A Richter Scale for Risk?

The scientific management of uncertainty versus the management of scientific uncertainty

Paper to be presented to the British Association meeting on environmental risk
10 September 1997, John Adams, UCL

Risk management involves balancing risks and rewards. Figure 1 is a simplified model of this process. The model postulates that
everyone has a propensity to take risks

- this propensity varies from one individual to another
- this propensity is influenced by the potential rewards of risk taking
- perception's of risk are influenced by experience of accident losses - one's own and others'
- individual risk taking decisions represent a balancing act in which perceptions of risk are weighed against propensity to take risk
- accident losses are, by definition, a consequence of taking risks; the more risks an individual takes, the greater, on average, will be both the rewards and losses he or she incurs.

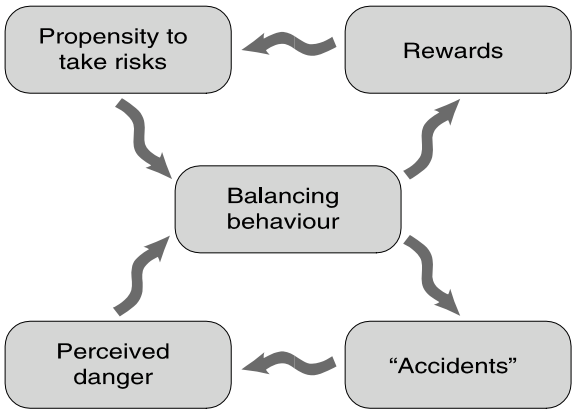

Figure 1 The risk `thermostat'

There has been a long-running and sometimes acrimonious debate between "hard" scientists - who treat risk as capable of objective measurement - and social scientists - who argue that risk is culturally constructed. In earlier papers[1] discussing how these perspectives might be reconciled, I suggested that it would be helpful, when considering how the balancing act is performed, to distinguish three categories of risk:

- *directly perceptible risks*: e.g. climbing a tree, riding a bicycle, driving a car,
- *risks perceptible with the help of science*: e.g. cholera and other infectious diseases,
- *virtual risks* - scientists do not know or cannot agree: e.g. BSE/CJD and suspected carcinogens.

In Figure 2 these categories are represented by three overlapping circles to indicate that the boundaries between them are indistinct, and also to indicate the potential complementarity of approaches to risk management that have previously been seen as adversaries.

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[1] Virtual Risk and the Management of Uncertainty, paper for the Royal Society Conference on Science, Policy and Risk 18 March 1997; short version published in the *Times Higher,* 14 March 1997.

What do mad cows, Brent Spar, the NHS and contaminated land have in common?, *What Risk?: Science, Politics and Public Health*, Roger Bate (ed), Butterworth Heineman, 1997.

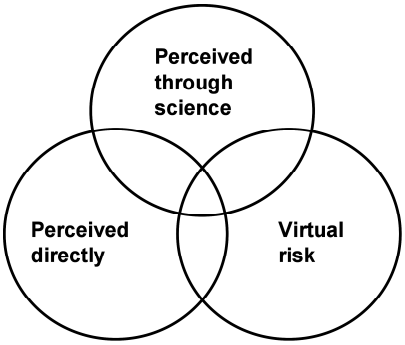

Figure 2. Three types of risk.

Directly perceptible risks

The management of *directly perceptible risks* - by toxicologists, doctors, the police, safety officials and numerous other "authorities" - is made difficult and frustrating by individuals insisting on being their own risk managers, and overriding the judgements of risk experts and the interventions of safety regulators - a phenomenon routinely attested to by millions of smokers, sunbathers, consumers of cream buns, and drinking and speeding motorists. Why do so many people insist on taking more risks than safety authorities think they should? It is unlikely that they are unaware of the dangers - there can be few smokers who have not received the health warning. It is more likely that the safety authorities are less appreciative of the *rewards* of risk taking. (Variable perceptions of risk will be discussed further in the section on *virtual risk* below.)

Directly perceptible risks are "managed" instinctively; our ability to cope with them has been built into us by evolution - contemplation of animal behaviour suggests that it has evolved in non-human species as well. Our method of coping is intuitive; everyone ducks if they see something that might hit them, without first doing a formal probabilistic risk assessment. There is now abundant evidence, particularly with respect to directly perceived risks on the road, that *risk compensation*, sometimes referred to as offsetting behaviour, accompanies the introduction of safety measures. Statistics for death by accident and violence, perhaps the best available aggregate indicator of the way in which societies cope with directly perceived risk, display a stubborn resistance, over many decades, to the efforts of safety regulators to reduce them[2].

