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"Fear of harm ought to be proportional not merely to the gravity of the harm, but also to the probability of the event," *Ars Cogitandi*, 1662.[1]

1. Introduction

You are in a bind. You have been looking for a house to buy and, now, after months of searching, you have been offered two interesting possibilities. Which one to choose? It is not an easy decision to make. One is better but more expensive. Can you afford to go into so much debt? Would you be taking too much risk? Decisions involving the purchase of a house happen seldom in a lifetime. Other decisions are more frequent, like purchasing durables, making saving or investing decisions, buying insurance, or selling your labor. What all decisions have in common is that they involve risk. A lot of them, involving relatively minor risks, are made on a daily basis. Uncertainty is always present and you are never completely sure of the consequences of your decisions. Consequently, all areas in economics plunge their roots in an uncertain environment, and economic modeling must cope with uncertainty.

A basic issue is risk attitude: when do people display risk aversion or risk attraction? What factors influence risk attraction? Elucidating which elements influence risk attitudes is an indispensable prerequisite to explain behavior. Moreover, understanding risk attitudes is crucial for policy and for institution building. If poor people were less risk averse, should the government enforce mandatory subsidized insurance for them? If people's risk attitudes are conditioned by age, education, experience, wealth or other changing circumstances, then we have to accept the idea that what people choose for themselves may later be considered contrary to their best interest. If so, shouldn't society push for a more paternalistic care of its members?

By the way, does your risk attitude change depending on the choice that you face? Suppose that you have to choose between (1) a lottery with a 0.8 probability of delivering a gain of €10 and (2) a sure gain of €8? Would you prefer to take the risk of gaining the larger amount (or nothing) or would you rather prefer to take the €8 and run? Notice that the expected value of the lottery is precisely €8. If you prefer the lottery, then we say that you display risk attraction. If you choose the certain gain, then we say that you display risk aversion.

Now imagine that the amount of money at risk is not €10 but €1,000,000. Would your decision be similar? Finally, imagine that you are asked to choose between (1) an uncertain loss of €10 with a 0.8 probability, and (2) the sure loss of €8. Would your decision be similar? And do you think that your daughter, your neighbor, your partner, would choose like you? Perhaps not.

Actually, we are fortunate that human beings differ in their appetites for risk.

The pioneer Daniel Bernoulli (1738) believed that risk aversion was universal: in his words "Everyone who bets any part of his fortune, however small, on a mathematically fair game acts irrationally…"[2] Subsequently, the mainstream analysis of decision-making under uncertainty has focused on risk aversion, relegating risk attraction to the category of an uninteresting exception. Risk aversion in decisions involving money implies that the decision maker will bear risk only if the expected money returns are higher than the certain alternative, i.e., at actuarially favorable odds. An overwhelming large fraction of the literature studies risk behavior under the double assumption of risk aversion and positive expected net returns, as the recent treatise by Christian Gollier (2001) exemplifies. On the other hand, the 1979 conception of prospect theory by Nobel laureate Daniel Kahneman and his late co-author Amos Tversky has advanced the view that individuals display risk aversion for gains and risk attraction for losses.[3]

In our quest to understand the factors that influence risk attitudes we focus on the following questions:

(1) Do risk attitudes change when more money is at stake?

(2) Are people more likely to display risk attraction as the probability of being unlucky increases?

(3) Are people more likely to display risk attraction when confronting losses than when confronting gains?

(4) Does personal wealth condition risk attitudes?

We address these issues by adopting the experimental method. In any scientific endeavor, the chief advantages of harvesting data from laboratory experiments are replicability and control. *Replicability* refers to the capacity of other researchers to reproduce the experiment, create a new set of data and independently verify the findings. *Control* is the capacity to manipulate laboratory conditions so that the observed behavior can be used to establish causality, as well as evaluate alternative theories and policies and measure behavior. In the social sciences, laboratory experiments have discovered behavioral patterns and inferred decision-making principles.

Our experimental work (Bosch-Domènech and Silvestre, 1999, 2002, In press) focuses on the conditions under which risk attraction and aversion appear, rather than on the extent of risk bearing under actuarially favorable conditions. Accordingly, we confront the participants in our experiments (or "subjects") with the choice between a monetary gamble and its expected value.[4] Gambles are characterized by probabilities of 0.2 or 0.8, away from the extremes.

Our evidence seems to vindicate the old tradition initiated by Bernoulli as far as substantial amounts of money are involved, because for choices where the potential gains or losses are large enough, the huge majority of individuals are risk averse. Only when money amounts are small, individual behavior grows heterogeneous. One is tempted to conclude that, when it matters, individuals are risk averse. This directly flies in the face of the *après* Kahneman and Tversky conventional view that risk attraction dominates in the face of potential losses.

However, we do observe a degree of risk attraction, which varies in response to three effects that we identify. We have just remarked that, when addressing question (1) above, we observe that people are more likely to display risk aversion, both for gains and for losses, as the amount of money at stake increases: this we call the *amount effect*. As we answer (2), we identify a *switch effect*, according to which people are more likely to display risk attraction as the probability of not obtaining a gain increases from 0.2 to 0.8.[5] And regarding (3) we discover that people are more likely to display risk attraction in a choice involving losses than in one involving gains when the probability of the bad event (loss or no gain) is kept at 0.2: this we call the *translation effect*. Finally, as for (4), we observe interesting connections between wealth and the maximal money amount that a participant is willing to gamble. Whereas wealthy participants are more likely than non-wealthy ones to risk small money amounts, the roles are somewhat reversed for larger amounts of money.

Perhaps surprisingly, the translation effect has more severe theoretical implications than the amount and the switch effects. Mainstream economics has taken individual preferences as having both positive and (socially) normative meaning. From the positive viewpoint, we use individual preferences to explain and predict behavior. Normatively, we take the individual to be the definitive judge of his or her welfare. But this requires the individual to have consistent, non-contradictory preferences: what we call "single-self preferences."

It turns out that single-self preferences are ruled out by the translation effect, which requires "multiple selves," in conflict with each other, one self for each possible level of wealth. Which of these selves, or combination of them, is the true representative of the individual welfare? This feature of the translation effect contrasts with the switch effect and the amount effect, which, singly or in combination, allow for a single self.

