behavior and Human Decision Processes* 39, 184–202.
- Camerer, Colin F. (1989), "An Experimental Test of Several Generalized Utility Theories," *Journal of Risk and Uncertainty* 2, 61–104.
- Cohen, Michèle, Jean-Yves Jaffray, & Tanius Said (1987), "Experimental Comparisons of Individual Behavior under Risk and under Uncertainty for Gains and for Losses," *Organizational Behavior and Human Decision Processes* 39, 1–22.
- Cohn, Richard A., Wilbur G. Lewellen, Ronald C. Lease, & Gary G. Schlarbaum (1975), "Individual Investor Risk Aversion and Investment Portfolio Composition," *Journal of Finance* 30, 605–620.
- Currim, Imran S. & Rakesh K. Sarin (1989), "Prospect versus Utility," *Management Science* 35, 22–41.

- Davies, Greg B. & Stephen E. Satchell (2003), "Continuous Cumulative Prospect Theory and Individual Asset Allocation," University of Cambridge, UK.
- Davis, Douglas D. & Charles A. Holt (1993), "*Experimental Economics*." Princeton University Press, Princeton.
- EOS Gallup Europe (2002), "Euro Attitudes—Euro Zone," Flash Eurobarometer N° 121/3, June 2002. URL:
http://europa.eu.int/comm/public_opinion/archives/flash_arch.htm
- European Commission (2002), "Eurobarometer—Public Opinion in the European Union." Report no. 57, Spring 2002. URL:
[\[http://europa.eu.int/comm/dg10/epo/eb.html\]](http://europa.eu.int/comm/dg10/epo/eb.html).
- Fennema, Hein & Marcel A.L.M. van Assen (1998), "Measuring the Utility of Losses by Means of the Tradeoff Method," *Journal of Risk and Uncertainty* 17, 277–295.
- Fehr, Ernst & Jean-Robert Tyran (2001), "Does Money Illusion Matter?," *American Economic Review* 91, 1239–1262.
- Fetherstonhaugh, David, Paul Slovic, Stephen M. Johnson, & James Friedrich (1997), "Insensitivity to the Value of Human Life: A Study of Psychophysical Numbing," *Journal of Risk and Uncertainty* 14, 283–300.
- Fishburn, Peter C. & Gary A. Kochenberger (1979), "Two-Piece von Neumann-Morgenstern Utility Functions," *Decision Sciences* 10, 503–518.
- Foltz, Gregory S., Steven E. Poltrock, & George R. Potts (1984), "Mental Comparisons of Size and Magnitude: Size Congruity Effects," *Journal of Experimental Psychology: Learning, Memory and Cognition* 10, 442–453.
- Forsythe, Robert, Thomas R. Palfrey and Charles R. Plott (1982), "Asset Valuation in an Experimental Market," *Econometrica* 50, 537–568.
- Friend, Irwin & Marshall E. Blume (1975), "The Demand for Risky Assets," *American Economic Review* 65, 900–922.
- Furnham, Adrian & Michael Argyle (1998), "*The Psychology of Money*." Routledge, London.
- Galanter, Eugene & Patricia Pliner (1974), "Cross-Modality Matching of Money against Other Continua." In Herbert Moskowitz, Bertram Sharf, & Joseph C. Stevens (Eds.), *Sensation and Measurement: Papers in Honor of S.S. Stevens*, 65–76, Reidel, Dordrecht, The Netherlands.