Risk perceived through science - some limitations

The risk and safety literature does not cover all three categories equally. It is overwhelmingly dominated by the second category - *risks perceived through science* - Figure 3. Does science deserve its current dominance in risk debates?

Central to this literature is the *rational actor paradigm*[3]; the advice of the risk experts about how to manage risks is based upon their judgement about how a rational optimiser would, *and should,* act if in possession of all relevant scientific information. In

[2] See Adams, J. *Risk*, UCL Press, 1995, for a discussion of this phenomenon, and Peterson, S., and Hoffer, G.E., Auto insurers and the airbag: comment, *The Journal of Risk and Insurance*, 1996, vol. 63, no. 3, 515-523, for recent evidence concerning airbags.

[3] See Renn, O., C. Jaeger, E. Rosa, and T. Webler. 1998. 'The Rational Action Paradigm in Risk Theories: Analysis and Critique,' in Risk in the Modern Age: Science, Trust, and Society, Maurie J. Cohen, ed., London: Macmillan Press.

this literature economists and scientists strive together to serve the interests of someone we might call *homo economicus-scientificus* - the offspring of the ideal economist and the ideal scientist.

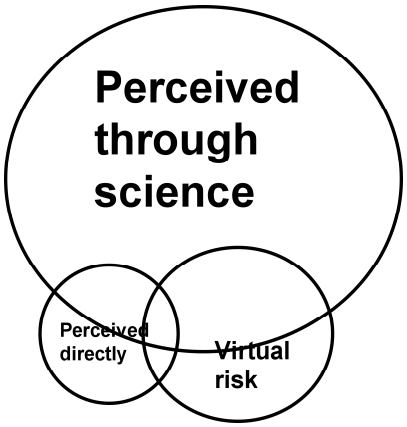

Figure 3. The dominance of the rational actor paradigm in the risk and safety literature

Infectious diseases such as cholera are not directly perceptible. One requires a microscope to see them, and a scientific training to understand what one is looking at. Science has an impressive record in making invisible, or poorly understood dangers perceptible, and in providing guidance about how to avoid them. Large decreases in premature mortality over the past 150 years, such as those shown for Britain in Figure 4, have been experienced throughout the developed world. Such trends suggest that ignorance is an important cause of death, and that science, in reducing ignorance has saved many lives. When the connection between the balancing-behaviour box and the accident box in Figure 1 is not perceptible, there is no way that it can inform behaviour.

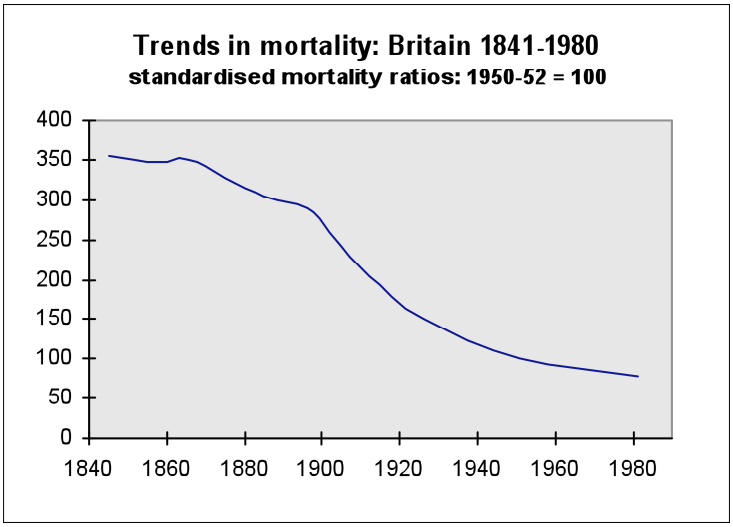

Figure 4. Source: *Living with Risk*, British Medical Association, 1987

A Richter Scale for Risk? Where this connection is poorly understood it is usually expressed in probabilistic terms, or sometimes in chains of probabilities in the form of fault trees or event trees. *Homo economicus-scientificus* is an expert gambler, sensitive to small variations in the odds associated with the risks he runs. The adherents to the rational actor paradigm, the authors of most of the "scientific" risk literature, frequently express their dismay at the inability of *ordinary* people to make sensible use of such

information, and seek ways to make their risk taking decisions better informed and more rational.