A last comment is addressed to the reader familiar with expected utility theory. The difference just discussed between the translation effect, on the one hand, and the amount and switch effects, on the other, concerns the possibility of single-self preferences, rather than their compatibility, or lack of it, with expected utility theory. In fact, Section 5 below shows that all three effects behave alike with respect to expected utility.

2. The experiments

2.1. The experimental protocol

Experiments have gradually seeped into the mainstream methodology of economics during the last two or three decades. Psychology experiments and clinical trials have inspired experimental economics, although basic differences remain in the various fields. In economics, many experiments are performed on students who volunteer. These participants are asked to make decisions following the instructions of the experiment, and are paid according to the decisions they make. On the basis of the observations made during the experiments, researchers draw conclusions about individual or group behavior, about the role of the different institutions or policy designs involved and, ultimately, about economic theories.

Interestingly, one could perhaps nominate Bernoulli's (1738) observation on the St. Petersburg game as the first economics experiment.[6] Instead of relying only on his own introspection and logic, Bernoulli decided to inquire what price others would in fact be willing to pay to enter the following gamble: a coin is being flipped until a head is produced; if you enter the game, you receive a payoff of 2^n euros, let's say, where n is the number of the throw producing the first head. The conventional wisdom at the time implied that every reasonable person would be willing to pay anything up to the expected value of the gamble in order to participate in it. But while the expected monetary payoff of this gamble is infinite, Bernoulli encountered no-one willing to pay even moderate amounts. This came to be known as the St. Petersburg paradox. Bernoulli concluded from these observations that the value of a gamble is not equal to its expected monetary value. Instead, he posited that rational individuals may well reject gambles with positive expected monetary value.

In our experiments, all participants were required to choose between real, not hypothetical, money prospects with the same expected money value.[7] In particular, they had to make a choice between (a) an uncertain gain (or loss) of an amount of money z with probability p (and zero with probability $1 - p$) and (b) the certain gain (or loss) of the amount of money pz. Typically, participants were asked to choose, sequentially, for each of seven classes corresponding to seven money amounts (euros 3, 6, 12, 30, 45, 60 and 90). The probability p was set at either $p = 0.8$ or $p = 0.2$.

In these experiments, we say that a participant displays *risk attraction* (resp. *risk aversion*) in a particular choice if she chooses the uncertain (resp. certain) alternative.

2.2. Risk attitudes and money at stake

All our experiments cover the possible dependence of risk attitudes on the amount of money at stake, and they all justify the following four results.

Result 1. *Diversity*. The majority of participants display risk attraction for choices involving some amounts of money, and risk aversion for some others, the number of safe choices varying across individuals.

Result 2. *Standard pattern*. Most individuals follow the *standard pattern*, defined as follows: whenever risk attraction is displayed in a choice involving a given money amount, risk attraction is also displayed for any smaller (in absolute value) amount of money.

Result 3. *Amount effect*. The proportion of participants who display risk aversion in a particular choice increases with the amount of money at stake.

Result 4. *Risk aversion by the majority for large amounts of money at stake*. For both gains and losses, and for low and high probabilities, a majority of participants display risk attraction for low amounts of money at stake (see, for example, the red area in Table 1 on page 17), but risk aversion for large amounts (the black area in Table 1).

Result 4 in particular says that a majority displays risk aversion for large, high probability losses. This is perhaps the most novel discovery in our research, because it directly challenges the assertions of Kahnemann and Tversky's prospect theory, now the dominant doctrine on this subject.

2.3. Risk attitudes and wealth

Are poor people more or less likely to take money risks than wealthy folks? In spite of the long-standing awareness that risk aversion may vary with wealth and that this relation "is of the greatest importance for prediction of economic reactions in the presence of uncertainty" (Kenneth Arrow, 1965), differences in personal wealth among subjects from the same culture do not appear to have ever been tested in the lab before the experiment reported in Bosch-Domènech and Silvestre (in press).

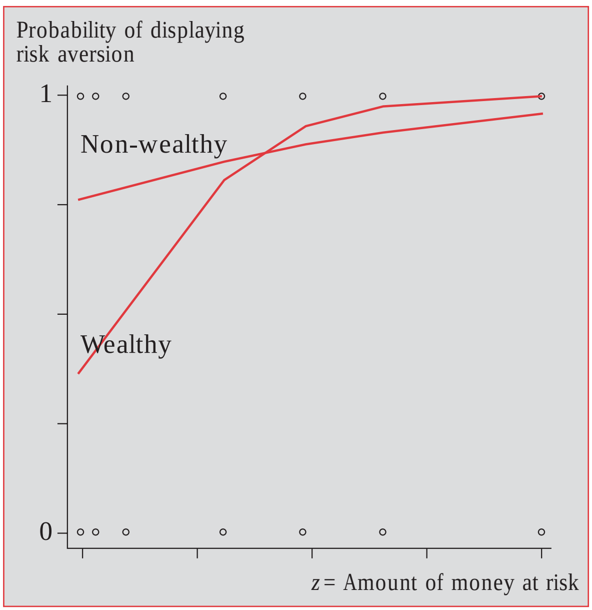
We run the experiment with two groups of high-school students, all in their last year of "batxillerat," which is the university-bound track. The two groups have the same age, identical formal education, same nationality, and involve similar proportions of males and females.[8] The first group includes students of a public high school in a low-income neighborhood in Barcelona. The second group includes students attending a high-tuition private school in a plush area in the same city. We will call these groups Non-wealthy and Wealthy, respectively. In Spain, public schools are free and, in large cities, attract mostly students from the neighborhood. A public school in a low-income neighborhood is unlikely to receive any applications from students living in well-to-do neighborhoods. Therefore, by choosing participants among the students in these two schools we are reasonably certain to observe children from families with middle to low incomes in one place and children from high income families in the other. A questionnaire about family and social background, which the participants in the experiment had to answer, reveals that this assumption appears to be correct.

From the data gathered at the experiment we can establish the following result.

Result 5. *Dependence on wealth*. On average, Wealthy participants are more likely to risk (i. e. choose the uncertain prospect) small money amounts, whereas this pattern does not carry over to large money amounts, where, if anything, Non-wealthy participants are more likely to choose the uncertain prospect.

This result can be made more precise using a logit regression model to compute the functional relations between the amount of money at risk and the probability of displaying risk aversion in Wealthy and Non-wealthy groups. Figure 1 shows the results.

