# Allez Allais!

By Aurélien Baillon, Han Bleichrodt & Kirsten Rohde

**What do Einstein's theory of relativity and von Neumann and Morgenstern's expected utility theory have in common? The answer is Maurice Allais, a Nobel laureate in economics who conducted experiments to falsify both.**

Maurice Allais passed away on 9 October, 2010, but his name will remain associated with an effect in physics and a paradox in economics. Discussing whether the "Allais effect" is a valid argument against Einstein's theory is beyond our competence. But as economists, we have been deeply influenced by the need Allais felt to confront economic theories with experimental tests. This contribution explains how experimental research has helped to improve economic theory. Our focus is on the three domains of individual decision-making that coincide most closely with our own research pursuits: decision under risk, decision under ambiguity, and choice over time.

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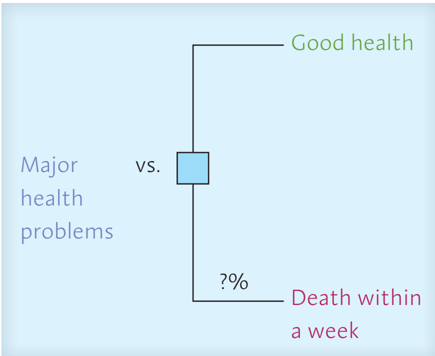
## Decision under risk

Suppose you have been diagnosed with a particular illness and have to choose between two treatment options, depicted in Figure 1. Option 1 is the certainty of living with major health problems for the rest of your life. This means that you have difficulty walking, are unable to participate in most leisure activities, and have moderate pain. Option 2 is to undergo a treatment that can either succeed, in which case you live in good health for the rest of your life, or fail, in which case you die within a week. The question you need to answer is essentially the following: Which risk of death are you willing to accept that will prompt you to opt for the treatment? 0%, 5%, 10%, 20%, or even 50%?

**Figure 1: Treatment choice**




Real data suggest that this maximum risk of death is about 10%. If the risk of death is less than 10%, we prefer the treatment, if it exceeds 10% we prefer to live with major health problems. Following expected utility (the theory that is traditionally used in economics to analyze risky decisions) would lead us to conclude that our value of major health problems is 90% of the value of good health. So, major health problems are not very serious. Their value is almost equal to good health. If we have them, we're quite all right, and policymakers concerned with healthcare shouldn't worry too much about us.

The above-mentioned method for measuring the value of health is referred to as the "standard gamble". It is widely used in health economics. But is it right? Can we deduce from the conclusion drawn above that the value of major health problems is really as much as 90% of the value of good health? Thanks to the pioneering work of Maurice Allais, we know that this is not so. Major health problems are serious, and their treatment will benefit us a great deal. Nevertheless, we still are not willing to run a large risk of death. The fault in the reasoning behind the standard gamble method lies with the conclusion that a small risk of death translates into a large value of major health problems. In other words, expected utility is wrong. It overestimates the value of life with major health problems. Consequently, cost-benefit analyses of healthcare will underestimate the burden imposed by major health problems, and too little will consequently be spent on their treatment.

The problem with expected utility is that people do not evaluate probabilities linearly, but instead weigh them. Suppose we ask you how much you are willing to pay to reduce the risk of cancer, from 1% to zero. Now, is that the same amount that you are willing to pay to reduce the risk from 5% to 4%? Expected utility says 'yes', but it appears that the two reductions are not the same. It's a different choice. Most people pay more for the former than for the latter. We find completely eliminating the risk very comforting. We want to feel safe.