In Britain, within the past year the Department of Trade and Industry has proposed the development of a "Richter Scale for Risk" which would "involve taking a series of common situations of varying risk to which people can relate"[4]; the Royal Statistical Society has called for "a simple measure of risk that [people] can use as a basis for decision making"[5]; and the Chief Medical Officer of Health has called for the development of an agreed standard scale for communicating information about risk to the general public (see the source of Table 1). The collection of risks presented in Table 1 is a typical example of what they have in mind.

Table 1. Risk of an individual dying (D) in any one year or developing an adverse response (A)

Term used	Risk estimate	Example	
High	Greater than 1:100	A. Transmission to susceptible household contacts of measles and chickenpox	1:1 - 1:2
		A. Transmission of HIV from Mother to child (Europe)	1:6
		A. Gastro-intestinal effects of antibiotics	1:10- 1:20
Moderate	Between 1:100-1:1000	D. Smoking 10 cigarettes per day	1:200
		D. All natural causes, age 40 years	1:850
Low	Between 1:1000- 1:10000	D. All kinds of violence and poisoning	1:3300
		D. Influenza	1:5000
		D. Accident on road	1:8000
Very low	Between 1:10000- 1:100000	D. Leukaemia	1:12000
		D. Playing soccer	1:25000
		D. Accident at home	!:26000
		D. Accident at work	1:43000
		D. Homicide	1:100000
Minimal	Between 1:100000- 1:1000000	D. Accident on railway	1:500000
		A. Vaccination-associated polio	1:1000000
Negligible	Less than 1:10000000	D. Hit by lightning	1:1000000
		D. Release of radiation by nuclear power station	0
			1:1000000
			0

Source: *On the State of the Public Health: the Annual Report of the Chief Medical Officer of the Department of Health for the Year 1995,* London, HMSO, 1996, p. 13.

The risk of dying in a road accident (1:8000) is commonly found about halfway down such tables. It is included because road accidents are the most common cause of accidental death - and hence assumed to be a familiar "benchmark" risk to which people can relate for purposes of seeing other risks in their proper perspective. But there are a number of problems with this number which place in doubt the utility of the table as a guide to individual risk taking decisions.

First, the number is out of date. 1:8000 was calculated by dividing the number of people dying in a road accident in Britain by the population of Britain. The most recent number available for *Road Accident Statistics Great Britain 1995* is about half the number in Table 1 (1:15686), moving road accidents from the "low" to the "very low" category. But this error is trivial compared to the complications that would arise should an individual seek to base a risk-taking decision upon it.

A trawl through the road safety literature[6] reveals that a young man is 100 times more likely to die in a road accident that a middle-aged woman; someone driving at 3am Sunday, 134 time more likely than someone driving at 10am Sunday; someone with a personality disorder 10 times, and someone two and half times over the alcohol limit 20

[4] Minister Ian Taylor in DTI Press Notice P96/686, 11 September 1996.

[5] Editorial in *RSS News*, vol. 24, no.4, December 1996.

[6] The following examples are taken from *Traffic Safety and the Driver*, Leonard Evans, 1991, Van Nostrand Reinhold, New York.

times. If these factors were all independent of each other one could predict that a disturbed, drunken young man driving at 3am Sunday would be about 2.7 million times more likely to die than a normal, sober, middle-aged woman driving to church seven hours later[7].

These four factors, of course, are not independent; there are almost certainly proportionately more drunken and disturbed young men on the road in the early hours of the morning than at other times of day. But I have listed only four complicating factors from a very long list. Does the car have worn brakes, bald tires, a loose suspension, a valid tax disc …? Is the road well-lit, dry, foggy, straight, narrow, clear, congested …? Does the driver have good hearing and eyesight, a reliable heart, a clean licence …? Is the driver sleepy, angry, aggressive, on drugs …? All these factors, plus many more, can influence a motorist's chances of arriving safely. Whether the number used for road accidents in the Richter Scale is 1:8000 or 1:16000, it is difficult to see how it could serve as a guide to an individual risk-taking decision.

