SCIENTIFIC UNCERTAINTY AND FABRICATED UNCERTAINTY

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Werner Heisenberg's most famous contribution to quantum mechanics is the Uncertainty Principle, that bears his name. When coining the principle, Heisenberg was unaware of the *Treatise on Probability* published by John Maynard Keynes in 1921. There Keynes makes a sharp distinction between risk, ie uncertainty fully structured by objective probability distributions, and genuine uncertainty. Should Heisenberg's principle be called "risk principle"? That would be slightly odd, dealing, not with conscious creatures, but with the elementary constituents of matter. It however remains -and this is the important point- that, whereas the behaviour of any individual constituent is random, collectively they follow objective probability distributions that quantum theory fully predicts, and that experiments confirm statistically. The uncertainty at the core of quantum mechanics might be philosophically disturbing (Einstein never accepted it: "God doesn't play dice", as he wrote in a letter to his colleague and friend Max Born), but operationally, be it in a computer, a laser, a nuclear reactor, or in magnetic resonance imaging, it is unconsequential: one is always dealing with such large numbers of particles (electrons, photons, neutrons) that only the perfectly determined statistical laws are relevant.

Contrast this convenient state of affairs with the scientifico-political mess the British government faced twenty years ago. In 1986, the bovine spongiform encephalopathy (BSE) was registered for the first time in English cows. Then the disease spread at an astonishing pace. But according to the government, "British beef is safe" , as no contagion to humans is possible thanks to the "barrier between species". This pseudo-scientific concept, more or less relevant for some other ailments, had no theoretical foundation, and had of course not been experimentally tested in the case of BSE. The test came in 1991, when scientists at the University of Bristol succeeded in inoculating a cat with BSE; as is well known, just one counterexample destroys an hypothesis, here the existence of a barrier between species against BSE. The British government and its experts were left without any science, not even with uncertain science, at a moment when they had to face a more sinister threat: a new form of the Creutzfed-Jacob disease (CJD) striking young people (the original form appears at older ages).

Both BSE and CJD are degenerative diseases of the brain. Could they be linked? A doctor in medicine and biochemist, Stanley Prusiner, happened to be working on related questions at the University of California at Los Angeles. More exactly he was working on neurodegenerative diseases that seemed to result from disorders of protein conformation: it seemed that proteins of the prion type could, after some mutations, become infectious agents in the brain. Never before had one observed proteins turned into infectious agents. Dr Prusiner had nevertheless gathered solid experimental results on mice and had elucidated some of the molecular events responsible for the mutations of the prions and for their infectious power. The foundations were by no means complete -the experimental data were still limited and not all the relevant molecular events had been elucidated- but they appeared to constitute a significant subset of what would be a satisfactory set of experimental data and theoretical links; and they were coherent. What Dr. Prusiner proposed at the time(1) was a piece of nonprobabilistic uncertain science, however sufficiently convincing -on the basis of its methodology and of the, admittedly partial, results already obtained- to scientifically support the decision to bar English beef from being consumed in Britain and the rest of the European Union.

Decisions must routinely be made despite the fact that the available relevant information is uncertain. To decide under uncertain scientific information is not exceptional, as doctors in medicine well know. But not every piece of uncertain science is sufficiently well founded, either theoretically or experimentally, to be credible, to be worth considering in a decision process ; that was the case with the "barrier between species" concept in the BSE context. It is therefore important to be able to answer the following question: what uncertain science is worth being considered for what kind of decision?

In the case of BSE/CJD, as in the case of asbestos (see European Environmental Agency(2001)), a piece of uncertain science not only became less uncertain, but even tended to certainty, as time passed and more research was done. But it was not optimal to wait for scientific certainty before making crucial decisions: that was recognized in the case of BSE/CJD, but unfortunately not in the case of asbestos.

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[1] He subsequently made rapid progress to more complete theoretical and experimental foundations and became a Nobel laureate in 1997, ie exceptionally shortly after the publication of his results.