Figure 1.
Functional relations between the amount of money at risk and the probability of displaying risk aversion in Wealthy and Non-wealthy groups.



The statistical analysis also allows us to state that for the Non-wealthy, the odds of choosing the certain prospect increase by 15% when the income at risk increases by €6. For this group, the probability of choosing the certain prospect is high (0.74) when the amount of money at risk is close to zero. For Wealthy, the odds of choosing the certain prospect increase by as much as 57% when the income at risk increases by €6, but the probability of choosing the certain prospect when the amount of money at risk is close to zero is lower than for Non-wealthy and equal to 0.31.

2.4. Risk attitudes towards gains and losses

2.4.1. Reflection = Translation + Switch

Both Harry Markowitz (1952) and Kahneman and Tversky (1979) argued that there is a fundamental asymmetry in the behavior towards gains vs. losses. Kahneman and Tversky asked "What happens when the signs of the outcomes are reversed so that gains are replaced by losses?" (1979, p. 268), and answered,

> "… the preference between negative prospects is the mirror image of the preference between positive prospects. Thus the reflection of prospects around zero reverses the preference order. We label this pattern the reflection effect,"

and continued,

> "…the reflection effect implies that risk aversion in the positive domain is accompanied by risk seeking in the negative domain."

In one of their experiments, Kahneman and Tversky (1979) asked their subjects to choose hypothetically between an 0.8 chance of winning $4,000 (and a 0.2 chance of winning nothing) and the sure gain of $3,000. Even though the risky choice has a higher expected value, $3,200, 80% of the subjects chose the $3,000 certain gain.

Next, they offered a hypothetical choice between a 0.8 chance of *losing* $4,000 (and a 0.2 chance of losing nothing) and the sure loss of $3,000. This time, 92% of the subjects chose the gamble, even though the expected loss was $3,200, higher than the certain loss of $3,000.

Following Kahneman and Tversky's path, the study of the gain-loss dichotomy has been largely confined to "reflected" choices where all the money amounts of a positive prospect are multiplied by minus one. Take for instance the choice between a 0.8 probability of gaining €100 (together with a 0.2 probability of gaining nothing) and a certain gain of €80. The reflected choice is then between a 0.8 probability of losing €100 (together with a 0.2 probability of losing nothing) and a certain loss of €80.

We submit that a reflection has two components: a *translation*, or change of origin, of the probability distributions of the money outcomes, which naturally captures the gain-loss asymmetry, and a *switch* of probabilities between the good and the bad outcomes (the bad outcome is "no gain" in choices between certain and uncertain gains, and is a "loss" when choosing between certain and uncertain losses).

In the previous example, we can go from the original choice to the reflected choice in two steps. First, we switch the probabilities of the good and bad outcome, while keeping the expected values of the choice alternatives equal to each other.[9] The switched choice is then between a 0.2 probability of gaining €100 (together with a 0.8 probability of gaining nothing), and a certain gain of €20. Second, we subtract €100 from all the money amounts, so that the translated choice (after switching) is then between a 0.2 probability of neither gaining nor losing anything (together with a 0.8 probability of losing €100) and a certain loss of €80.

Alternatively, we could reverse the order of the steps, first effecting a translation and then a switch. If we first subtract €100 from the original choice, we get the choice between a 0.8 probability of neither gaining nor losing anything (together with a 0.2 probability of losing €100), and a certain loss of €20. If we now switch probabilities, we obtain the choice between a 0.2 probability of neither gaining nor losing anything (together with a 0.8 probability of losing €100), and a certain loss of €80. Summarizing, the order in effecting the translation and the switch does not matter, which leads us to the decomposition

REFLECTION = TRANSLATION + SWITCH.

Conceptually, the switching of the probabilities between money changes of the same sign has little to do with "turning gains into losses." Accordingly, we view a translation as a more natural way of capturing the idea of "a choice involving losses that corresponds to a given choice involving gains" than Kahneman and Tversky's reflection.

Our experimental design allows us separately to test for the effects of translations and switches, as well as that of reflections. We say that a person exhibits a *switch effect* if she displays risk aversion for a choice but risk attraction for the switched choice. Similarly, she exhibits a translation (resp. *reflection*) effect if she displays risk aversion for a choice but risk attraction for the translated (resp. reflected) choice.

Focusing on the switches and translations, rather than on reflections, allows us to discover an interesting difference between the translation and the switch effect (or between reflections due only to the switch effect and those where the translation effect plays a role): as we will see in Section 3, the switch effect does not contradict "single-self preferences", whereas the translation effect does.

2.4.2. Our experimental results on gains and losses

The experiment reported in Bosch-Domènech and Silvestre (2002) tests the gain-loss dichotomy, in addition to experimentally examining the role of probabilities (0.2 vs. 0.8) and of the amount of money at stake. It is implemented in four treatments named *G*, *G'*, *L* and *L'* (*G* and *L* stand for gains and losses), each dealing with the same seven amounts of money at risk as before, positive amounts for gains, and negative amounts for losses. The probability of the bad outcome is 0.20 in treatments *G* and *L*, and of 0.80 in treatments *G'* and *L'*: see Figure 2 on page 18, which summarizes our next results.

Hence, our treatments *G* and *L* differ only by a translation from gains to losses, and so do treatments *G'* and *L'*. Treatments *G* and *G'*, on the contrary, differ only in the switch of the probabilities of the good and bad outcomes, and so do treatments *L* and *L'*. Taken together, the four treatments explore the effects on risk attitudes of the two components of a reflection, namely a "translation" (gain vs. loss) and a "probability switch" (0.2 vs. 0.8), which permits a better understanding of any gain-loss asymmetry for each amount of money at stake.

In addition, the design of treatments *L* and *L'* addresses a basic difficulty in real-money experiments with losses and gains, namely the need for the experimenter and the participants to agree on their perceptions of *what is a loss and what is a gain*. Because experimental participants cannot legally lose relative to their pre-experiment wealth, all real-money experiments with losses require that participants previously receive, or earn, from the experimenter the money that they may eventually lose. Therefore, in the experiments with losses, either the losses are hypothetical or participants play with "house money," which seems to increase their willingness to accept risk. In order to mitigate these difficulties, our participants make their choices between certain and uncertain losses several months after earning some income by taking a quiz. According to their answers to a questionnaire, this delay makes most participants feel that they have fully spent the earned cash by the time they make their decisions, and hence that they are playing with their own money.