Consider another "familiar" comparator for risk frequently found in risk tables - the risk of death in an air crash. It is commonly asserted that the fear of flying is irrational, because "objectively" flying is safer than driving. John Durant, in a paper for the Royal Society's conference on *Science, Policy and Risk*[8], sets out what might be called the orthodox-expert view of the safety of flying and the problem created by popular "subjective biases".

> "the fact that many people behave as if they believe that driving a car is safer than flying in an aeroplane (when on objective criteria the opposite is the case) has been attributed to a combination of the greater dread associated with plane crashes and the greater personal control associated with driving. Faced with a mismatch between scientific and lay assessments of the relative risks of driving and flying, few of us[9] are inclined to credit the lay assessment with any particular validity. On the contrary we are more likely to use the insight to help overcome our own subjective biases in the interests of a more 'objective' view."

Evans[10] succinctly deconstructs this view. He begins with the most commonly quoted death rates for flying (0.6/billion miles) and road travel (24/billion miles) and comes to a much less commonly-quoted conclusion. He notes

1. that the airline figure includes only passengers, while the road figure includes pedestrians and cyclists,
2. that the relevant comparison to make with air travel is the death rate on the rural Interstate system which is much lower than the rate for the *average* road,
3. that the average road accident death rates that lead to the conclusion that it is safer to fly are strongly influenced by the high rates of drunken young men, while people dying in air crashes are, on average, much older and, when on the road, safer-than-average drivers, and
4. that, because most crashes occur on take-off or landing, the death rate for air travel increases as trip length decreases.

Taking all these factors into account he concludes that a 40-year-old, belted, alcohol-free driver in a large car is slightly *less* likely to be killed in 600 miles of

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[7] These factors are based on US statistics and taken from *Traffic Safety and the Driver*, Leonard Evans, Van Nostrand Reinhold, New York, 1991

[8] Overcoming the fear of flying with Joe-Public as co-pilot, *The Times Higher Education Supplement*, 14 March 1997.

[9] "Us" in this context refers, I presume, to his scientific audience at the Royal Society, and not the lay public.

[10] *Traffic Safety and the Driver* (p.362) contains a summary of the argument set out in Evans, L., Frick, M.C., and Schwing, R.C., Is it safer to fly or drive? - a problem in risk communication. *Risk Analysis*, 10:259-268; 1990.

Interstate driving - the upper limit of the range over which driving is likely to be a realistic alternative to flying - than in trip of the same distance on a scheduled airline. For a trip of 300 miles he calculates that the air travel fatality risk is about double the risk of driving. This comparison, of course, is not the complete story. The risks associated with flying also need to be disaggregated by factors such as aircraft type and age, maintenance, airline, the pilots' age, health and experience, weather, air traffic control systems etc.

The cost of insurance as a measure of risk? The insurance industry uses, generally successfully, past accident rates to estimate the probabilities associated with future claim rates. This success is sometimes offered as an argument for using the cost of insuring against a risk as a measure of risk that would be a useful guide to *individual* risk takers. Weinberg has argued[11] that "the assessment is presumably accurate, since in general it is carried out by people whose livelihood depends on getting their sums right."

However, the fact that the livelihoods of those in the insurance business depend on "getting their sums right" does not ensure that the cost of insuring against a risk provides a good measure of risk *for individuals*. The sum that the insurance business must get right is the *average* risk. For most of the average risks listed in Table 1 the variation about the average will range, depending on particular circumstances, over several orders of magnitude. Insurers depend on ignorance of this enormous variability because they need the good risks to subsidise the bad. If the good and bad risks could be accurately identified the good ones would not consider it worthwhile to buy insurance and the bad ones would not be able to afford it. This is precisely the threat to the insurance business posed by discoveries about genetic predispositions to fatal illness. The greater the precision with which individual risks can be specified, the less scope remains for a profitable insurance industry. The current debate about whether insurance companies should be allowed to demand disclosure of the results of genetic tests focuses attention on the threat to the industry of knowledge that assists the disaggregation of these averages. If disclosure is not required, people who are poor risks will be able to exploit the insurance companies, and if it is required the insurance companies will be able to discriminate more effectively against the bad risks - making them, in many cases, uninsurable.

Accident statistics do not measure danger. If a road has many accidents it might fairly be called dangerous; but using past accident rates to estimate future risks can be positively misleading. There are many dangerous roads that have good accident records *because* they are seen to be dangerous - children are forbidden to cross them, old people are afraid to cross them, and fit adults cross them quickly and carefully. The good accident record is purchased at the cost of community severance - with the result that people on one side of a busy road tend no longer to know their neighbours on the other. But the good accident record gets used as a basis for risk management. Officially - "objectively" - roads with good accident records are deemed safe, and in need of no measures to calm the traffic.