- Gamble, Amelie, Tommy Gärling, John P. Charlton, & Rob Ranyard (2002), "Euro Illusion: Psychological insights into Price Evaluations with a Unitary Currency," *European Psychologist* 7, 302–311.
- González-Vallejo, Claudia C., Aaron A. Reid, & Joel Schiltz (2003), "Context Effects: The proportional Difference Model and the Reflection of Preference," *Journal of Experimental Psychology: Learning, Memory, and Cognition* 29, 942–953.
- Guiso, Luigi & Monica Paiella (2000), "Risk Aversion, Wealth and Background Risk," Discussion paper, University of Sassari.
- Harless, David W. & Colin F. Camerer (1994), "The Predictive Utility of Generalized Expected Utility Theories," *Econometrica* 62, 1251–1289.
- Harris, Lawrence (1991), "Stock Price Clustering and Discreteness," *Review of Finance* 16, 1533–1597.
- Harrison, Glen W. (1994), "Expected Utility Theory and the Experimentalists," *Empirical Economics* 19, 223–253.
- Harrison, Glen W., Eric Johnson, Melayne M. McInnes, & E. Elisabet Rutström (2003, March), "Risk Aversion and Incentive Effects: Comment," Dept. of Economics, Moore School of Business, University of South Carolina, USA.
- Hershey, John C. & Paul J.H. Schoemaker (1980), "Prospect Theory's Reflection Hypothesis: A Critical Examination," *Organizational Behavior and Human Performance* 25, 395–418.
- Hogarth, Robin M. & Hillel J. Einhorn (1990), "Venture Theory: A Model of Decision Weights," *Management Science* 36, 780–803.
- Holt, Charles A. & Susan K. Laury (2002), "Risk Aversion and Incentive Effects," *American Economic Review* 92, 1644–1655.
- Huber, Joel, Dan Ariely, & Gregory Fischer (2001), "Expressing Preference in a Principal-Agent Task: A Comparison of Choice, Rating, and Matching," *Organizational Behavior and Human Decision Processes* 87, 66–90.
- Jevons, W. Stanley (1889), *The Theory of Political Economy*. (Fifth edition 1957, Kelley and MacMillan, New York; other ed. Penguin, 1970.)
- Jonas, Eva, Tobias Greitemeyer, Dieter Frey, & Stefan Schulz-Hardt (2002), "Psychological Effects of the Euro—Experimental Research on the Perception of

- Salaries and Price Estimations," *European Journal of Social Psychology* 32, 147–169.
- Kachelmeier, Steven J. & Mohamed Shehata (1992), "Examining Risk Preferences under High Monetary Incentives: Experimental Evidence from the People's Republic of China," *American Economic Review* 82, 1120–1141; for comment see Steven J. Kachelmeier & Mohammed Shehata (1994), *American Economic Review* 84, 1104–1106.
- Kahneman, Daniel (2003a), "Maps of Bounded Rationality: Psychology for Behavioral Economics," *American Economic Review* 93, 162–168.
- Kahneman, Daniel (2003b), "A Perspective on Judgment and Choice; Mapping Bounded Rationality," *American Psychologist* 58, 697–720.
- Kahneman, Daniel & Amos Tversky (1979), "Prospect Theory: An Analysis of Decision under Risk," *Econometrica* 47, 263–291.
- Kühberger, Anton, Michael Schulte-Mecklenbeck, & Josef Perner (1999), "The Effects of Framing, Reflection, Probability, and Payoff on Risk Preference in Choice Tasks," *Organizational Behavior and Human Decision Processes* 78, 204–231.
- Laury, Susan K. & Charles A. Holt (2000), "Further Reflections on Prospect Theory," Dept. of Economics, Georgia State University, Atlanta, GA.
- Levin, Irwin P. & Stephanie S. Hart (2003), "Risk Preferences in Young Children: Early Evidence of Individual Differences in Reaction to Potential Gains and Losses," *Journal of Behavioral Decision Making* 16, 397–413.
- Loehman, Edna (1998), "Testing Risk Aversion and Nonexpected Utility Theories," *Journal of Economic Behavior and Organization* 33, 285–302.
- Loomes, Graham (1998), "Probabilities vs Money: A Test of Some Fundamental Assumptions about Rational Decision Making," *Economic Journal* 108, 477–489.
- Lopes, Lola L. & Gregg C. Oden (1999), "The Role of Aspiration Level in Risky Choice: A Comparison of Cumulative Prospect Theory and SP/A Theory," *Journal of Mathematical Psychology* 43, 286–313.
- Marques, J. Frederico (1999), "Changing 'Europe'—The Euro as a New Subject for Psychological Research in Numerical Cognition," *European Psychologist* 4, 152–156.