As in previous experiments, participants must choose between a certain and an uncertain prospect in each of the seven groups of money at risk. The experimental results can be collected as percentages in Table 1.

The experiment yields the following results.

Result 6. *Translation effect*. For all amounts of money at stake, if gains and losses are related by a translation, then participants are more likely to display risk attraction with losses than with gains. In other words, risk attraction becomes more frequent as we move right in Figure 2 below, both along the top row (probability of bad outcome = 0.2) and along the bottom row (probability of bad outcome = 0.8).

Result 7. *Switch effect.* Both for gains and for losses, and for all amounts of money at stake, participants are more likely to display risk attraction when the probability of the bad outcome is high. In terms of Figure 2 below, risk attraction becomes more frequent as we move down along either column. In fact, at a low probability of gains, and for small amounts of money, a substantial majority of individuals show risk attraction.

Result 8. *Equal strength of the translation and switch effect.* Statistically, the translation and switch effects are of similar magnitude.

Next, Results 9 and 10 refer to the "reflection effect" as defined by Kahneman and Tversky (1979). Recall that a reflection effect occurs if risk attraction increases when all the money amounts of a positive prospect are multiplied by minus one, i.e., when gains are translated into losses, and the probabilities of the bad and good outcomes are switched. Because "reflection = translation + switch," Results 9 and 10 agree with Results 6-8.

Result 9. *Large reflection effect for high probability of gains and losses.* The frequency of risky choices substantially increases when moving from a prospect with a high probability of gain (low probability of the bad outcome) to a prospect with a high probability of loss, i.e., along the main diagonal of Figure 2. Indeed, along the main diagonal, the translation and switch effects reinforce each other, and hence this result is in line with Results 6 and 7 above.

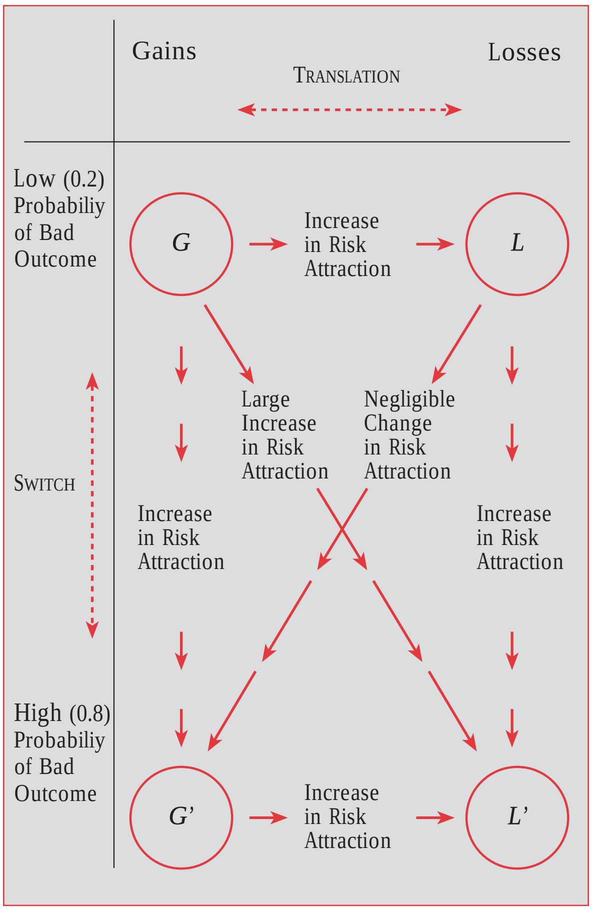
Table 1

Fraction of participants in treatments *G*, *L*, *G'* and *L'* who display risk attraction (by choosing the uncertain alternative) for the various amounts of money a stake. The color red highlights a majority of participants displaying risk attraction, the color black a majority displaying risk aversion.

	Amount of Money (in Euros)						
	3	6	12	30	45	60	90
Exp. *G* (gains with prob. = 0.8) (i.e., prob. of bad outcome = 0.2) Number of participants: 21	0.57	0.57	0.29	0.05	0.10	0.10	0.05
Exp. *L* (losses with prob. = 0.2) Number of participants: 21	0.86	0.71	0.62	0.29	0.19	0.17	0.17
Exp. *G'* (gains with prob. = 0.2) (i.e., prob. of bad out. = 0.8) Number of participants: 24	0.92	0.92	0.79	0.46	0.50	0.17	0.17
Exp. *L'* (losses with prob. = 0.8) Number of participants: 34	0.91	0.97	0.71	0.47	0.43	0.29	0.24

Result 10. *Negligible reflection effect for low probability gains and losses.* The frequency of risky choices is essentially unchanged when moving from a prospect with a low probability of loss to one with a low probability of gain, i.e., along the skew diagonal of Figure 2. This is consistent with Result 8 above, and is also suggested by the comparison of the second and third rows (treatments *L* and *G*') of Table 1.

Figure 2.
Summary of results on gains and losses



3. Are people who display the amount, switch or translation effects irrational?

3.1. The amount, switch and translation effects for a range of wealth levels

We will be using the following notation. The individual's initial wealth is denoted *w*. She will be facing random prospects where her final wealth will be x_1 with probability *p*, and x_2 with probability (1-*p*). When the initial wealth is *w*, a final wealth of *x* entails a change of wealth of

$$z = x - w,$$

which is positive if she experiences a monetary gain, and negative if a loss. Of course, we can write this definition as $x = w + z$, i.e., final wealth = initial wealth + change in wealth.

We have observed, as previous researchers had before us, a rich variety of behavior among individuals: for instance, some display risk attraction in all the choices. Here we wish to focus on some qualitative patterns that, without being universal, are well represented in our findings. We view them as plausible, and conjecture that individuals would display them even if their wealth changed.

First, we say that a person exhibits an *amount effect* if she displays risk attraction when the amounts *z* of money at risk are small (positive or negative, but small in absolute value) but risk aversion for large ones, at all levels of wealth, or, at least, for a wide interval of wealth values *w*. This, we submit, is a realistic phenomenon, as our Results 2 to 4 of Section 2.2 above show. Moreover, the experiment described in Section 2.3 supports our extrapolation to various levels of wealth.