The meaning of *probability*. Britain's Chief Medical Officer of Health (Sir Kenneth Calman) says that "it is possible for new research and knowledge to change the level of risk, reducing it or increasing it."[12] This view sits uncomfortably alongside the

[11] Letter to *The Times*, 28 December 1996.

[12] See source of Table 1, p.8

Royal Society's view[13] of risk as something "actual" and capable of "objective measurement". The probabilities that scientists attach to accidents and illnesses, and to the outcomes of proposed treatments, are quantitative, authoritative, confident-sounding expressions of uncertainty. They are not the same as the probabilities that can be attached to a throw of a pair of dice. The "odds" cannot be known in the same way, because the outcome is not independent of previous throws. When risks become perceptible, when the odds are publicly quoted, this information is acted upon in ways that alter the odds. One form that this action might take is new research to produce new information.

Einstein famously argued with the quantum physicists about whether God played dice. The argument remains in the realm of theology. The current majority view among scientists is that He does. But to the extent that scientists, insurance company actuaries, and other risk specialists are successful in identifying and publicising risks that have previously been shrouded in ignorance, they shift them into the directly perceptible category - and people then act upon this new information. Risk is a continuously reflexive phenomenon; we all, routinely, monitor our environments for signs of safety or danger and modify our behaviour in response to our observations - thereby modifying our environment and provoking a further round of responses *ad infinitum*. For example, the more highway engineers signpost dangers such as potholes and bends in the road, the more motorists are likely to take care in the vicinity of the now perceptible dangers, but also the more likely they are to drive with the expectation that *all* significant dangers will be signposted.

What Calman perhaps meant when he said that new research might change the level of risk is that the probabilities intended to convey the magnitude of the scientist's uncertainty are themselves uncertain in ways that cannot be expressed in probabilities. He should perhaps have said that a scientific risk estimate is the scientist's "best guess at the time, but subject to change in ways that cannot be predicted." This brings us to uncertainty and *virtual risk*.

Virtual Risk

We do not respond blankly to uncertainty; we impose meaning(s) upon it. These meanings are virtual risks. Whenever scientists disagree or confess their ignorance the lay public is confronted by uncertainty. Virtual risks may or may not be imaginary, but they have real consequences - people act upon the meanings that they impose upon uncertainty.

The 1995 contraceptive pill scare in Britain is an example of a "scientific" risk assessment spilling over into the virtual category. On the basis of preliminary, unpublished, non-peer-reviewed evidence suggesting that the new third generation pill was twice as likely to cause blood clots as the second generation pill, Britain's Committee on the Safety of Medicines issued a public warning to this effect. The result was a panic in which large numbers of women stopped taking the new pill, with the further result that there were an estimated 8000 extra abortions plus an unknown number of unplanned pregnancies. The highly-publicised two-fold increase in risk amounted to a doubling of a very small number, which might have caused, according to the original estimates, an extra two fatalities a year[14]; even when doubled the mortality risk was far below that for abortions and pregnancies. Such minuscule risks are statistical speculations and cannot be measured directly. Subsequent research cast doubt on the plausibility of *any* additional risk associated with the new pill. The lesson that the Chief

[13] *Risk: Analysis, perception and management*, Royal Society 1992

[14] Quoted on Anxiety Attack, BBC2, 11 June 1997.

Medical Officer of Health drew from this panic (i.e. behavioural response to new information) in his annual report[15] was that "there is an important distinction to be made between relative risk and absolute risk."

Perhaps a more important lesson is that scientists, by combining uncertainty with potential dire consequences can frighten large numbers of people. Dressing up their uncertainties in very low absolute probabilities does not seem to help - especially when they are presented via a hastily called press conference which begins with the advice "don't panic". Calman observed that "although the increased risk was small, women did need to be informed that there was a difference in risk between the oral contraceptives available to them" and that "the message, to continue to take the oral contraceptive pill, seemed to be ignored in the pressure for action." From where, he might have asked himself, did this pressure for action come? Why, women might sensibly ask themselves, are they giving us this new information with such a sense of urgency if they expect us to take no action?