Probability weighting implies that the standard gamble overestimates the value of health (Bleichrodt, Pinto and Wakker 2001, Bleichrodt et al. 2007). It thus underlines the fact that our health problems are serious and that their value is much less than 90% of the value of good health. Having established this, we need to

**Table 1: One of Machina's paradoxes**

| Number on the ball | 50 balls: 1 | 50 balls: 2 | 50 balls: 3 | 50 balls: 4 |
|---|---|---|---|---|
| *Problem 1: Which option do you prefer?* | | | | |
| Option A | €1,000 | **€2,000** | €1,000 | €0 |
| Option B | €1,000 | €1,000 | **€2,000** | €0 |
| *Problem 2: Which option do you prefer?* | | | | |
| Option C | €0 | **€2,000** | €1,000 | €1,000 |
| Option D | €0 | €1,000 | **€2,000** | €1,000 |

find out exactly *how wrong* expected utility is. Empirical estimates suggest that the overestimation is substantial. In the question posed above, using expected utility, we concluded that the value of major health problems was 90% of the value of good health. Adjusting for the empirically observed degree of probability weighting (Bleichrodt and Pinto 2000), this value is actually only 70% of the value of good health – much lower than 90%, and much more realistic.

## Decision under ambiguity

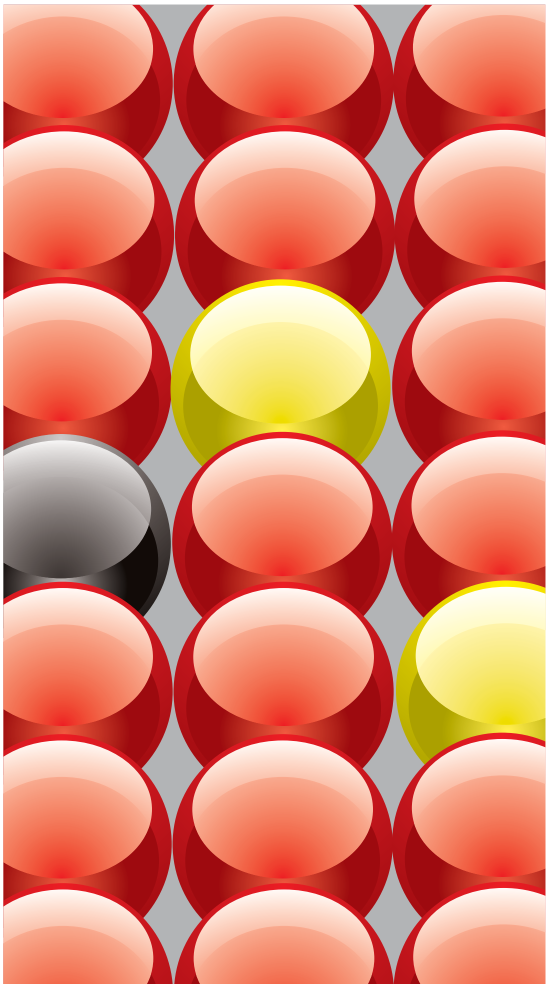
Eight years after Allais' famous paper criticizing expected utility as a model of decision making under risk, Ellsberg proposed a comparable thought experiment to show the limitations of expected utility for decision under uncertainty, where probabilities are not objectively given but are subjectively determined. Imagine an urn containing 90 balls. You know that 30 balls are red, the others being yellow or black in an unknown proportion. You can choose a colour (red, yellow or black), randomly draw a ball, and win, say, €1,000 if the colour of the ball is the one you chose. Which colour would you choose?

If you answered "red", we have good news and bad news for you. The good news is that you are like most people. The bad news is that you have just violated expected utility. Indeed, under expected utility, your answer means that your subjective probability of drawing a yellow ball is less than 1/3. The same holds for the probability of drawing a black ball. As a consequence, the sum of your probabilities for red, yellow, and black, is less than 1, which cannot be. Drawing a yellow ball and drawing a black ball are *ambiguous* events: we don't know their probabilities. Systematically choosing red corresponds with *ambiguity aversion*.

Many models have been developed to account for ambiguity aversion. One of the most widely-used is a variant of expected utility. Suppose you chose "red", because you were not sure about the probabilities of yellow and black. For instance, you thought those probabilities could be somewhere between 1/6 and 1/2, and considered a choice for red to be safer after focusing on the lower bound (1/6). Such a decision process can be captured by maxmin expected utility: you evaluate each option by its minimum expected utility (worst-case scenario) and choose the option that maximizes this minimum. Advocates of expected utility might feel relieved: it seems that expected utility can still be used, after all, albeit with minor modification.