Second, when we refer to the translation, switch or reflection effects, we will assume that they are present for a wide range of initial wealth values *w* and wealth changes *z*, again extrapolating our observations in the experiments described in Section 2.4 to a range of wealth levels.

Sections 3 and 4 will establish a fundamental difference between the amount and switch effects, on the one hand, and the translation effect on the other: the former turn out to be compatible with consistent, single-self preferences, whereas the translation effect does not.

3.2. Single-self vs. multiple selves

Economists often base their policy recommendations on the premise that individuals are the ultimate judges of their welfare. This nonpaternalistic attitude assumes that the individual is rational in the minimalist sense of being able *consistently* to evaluate the economic states where she can find herself, i.e., having a single self, free of contradictions, so that her evaluation does not depend on the circumstances in which she makes the evaluation. If the person lacks consistent preferences, then the evaluation of any policy that affects her reference point must appeal to an external notion of welfare.

Whether the single-self assumption is or not largely depends on the issue at hand: modern behavioral economics has uncovered a variety of instances where individuals act as if they have multiple selves, depending on, say, the presence or absence of previous consumption (addiction) or on the distance in time between the decision and its outcome (myopia with respect to the future). In those cases, traditional nonpaternalistic welfare criteria are no longer justified.[10]

Consider for example an individual who, both for initial wealth of €1000 and €1100, displays (1) risk aversion in the choice between an uncertain gain of €100 with probability 0.8, and a certain gain of €80, but (2) risk attraction in the choice between an uncertain loss of €100 with probability 0.2, and a certain loss of €20. She then has two different selves. Her “poor self”, relevant when her wealth is €1000, prefers a certain total wealth of €1080 to a 0.8 probability of a total wealth of €1100 coupled to a 0.2 probability of a total wealth of €1000 (because she prefers a certain gain of €80 to a 0.8 chance of a gain of €100). But her “wealthy self”, relevant when her initial wealth is €1100, reverses her preference (because she now prefers a 0.2 chance of losing €100 to a certain loss of €20).

Her multiple selves raise two kinds of problems, positive and normative. From the positive viewpoint, knowing the preferences of both her poor and her wealthy selves does not suffice to predict her choice in the following situation.[11] Her initial wealth is €1000, and she has to choose between a certain loss of €20 and a loss of €100 with probability 0.2. But just before making her choice, she is given €100. Does she see this €100 as being added to her initial wealth, so that her wealthy self takes over, displaying risk attraction (preferring a loss of €100 with probability 0.2 to a certain loss of €20)? Or, on the contrary, does she see this €100 as being part of the changes in her wealth, and, thus, her poor self takes over, preferring to increase her wealth by a certain €80 (100 – 20), rather than by an uncertain €100 with probability

0.80? Or does she actually have a third, “nouveau riche self”, which resolves this particular conflict between her two previous selves?

The normative problem is more serious. Suppose that a policy decision must be made by choosing between actions A and B, and that the only consideration is the welfare of this particular individual. If action A is taken, then she may be lucky (probability 0.8), in which case her total wealth will be €1100, or unlucky, in which case her total wealth will be €1000. If action B is taken, then her final wealth will be a certain €1080. Which action should be taken? Her poor self prefers action B, but her wealthy one prefers action A. Is one of her selves socially relevant? If yes, which one, and who chooses it, and how? Preferences that depend on wealth, an economic variable, are particularly unsuitable for welfare analysis.

3.3. Single-self preferences and the translation, amount and switch effects

The previous example is an instance of the translation effect: at two different wealth levels (€1000 and €1100), the individual displays:

(a) risk aversion in the choice between an uncertain gain of €100 with probability 0.8, and a certain gain of €80 (here, the bad event is “not winning €100, which occurs with probability 0.2),

yet

(b) risk attraction in the choice between an uncertain loss of €100 with probability 0.2 and a certain loss of €20 (where the bad event is “losing €100,” also occurring with probability 0.2).

As just noted, this is incompatible with single-self preferences. More generally, *the translation effect is incompatible with rationality in the sense of single-self preferences.*

Thus, the translation effect (or a reflection involving translation) is in the same category as inconsistencies due to addiction or myopia. They do occur, yet they imply a departure from full individual rationality.

But it turns out that, contrary to the translation effect, our other two effects, namely the amount effect and the switch effect, are consistent with single-self preferences (see Bosch-Domènech and Silvestre, 2002, 2005). Thus, an individual who displays both the amount effect and the switch effect, but not the translation effect, may well have rational, in the sense of single self, preferences, which can then be used in the standard manner both to explain her behavior and to evaluate her welfare in a nonpaternalistic manner.

It follows that the reflection effect, if exclusively due to the switch effect, is compatible with single-self preferences. Thus, the answer to the question of whether a reflection effect contradicts single-self preferences is “it depends”, i.e., it depends on whether it is solely due to the switch effect, in which case a single self is conceivable, or, on the contrary, is influenced by a translation effect, in which case it requires multiple selves.

4. Expected utility, and the amount, switch and translation effects

4.1. Single-self, expected utility preferences

Bernoulli (1738) introduced what we now call the Expected Utility Hypothesis, with final wealth x as argument.[12] The canonical notion of "expected utility" can be expressed as follows.

Single-Self Expected Utility Preferences. The objective of the individual is the maximization of

$$pu(x_1) + (1\text{-}p)u(x_2)$$
$$(\text{or } p\, u(w + z_1) + (1\text{-}p)u(w + z_2)\ ),$$