Cultural Filters

The women who stopped taking the pill were imposing meaning upon the uncertainties of the British medical establishment. This uncertainty was projected through, and amplified by the media. The fact of the hastily convened press conference, the secretive procedures by which the Committee on the Safety of Medicines and other government agencies arrive at their conclusions, and histories of government cover-ups of dangers such as radiation and mad cow disease have resulted in a very low level of public trust in government to tell the truth about environmental threats. A recent survey which asked people if they would trust institution X to tell them the truth about risks found that only 7 per cent would trust the Government, compared to 80 per cent who said they would trust environmental organisations.[16] This mistrust feeds a paranoid tendency which can hugely exaggerate trivial dangers.

We all, scientists included, perceive virtual risks through different *cultural filters* (Figure 5).[17] The cultural filters of scientists are usually referred to as paradigms. The discovery of the Antarctic ozone hole was delayed by such a filter. U.S. satellites failed to pick it up because their computers had been programmed to reject as errors the data that their instruments were collecting; their values lay beyond the range that the programmers had considered credible.

The influence of filters can also be detected in the debate about the effects of low-level radiation. Despite the accumulation of many decades of evidence, there is still no agreement about whether or not there is a safe dose, or perhaps even a therapeutic dose. The current issue of *Chemistry in Britain* (July 1997) continues a long-running debate on the effects of radon. The April issue contained an article (Eric Hamilton p 49) noting that "large epidemiological studies for radon levels in parts of the US, Sweden, Finland and China show that the incidence of lung cancer actually decreases with increasing radon exposures, even for levels of up to 300 Bq m^{-3}" and that "even in Cornwall and Devon, where soils and houses contain the highest levels of uranium and radon in the UK … the number of lung cancers is lower than in most other regions of the UK - despite the fact that the southwest includes a high proportion of cigarette smokers." This provoked a strong reply (July 1997) from G.M. Kendall and C.R

[15] Source of Table 1.

[16] C Marris, I Langford & T O'Riordan, *Integrating sociological and psychological approaches to public perceptions of environmental risks: detailed results from a questionnaire survey.* CSERGE Working Paper GEC 96-07, University of East Anglia, 1996.

[17] See *Risk* chapter 3, Patterns in uncertainty.

Muirhead of Britain's National Radiological Protection Board who insisted that radon caused about 2000 deaths a year in Britain and suggested that the effect in Devon and Cornwall was probably obscured by smoking. Neither side of the argument presented any statistics on smoking in Devon and Cornwall.

John Graham, vice-president in charge of environment, safety and health for British Nuclear Fuels Inc., takes the argument one step further[18], advancing the hypothesis that low-level radiation can have beneficial effects. He argues that background radiation routinely causes cell damage, for which effective repair mechanisms exists, and that there are optimum exposure levels at which the stimulation of the repair mechanisms outweighs the damage. This lay spectator judges the debate to be still unresolved.

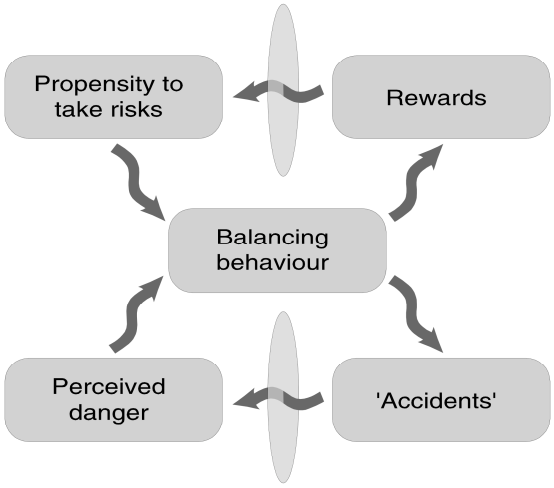

Figure 5. The risk thermostat fitted with cultural filters

Figure 6 helps to explain why the debate is likely to remain unresolved for some time yet. It is taken from *Risk Assessment in the Federal Government: Managing the Process* - a report for the US Government by the National Research Council on the assessment of the risk of cancer and other adverse health effects associated with exposure to toxins. It shows the very different dose-response relationships for low levels of exposure that it is possible to derive from the same experimental data. At high dose levels there is a predictable response. At low dose levels one is in the realm of assumption and speculation. Data simply do not exist to settle the argument about whether or not there is a "safe dose" or threshold below which one can assume no harmful effect.