Unfortunately, this rescue strategy does not work. Elaborating on two paradoxes introduced by Machina (2009), Baillon, L'Haridon and Placido (2010) showed that all popular models for ambiguity aversion, including maxmin expected utility, can also be falsified.

Imagine a new urn, now with 100 balls. Fifty are marked with a '1' or a '2', and the other 50 with a '3' or a '4'. We randomly draw a ball from this urn, and your payment depends on the number on the ball. Table 1 presents two decision problems, with two options each. For instance, option B in problem 1 means that you can get €1,000 if the ball is marked with a '1' or a '2' (thus, with probability 1/2), and €2,000 if the ball is marked with a '3'. Option B is the symmetric counterpart of Option C. It is therefore likely that if you choose B, you would also choose C. There is some evidence that people are attracted by B and C because in those options, at least one outcome is associated with an objective probability. But choosing both B and C cannot be explained by maxmin expected utility: there is no set of probabilities that could justify such a



"Decisions about the future are influenced by our assessment of future risks and by our degree of impatience."

“The problem with expected utility is that people do not evaluate probabilities linearly, but instead weigh them.”

choice pattern by considering the worst-case scenarios. If you chose B and C, you violated maxmin expected utility.

Since studying urns and balls sheds light on merely one aspect of everyday decision-making, we use other sources of ambiguity in our studies (weather, stock indexes) to help us understand people’s reactions to unknown risks. In the past few years, decisions made by both the government and individual citizens have highlighted the tendency to react strongly (dare we suggest, overreact?) when new threats appear. Examples include strategies to combat swine flu (for which far too many vaccines were purchased, and which governments are now desperately trying to sell), and to neutralize terrorist threats (which have led to draconian security measures like body scans at airports). Our models provide insight into such (over) reactions and help to improve government policy.

## Choice over time

Decisions about the future are influenced by our assessment of future risks and by our degree of impatience. Suppose you are asked to choose between one chocolate bar today and two chocolate bars tomorrow. Many people are impatient and choose the chocolate bar today. But what if instead you had to choose between one chocolate bar in 50 days and two chocolate bars in 51 days? Most people then choose the two chocolate bars in 51 days. What is the difference between 50 and 51 days after all? Well, this difference is the same as the difference between today and tomorrow: one day. Nevertheless, the former difference feels much smaller than the latter – just like the reduction in the risk of cancer from 5% to 4% felt smaller than the reduction from 1% to 0%. In Rohde (2010) and Attema, Bleichrodt, Rohde and Wakker (2010) we developed and implemented a method to measure such decreasing sensitivity to delay.

Assigning less weight to delays in the far future than to more immediate delays can lead to inconsistencies. This decreasing sensitivity to delay is at the heart of our tendency to keep postponing unpleasant tasks. We often have many good intentions and plans, but tend not to carry them out. Smokers intending to quit soon end up smoking their entire lives. Similarly, many people intending to save for their pension end up saving too little.

Standard economics assumes that people discount the future at a constant rate, implying constant sensitivity to delay; a delay is always perceived to be equally inconvenient, regardless of whether it occurs in the near or the far future. As noted above, this does not accurately describe people’s preferences. In Attema, Bleichrodt, Rohde and Wakker (2010) we found that the alternatives that are widely-used these days (“hyperbolic discounting” models) are too limited. In Bleichrodt, Rohde and Wakker (2009) we introduced new discounting models that can capture any degree of sensitivity to delay but that remain tractable for economic analysis. These models are based on insights from decision under risk, showing the similarities between different domains of individual decision-making. In our research we exploit these similarities, keeping in mind the wise lessons of Maurice Allais on the fruitfulness of combining insights from different areas of research.

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