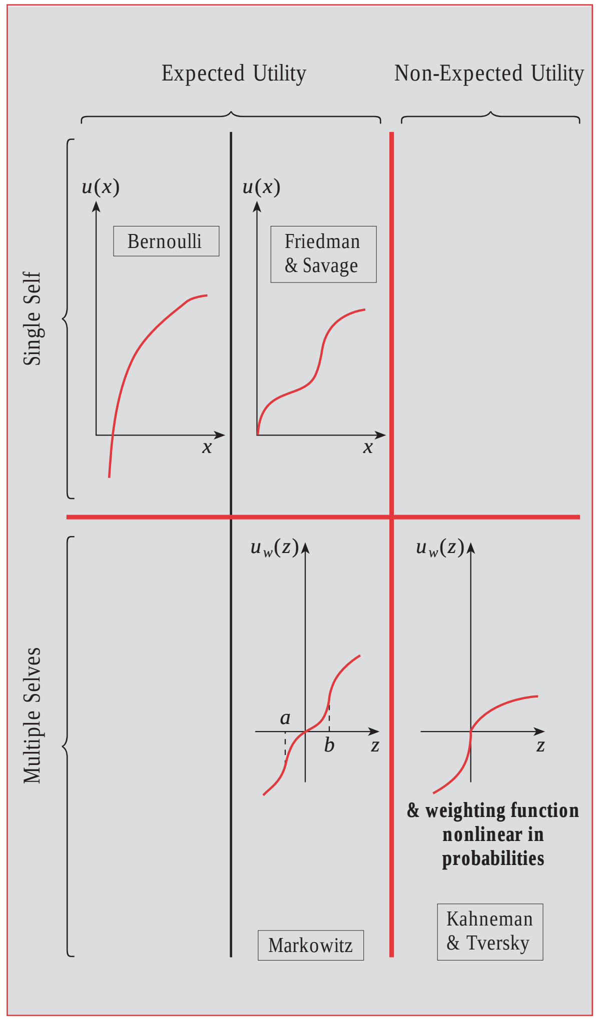
where the function $u(x)$, defined on the amounts of final wealth x, is called her von Neumann-Morgenstern (vNM) function.[13]

Bernoulli postulated risk aversion for all choices, which in this context is equivalent to a negative second derivative $u''(x)$, i.e., a strictly concave vNM function. He actually posited that $u(x) = \ln x$, see the graph labeled "Bernoulli" in Table 2. But, in order to accommodate some extent of risk attraction, Milton Friedman and Leonard Savage (1948) assumed that u was concave (risk aversion) for low wealth levels, convex (risk attraction) for intermediate ones and concave again for high wealth levels (see "Friedman & Savage" in Figure 3). The shape of $u(x)$ postulated by Friedman and Savage has the following implications.

- Poor people display risk aversion for small risks, but risk attraction for some large risks involving gains
- People with intermediate wealth ("the middle class") display risk attraction for all small risks, but risk aversion some for large ones
- Wealthy people display risk aversion for all small risks, but risk attraction for some large risks involving losses.

Figure 3

Clasification of various theories



4.2. Multiple-selves, expected utility preferences

It is by now generally recognized that the Friedman-Savage model fails to realistically integrate risk aversion and risk attraction. Markowitz (1952) was an early critic. He submitted that the argument of the utility function should not be total wealth $w + z$, but the deviations z from the reference wealth w (which he called "customary wealth"). His view was that such function, which we denote $u_w(z)$, had three inflection points, a, 0, and b, with $a < 0 < b$, and

- Risk attraction for small positive risks (u_w convex between 0 and b)
- Risk aversion for large positive risks (u_w concave to the right of b)
- Risk aversion for small negative risks (u_w concave between a and 0)
- Risk attraction for large negative risks (u_w concave to the left of a)

He also submitted that the inflection points a and b would be farther from zero the higher the reference wealth.

The Markowitz formulation is incompatible with the expected utility hypothesis if we assume a single self, i.e., a single vNM utility function $u(x)$ defined on total wealth. But it can be represented in the multiple-selves manner by a family of "vNM" functions $u_w(z)$, indexed by the wealth level w: see the "Markowitz" graph in Figure 3.[14]

Should we apply the label "expected utility" to such preferences? The usage is not unanimous: Matthew Rabin (2000), or Ignacio Palacios-Huertas, Roberto Serrano and Oscar Volij (2001), would not, whereas James Cox and Vjolica Sadiraj (2001) and Rubinstein (2001) would: without taking sides on the debate which is the subject of these papers (more on this in Section 5.2 below) let us adopt the loosest usage of the term "expected utility" and admit both single-self and multiple selves preferences.[15]

When her wealth is w, the objective of the individual is to maximize $pu_w(z_1) + (1\text{-}p)u_w(z_2)$, where $u_w(z)$ is the vNM utility function of her "self with wealth w", defined on gains or losses z, so that her final wealth is $w + z$, with $u_{\bar{w}}(x\text{-}\bar{w}) \neq u_{\bar{\bar{w}}}(x\text{-}\bar{\bar{w}})$ for some $(x, \bar{w}, \bar{\bar{w}})$.[16]

4.3. Are the effects consistent with expected utility?

The answer to the question "Are the amount, switch and translation effects each consistent with expected utility?" depends on whether we mean *single-self* expected utility or *multiple-selves* expected utility. In fact, all three effects contradict single-self expected utility theory, and none contradicts multiple-selves expected utility theory, as summarized in Table 2 (see Bosch- Domènech and Silvestre, 2002, 2005). Thus, all three effects behave in the same manner *vis-à-vis* expected utility.

Hence, it is the single-self vs. multiple-self divide, and not the expected vs. non-expected utility one, that separates the theoretical implications of the amount or switch effects from those of the translation effect.

Table 2

The amount, switch and translation effects vs. single-self and expected utility: summary

	Single-Self Expected Utility	Single-Self Non-expected Utility	Multiple-Selves Expected Utility
Amount Effect	Contradiction 💣	OK ☺	OK ☺
Switch Effect (or reflection due to switch)	Contradiction 💣	OK ☺	OK ☺
Translation Effect (or reflection due to translation)	Contradiction 💣	Contradiction 💣	OK ☺

5. Multiple selves and non-expected utility

5.1. Non-expected-utility, multiple-selves preferences

Kahneman and Tversky's (1979) prospect theory includes a utility function *à la* Markowitz with multiple selves. They were well aware of the implications. As Tversky (1990) states, "our preferences … can be manipulated by changes in reference points", while what they call the "invariance axiom" (synonymous with what we call "single-self preferences") is at the core of the rational behavior postulated in most of economics. In this juncture, we may quote Kahneman and Tversky (1984):

> "The moral of these results is disturbing. Invariance is normatively essential, intuitively compelling, and psychologically unfeasible".