But what about possible *beneficial* effects? It is not possible to display such effects on the typical dose-response graph. It is possible only to show harmful effects approaching zero. This method of presenting the data might be considered as both the product of a cultural filter that precludes the possibility of beneficial effects, and as a cultural filter in its own right.

Why, one wonders, when virtually all of the therapies produced by the pharmaceutical industry, including aspirin, are toxic above certain doses and beneficial below certain doses, should the conventional dose-response curve preclude the possibility of a benign effect? The answer, perhaps lies in the division of labour that one discovers in the risk management literature. "Risk management" usually means "risk

[18] John Graham, The benefits of low level radiation, *Uranium and Nuclear Energy 1996*, Proc. of Annual Symposium of the Uranium Inst. London, September 1996.

reduction". The remit of most risk managers is to focus on the bottom loop of Figures 1 and 5, to try to minimise the number and magnitude of adverse outcomes. Thus the first question that the US Food and Drug Administration or the British Committee on the Safety of Medicines will ask of a new food or drug is does it have *harmful* effects? The emphasis of the manufacturers, the food and drug companies, is likely to be on the top loop, the rewards to the customer and the profits to themselves. For medical risks there is a dearth of risk management institutions that seek to strike a balance between potential adverse and beneficial consequences.

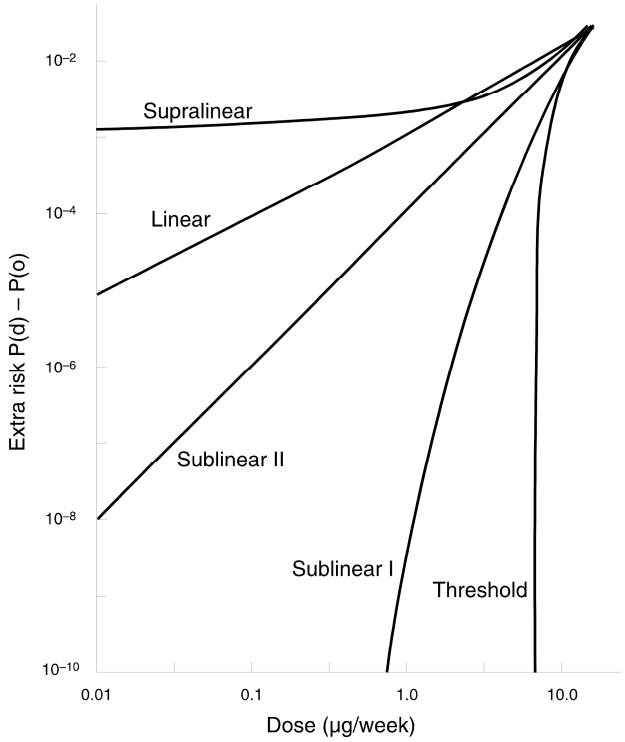

Figure 6. A family of dose-response curves

Anthropologist Michael Thompson[19] has developed a typology of cultural filters that helps to account for the different meanings imposed on uncertainty. Some people, he calls them *egalitarians*, view environmental threats as punishment for technocratic hubris, and failure to respect a fragile nature and obey its commands. They, the egalitarians, urge a retreat to practices that they label sustainable. Others, *individualists*, consider nature to be robust and capable of looking after itself, and argue that the best protection in an uncertain world is power over nature; they advocate more science and technology to buttress our defences against any nasty surprises that nature might have in store. The Government, the *hierarchists,* assure everyone that everything is under control, their control, and commission more research that they hope will prove it. And the *fatalists,* who harbour no illusions about their power to guide events, continue to read *The Sun*, watch videos, drink lager and buy lottery tickets; *que sera sera.*

Long-running controversies about large scale risks are long running because they are scientifically unresolved, and unresolvable within the time scale imposed by necessary decisions. The clamorous debates that take place in the presence of uncertainty are characterised not by irrationality, Thompson argues, but by *plural rationalities.* The contending parties argue logically, but from different premises.