- Meier-Pesti, Katja & Erich Kirchler (2003), "Attitudes towards the Euro by National Identity and Relative National Status," *Journal of Economic Psychology* 24, 293–299.
- Müller-Peters, Anke (1998), "The Significance of National Pride and National Identity to the Attitude toward the Single European Currency: A Europe-Wide Comparison," *Journal of Economic Psychology* 19, 701–719.
- Mussweiler, Thomas & Birte Englich (2003), "Adapting to the Euro: Evidence from Bias Reduction," *Journal of Economic Psychology* 24, 285–292.
- Myagkov, Mikhail G. & Charles R. Plott (1997), "Exchange Economies and Loss Exposure: Experiments Exploring Prospect Theory and Competitive Equilibria in Market Environments," *American Economic Review* 87, 801–828.
- Nestle, Frank O., Hannes Speidel, & Markus O. Speidel (2002), "High Nickel Release from 1- and 2-Euro Coins," *Nature* 419, 132.
- Noël, Marie-Pascale & Xavier Serron (1997), "On the Existence of Intermediate Representations in Numerical Processing," *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23, 697–720.
- Ogaki, Masao & Qiang Zhang (2001), "Decreasing Relative Risk Aversion and Tests of Risk Sharing," *Econometrica* 69, 515–526.
- Pepermans, Ronald, Carole B. Burgoyne, & Anke Müller-Peters (1998), "European Integration, Psychology and the Euro," *Journal of Economic Psychology* 19, 657–661.
- Plott, Charles R. & Shyam Sunder (1982), "Efficiency of Experimental Security Markets with Insider Information: An Application of Rational-Expectations Models," *Journal of Political Economy* 90, 663–698.
- Quattrone, George A. & Amos Tversky (1988), "Contrasting Rational and Psychological Analyses of Political Choice," *American Political Science Review* 82, 719–736.
- Rabin, Matthew (2000), "Risk Aversion and Expected-utility Theory: A Calibration Theorem," *Econometrica* 68, 1281–1292.
- Rapoport, Anatol (1984), "Effects of Wealth on Portfolios under Various Investment Conditions," *Acta Psychologica* 55, 31–51.
- Roth, Alvin E. & Michael W. Malouf (1979), "Game-Theoretic Models and the Role of Information in Bargaining," *Psychological Review* 88, 574–594.

- Schneider, Sandra L. & Lola L. Lopes (1986), "Reflection in Preferences under Risk: Who and When May Suggest Why," *Journal of Experimental Psychology: Human Perception and Performance* 12, 535–548.
- Selten, Reinhard, Abdolkarim Sadrieh, & Klaus Abbink (1999), "Money Does not Induce Risk Neutral Behavior, but Binary Lotteries Do even Worse," *Theory and Decision* 46, 211–249.
- Shafir, Eldar, Peter A. Diamond, & Amos Tversky (1997), "Money Illusion," *Quarterly Journal of Economics* 112, 341–374.
- Smith, Kip, John W. Dickhaut, Kevin McCabe, & José V. Pardo (2002), "Neuronal Substrates for Choice under Ambiguity, Risk Certainty, Gains and Losses," *Management Science* 48, 711–718.
- Smith, Vernon L. (1982), "Microeconomic Systems as an Experimental Science," *American Economic Review* 72, 923–955.
- Sonnemans, Joep (2003), "Price Clustering and Natural Resistance Points in the Dutch Stoch Market: A Natural Experiment, CREED, Dept. of Economics, University of Amsterdam, The Netherlands.
- Thaler, Richard H. (1985), "Mental Accounting and Consumer Choice," *Marketing Science* 4, 199–214.
- Tversky, Amos & Daniel Kahneman (1992), "Advances in Prospect Theory: Cumulative Representation of Uncertainty," *Journal of Risk and Uncertainty* 5, 297–323.
- Wakker, Peter P., Daniëlle R.M. Timmermans, & Irma A. Machielse (2001), "The Effects of Information about Probabilities on Insurance Decisions," CREED, University of Amsterdam, The Netherlands.
- Weber, Elke U. & William P. Bottom (1989), "Axiomatic Measures of Perceived risk: Some Tests and Extensions," *Journal of Behavioral Decision Making* 2, 113–131.
- Zorzi, Marco, Konstantinos Priftis, & Carlo Umiltà (2002), "Neglect Disrupts the Mental Number Line," *Nature* 417, May 2002, 138–139.