The shape that they propose differs from Markowitz's: they view as typical a curve concave for positive z and convex for negative z, with Markowitz's inflection point at zero replaced by a kink, so that the left slope is higher than the right slope: see the graph "Kahneman & Tversky" in Figure 3. Moreover, they do not call it a vNM utility function, but a "value function." (In addition, they view their "value function" as independent from wealth, so that $u_w(z) = u_{w'}(z)$ even when $w \neq w'$.) This would be an innocuous terminological change if these values were still the coefficients of a utility function linear in the probabilities. In that case, the concavity (resp. convexity) for positive (resp. negative) z would imply risk aversion (resp. attraction) for gains (resp. losses).

But Kahneman and Tversky further depart from previous theory by substituting "decision weights" or "transformed probabilities" for the probabilities. The decision weights may depend on the probabilities and on the sign of z. In the simpler case where they depend only on the probabilities, preferences are represented by the combination of a family of "value functions" $u_w(z)$ and a *weighting function* $\pi(p)$ that "overestimates" small probabilities and "underestimates" large probabilities: a decision maker with wealth w then maximizes $\pi(p)u_w(z_1) + \pi(1\text{-}p)u_w(z_2)$.

Summarizing, we see that Kahneman and Tversky's preferences have multiple selves and are of the non-expected utility type, because $\pi(p)u_w(z_1) + \pi(1\text{-}p)u_w(z_2)$ differs from the "expected utility" $pu_w(z_1) + (1\text{-}p)\,u_w(z_2)$.[17] Many other non-expected utility theories, with a single self or with multiple selves, have been developed in the last half century. See Chris Starmer (2004) for a recent survey.

5.2. Large vs. small decisions: the amount effect and the Rabin critique

Recall that our experimental observations contradict single-self expected utility theory. In particular, our extremely robust findings of an amount effect (i.e., risk attraction for small deviations of current wealth, together with risk aversion for larger deviations) contradict single-self expected utility in a fundamental manner, because risk attraction for small risks in a range of wealth levels would then mean that $u'' > 0$ there, implying risk attraction for all risks with final outcomes in that range.

In other words, single-self expected utility implies this minimal consistency between behavior in the small and in the large. Rabin's critique of expected utility theory (Rabin, 2000) is also based on a required consistency between behavior in the small and in the large, and hence shows a formal parallelism with the implications of our amount effect. In a nutshell, Rabin's critique is of the form:

(a) *The avoidance of small, slightly favorable risks at an interval of wealth is plausible;*[18]

It follows from (a) *that, under single-self expected utility:*

(b) *Large, greatly favorable risks must be avoided.*

But this is ridiculous.

On the other hand, our amount-effect-based negation of single-self expected utility runs as follows.

(a') *We observe attraction to small, fair risks at an interval of wealth;*

It follows from (a') *that, under single-self expected utility:*

(b') *There must be attraction to large, fair risks.*

But this is not what we observe: we find generalized risk aversion to large, fair risks.

Besides the formal parallelism, Rabin's critique and our negation of single-self expected utility share an underlying theme: plausible or observed behavior in the small implies, under single-self expected utility, a behavior in the large that contradicts common sense or observation. It is true that, in the small, what we observe is risk attraction, whereas Rabin posits risk aversion. But what Rabin calls "small" involves gambles with hypothetical amounts of money closer to what we call large (around €100). In addition, his gambles are two-sided, combining gains and losses, which may favor risk aversion.

6. Two concluding comments

First, we have observed the prevalence of risk aversion when facing large money risks, hence vindicating Bernoulli's insight while casting doubt on the validity of prospect theory, for the case where the amounts of money at stake are large. But we have also found interesting patterns of risk attraction in decisions involving smaller payoffs. We should resist the temptation to consider these instances of risk attraction as irrelevant, because typically small decisions are made frequently and, hence, may have cumulative substantial effects.

Second, reality is obviously more complex that the enclosed world of the lab where the participants in our experiments make decisions. In a sense, this concern is inherent to the experimental method. As Daniel Friedman and Shyam Sunder (1994) explain:

> "Galileo's critics did not believe that the motion of pendulums or balls on inclined planes had any relation to planetary motion in the celestial sphere. More recently, some people question whether substances found to be toxic in large doses for laboratory rats will harm human beings in small doses over longer periods of time."

A sharp critic may identify some features present in the real world, and absent in the lab, that may have an effect on the observations. For instance, she may note that many professional financial decisions involve amounts of money larger than the highest quantity in our experiments, and are made by experts with years of experience. Strictly speaking, her concerns can only be assuaged by performing further tests with experienced participants and large payoffs. But a by now substantial literature indicates that, as was the case with Galileo's pendulums, usually the results carry over to the world outside the lab.

Notes

(1) As quoted in Ian Hacking (1975), p. 77. The authors of Ars Cogitandi *were never revealed.*

(2) Quoted by Peter Bernstein (1996), p. 113.

(3) See Kahneman and Tversky (1979, 1984, 2000) and Tversky and Kahneman (1992).

(4) In other words, our participants always face actuarially fair choices.

(5) Of course, the certain alternative must then be adjusted in order to maintain actuarial fairness.

(6) See Alvin Roth (1995), p. 4.

(7) A prospect is understood as a list of consequences with attached probabilities.

(8) According to Luigi Guiso and Monica Paiella (2001), p. 9, "risk averse are younger and less educated; they are less likely to be male… ." Empirical research on wealth and risk has to wrestle to separate the effects of different types of wealth, in particular, wealth measured in human capital and wealth measured in net assets, two types of wealth that often yield opposite effects on risk taking, see Martin Halek and Joseph Eisenhauer (2001), pp. 13 and 22. We have no such problem in our experiment, since we can safely assume that participants have similar amounts of human capital.

(9) I.e., all choices are actuarially fair.

(10) See Mark Machina (1982). Kahneman and Tversky were well aware of the normative significance of what we call multiple selves: see e. g. their words quoted in Section 5.1. Colin Camerer et al. *(2003) and Richard Thaler and Cass Sunstein (2003) discuss new developments in paternalistic welfare economics under the assumption of certainty.*

(11) This point is raised by Ariel Rubinstein (2001).

(12) John von Neumann and Oskar Morgenstern (1944) axiomatized Bernoulli's idea.

(13) Note that, understood as a function of the probabilities p and 1-p, the function $pu(x_1) + (1-p)u(x_2)$ *is linear, with* $u(x_1)$ *as the coefficient of p and* $u(x_2)$ *as the coefficient of* $1 - p$.