[2] See for example Pollack.(2003) on ecosystems: "Because of the complexity, it is extremely difficult for even the most capable ecologists to study a forest ecosystem in its full detail, and so they develop simplified concepts about the workings of the ecosystem, focusing on a few components and their interactions that are thought to be particularly significant. This conceptualization of the ecosystem web of interactions is called a model. To be sure different ecologists may perceive the interactions differently, weigh the participation of the different components differently and, therefore, develop different models. Because of the complexity, the ecosystem is imperfectly understood and uncertainty about how it all hangs together is attendant." For a concurrent appraisal concerning climatology, see Edwards (2010): "There is still a lot wrong with climate models, and many of the problems may never be solved.[...] However everything we know about the world's climate -past, present, and future- we know through models"(pp.13-14R).

In other highly complex contexts(2) -medical sciences, ecology, climatology, for example- scientific certainty cannot be expected ; scientific information may improve while remaining irreducibly uncertain . Then waiting for certainty not only is nonoptimal but even meaningless, and the concept of reliable, albeit uncertain, science is even more critical. A piece of scientific information is all the more reliable as it rests on a coherent , even if not complete, theoretical basis, and on a corresponding body of empirical evidence both well adjusted and sufficiently broad; and as it has been submitted to the rigorous scrutiny of the relevant scientific communities .

For the last twenty years, mathematicians and economists have developed structured and rigorous approaches to the processes of deciding under uncertainty, ie approaches for making proper use of a body of uncertain information. Particularly interesting are generalizations of the von Neumann-Morgenstern approach to deciding under risk: instead of relying on one exogeneously given probability distribution, the decision-maker deals with the information on the basis of an endogeneous set of probability distributions; some of these distributions put more weight on pessimistic assessments of the situation at hand; some others put more weight on optimistic assessments (see Klibanoff(2005) and Henry(2010)). It is interesting that the global reinsurance companies, like Swiss Re, München Re, Partner Re,..., use methods of that kind in order to write contracts on events for which no meaningful statistical series are available. So do specialized rating agencies in the US whose main activity is to assess the portfolios of contracts sold by insurance and reinsurance companies. In both case, it has been recognized that previous practices relying on just one (so-called) mean distribution is misleading as, in that way, a huge amount of information, uncertain albeit valuable, is lost. It is a general proposition that dismissing knowledge, however uncertain to a certain extent, amounts to losing valuable information, and this is all the more unacceptable as it is possible to deal with uncrtainty in a rational way.

"Credible science can be translated directly into political power" (Edwards (2010)). And this is true more generally for science that is perceived as credible. From Akerlof, Spence and Stiglitz' asymmetric information models, economists well know that a frequent winner is not he or she who is good,
but who looks good while avoiding the cost of actually being good. As Oreskes and Conway(2010) put it in the introduction to their book: "Call it the Tobacco Strategy. Its target was science, and so it relied heavily on scientists -with guidance from industry lawyers and public relations experts- willing to hold the

rifle and pull the trigger". They are actual "junk scientists" (see the discussion in chapter 9 of Hoggan(2009)); but such a strategy works well as long as they are seen as good, reliable scientists. and not as producers of unscientific, fabricated uncertainty; as puppets in the hands of manipulators like Frank Luntz: "Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. Therefore you need to continue to make the lack of scientific certainty a primary issue in the debate." (from the *Straight Talk Memo*, prepared for Republican candidates in the 2004 elections).

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.EPILOGUE : THE TROJANS, CASSANDRA AND THE HORSE

Blind with frenzy, we site the accursed creature on top of our sacred citadel. Then Cassandra, who, by the god's decree, is never to be believed by Trojans, reveals our future fate by her lips. We unfortunate ones for whom that day is our last, clothe the gods' temples, throughout the city, with festive branches.

Aeneid,Book II(Relation of the last days of Troy, by Aeneas to Dido)