(14) Taken from Markowitz (1952, Figure 5 p. 154). In other words, there is still linearity in the probabilities, where the coefficients of the probabilities are the values of $u_w(z)$, *which depend on both w and z.*

(15) Thus applying the term "expected utility" to any preferences that can be represented by functions that are linear in the probabilities, independently of the number of selves.

(16) Note that writing z instead of x as the argument in $u_w(z)$ *is just a convention: we could as well use functions* $\hat{u}_w(x)$ *by defining* $\hat{u}_w(x) = u_w(x - w)$. *It is the inequality "*$u_{\bar{w}}(x - \bar{w}) \neq u_{\bar{\bar{w}}}(x - \bar{\bar{w}})$ *for some* $(x, \bar{w}, \bar{\bar{w}})$*" that captures the multiplicity of selves.*

(17) In other words, the linearity in the probabilities is lost, because $\pi(p)$ *is nonlinear.*

(18) This is not uncontroversial: Palacios-Huerta, Serrano and Volij (2001) argue that the "avoidance of small slightly favorable risks at an interval of wealth" (which Rabin finds plausible) implies unrealistically high degrees of risk aversion, contradicted by empirical evidence.

References

Arrow, Kenneth (1965) *Aspects of the Theory of Risk Bearing*, Yrjo Jahnsson Lectures, Helsinki, The Academic Bookstore.

Bernoulli, Daniel (1738) "Specimen theoriae novae de mensura sortis," *Comentarii Academiae Scientiarum Imperialis Petropolitanae* Tomus V (1738), 175-192, translated as "Exposition of a new theory on the measurement of risk," *Econometrica* 22(1), 1954, 23-26.

Bernstein, Peter (1996) *Against the Gods*, New York: John Wiley & Sons.

Bosch-Domènech, Antoni, and Joaquim Silvestre (1999) "Does risk aversion or attraction depend on income? An experiment," *Economics Letters* 65, 265-273.

Bosch-Domènech, Antoni, and Joaquim Silvestre (2002) "Reflections on gains and losses: A 2x2x7 experiment," mimeo, UPF working paper.

Bosch-Domènech, Antoni, and Joaquim Silvestre (2005) "The gain-loss asymmetry and single-self preferences," mimeo, UPF working paper.

Bosch-Domènech, Antoni, and Joaquim Silvestre (In press) "Do the wealthy risk more money? An experimental comparison," Chapter 6 in Karl Vind and Christian Schultz, editors. *The Birgit Grodal Symposium*, Berlin: Springer-Verlag.

Camerer, Colin, Samuel Issacharoff, George Loewenstein, Ted O'Donoghue and Matthew Rabin (2003) "Regulation for conservatives: Behavioral economics and the case for 'asymmetric paternalism'," *University of Pennsylvania Law Review* 151(3), 1211-1254.

Cox, James C., and Vjolica Sadiraj (2001) "Risk aversion and expected utility theory. Coherence for small and large scale gambles," mimeo.

Friedman, Daniel, and Shyam Sunder (1994) *Experimental Methods*, Cambridge: Cambridge University Press.

Friedman, Milton, and Leonard J. Savage (1948) "The utility analysis of choices involving risk," *Journal of Political Economy* 56 (4), 279 304.

Gollier, Christian (2001) *The Economics of Risk and Time*, Cambridge: MIT Press.

Guiso, Luigi, and Monica Paiella (2001) "Risk aversion, wealth and background risk," CEPR Discussion Paper No. 2728.

Hacking, Ian (1975) *The Emergence of Probability: A Philosophical Study of Early Ideas about Probability, Induction and Statistical Inference*, Cambridge: Cambridge University Press.

Halek, Martin, and Eisenhauer, Joseph G. (2001) "Demography of risk aversion," *Journal of Risk and Insurance* 68 (1), 1-24.

Hogarth, Robin M., and Hillel J. Einhorn (1990) "Venture theory: A model of decision weights," *Management Science* 3 (7), 780-803.

Kahneman, Daniel, and Amos Tversky (1979) "Prospect theory: An analysis of decision under risk," *Econometrica* 47 (2), 263-291.

Kahneman, Daniel, and Amos Tversky (1984) "Choices, values, and frames," *American Psychologist* 39, 341-350.

Kahneman, Daniel, and Amos Tversky, editors (2000) *Choices, Values and Frames*, Cambridge: Cambridge University Press.

Machina, Mark (1982) "'Expected utility' analysis without the independence axiom," *Econometrica* 50 (2), 277-324.

Markowitz, Harry (1952) "The utility of wealth," *Journal of Political Economy* 60(2), 151-158.

Palacios-Huerta, Ignacio, Roberto Serrano and Oscar Volij (2001) "Rejecting small gambles under expected utility: A Comment on Rabin," mimeo.

Rabin, Matthew (2000) "Risk aversion and expected utility theory: A calibration theorem," *Econometrica* 68, 1281-1292.

Roth, Alvin E. (1995) "Introduction to experimental economics," in John H. Kagel and Alvin E. Roth, editors, *The Handbook of Experimental Economics*, Princeton: Princeton University Press.

Rubinstein, Ariel (2001) "Comments on the risk and time preference in economics," Mimeo.

Starmer, Chris (2004) "Developments in nonexpected-utility theory: The hunt for a descriptive theory of choice under risk," in Colin F. Camerer, George Loewenstein and Matthew Rabin, editors, *Advances in Behavioral Economics*, Princeton: Princeton University Press.

Thaler, Richard H., and Cass Sunstein (2003) "Libertarian paternalism," *American Economic Review* 93 (2) (Papers and Proceedings), 175-179.

Tversky, Amos (1990) "The psychology of risk," in William F. Sharpe, editor, *Quantifying the Market Risk Premium Phenomenon for Investment Decision Making*, Charlottesville: The Institute of Chartered Financial Analysis.

Tversky, Amos, and Daniel Kahneman (1992) "Advances in prospect theory: Cumulative representation of uncertainty," *Journal of Risk and Uncertainty* 5, 297-323.

von Neumann, John, and Oskar Morgenstern (1944) *Theory of Games and Economic Behavior*, Princeton: Princeton University Press.

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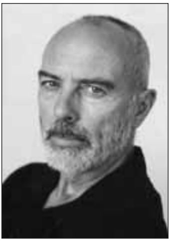

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