Figure 7 illustrates this typology with reference to the diverse postures adopted in the controversy about whether or not new variant CJD is caused by eating BSE

[19] M Thompson, R Ellis & A Wildavsky, *Cultural Theory*, Westview Press, 1990.

infected meat. This is yet another question that remains to be resolved by science. The most recent survey of the epidemiological evidence published in the *British Medical Journal*[20] sums up the current state of knowledge: "we do not know how or indeed if bovine spongiform encephalopathy is transmitted to humans." One of the report's "key messages" is that "the observation of a group of comparatively young patients with Creutzfeldt-Jakob disease characterised by unusual neuropathological features during 1994-6 remains unexplained." And yet a leading researcher in the field, Professor John Collinge, proclaims in an interview with *The Times'* medical correspondent (7 August 1997) that "CJD could become an epidemic of biblical proportions" (this dramatic quotation served as the headline for the article). Professor Collinge went on to say "I am now coming round to the view that doctors working in this field have to say what they think, even though this may give rise to anxieties which later turn out to be groundless. … we have to face the possibility of a disaster with tens of thousands of cases … we just don't know if this will happen, but what is certain is that we cannot afford to wait and see." This *egalitarian* call for precautionary action in the face of uncertainty met, two days later in the *Sunday Telegraph*, a robust *individualist* response which also raised the question of what the nation could afford: "the efforts of the scientists behind last year's BSE scare to defend their alleged link with 'new variant Creutzfeldt Jacob disease' become ever more comical as the epidemic they promised fails to materialise … how much longer should we continue to look for objective guidance on this matter to experts who have invested so much of their own personal reputations in the theory that a link between BSE and new variant CJD exists … faced with a bill now rising above £5 billion … how much longer can we afford it?"

The contending rationalities not only perceive risk and reward differently, they also differ about how the balancing act ought to be performed. *Hierarchists* are committed to the idea that the management of risk is the job of "authority" - appropriately advised by experts. They cloak their deliberations in secrecy because the ignorant lay public cannot be relied upon to interpret the evidence correctly or use it responsibly. The *individualist* scorns authority as "the Nanny State" and argues that that decisions about whether to wear seat belts or eat beef should be left to individuals. *Egalitarians* focus on the importance of *trust*; risk management, they argue, should be a consensual activity requiring openness and transparency in considering the evidence.

These different styles of balancing act respond differently to uncertainty. Ignorance is a challenge to the very idea of authority and expertise. The response of *hierarchists* is to conceal their doubts and present a confident public face. Confession of ignorance or uncertainty does not come easily to authority; in the face of uncertainty about an issue such as BSE they seek to reassure. *Individualists* are assiduous collectors of information - even paying for it - but are also much more comfortable with uncertainty. Their optimism makes them gamblers - they expect to win more than they lose. Markets, in their view, are institutions with a record of coping with uncertainty successfully. If the

Figure 7. BSE/CJD: a typology of bias

Fatalist	**Hierarchist**
• "They should shoot the scientists, not cull the calves. Nobody seems to know what is going	• "We require public policy to be in the hands of elected politicians. Passing responsibility to scientists can only undermine confidence in politics and science." John Durant, *The Times Higher*

[20] Sporadic Creutzfeldt-Jakob disease in the United Kingdom: analysis of epidemiological surveillance data for 1970-96, SN Cousens, M Zeidler, TF Esmonde, R De Silva, JW Wilesmith, PG Smith, RG Will, *BMJ* 16 August 1997.

on." Dairy Farmer quoted in *The Times* (2.8.96)  • "**Charles won't pay for Diana's briefs**" Main headline in *The Sun* on 21.3.96, the day every other paper led with the BSE story.	5.4.1996 • "As much as possible, scientific advice to consumers should be delivered by scientists, not politicians." *The Economist*, 21 March 1996 • "I believe that British beef is safe. I think it is good for you." (Agriculture Minister Douglas Hogg 6.12.95) "I believe that lamb throughout Europe is wholly safe." (Douglas Hogg, 23.7.96) • "I felt the need to reassure parents." Derbyshire Education chief quoted in *The Sun*, 21,3.96 • "I have not got a scientific opinion worth listening to. My job is simply to make certain that the evidence is drawn to the attention of the public and the Government does what we are told is necessary." Health Secretary Stephen Dorrel, *Daily Telegraph,* 22.3.96 • "We felt it was a no-goer. MAFF already thought our proposals were pretty radical." Richard Southwood explaining why he had not recommended a ban on cattle offal in human food in 1988, quoted by B Wynne, *Times Higher* 12.4.96
Individualist • "The precautionary principle is favoured by environmental extremists and health fanatics. They feed off the lack of scientific evidence and use it to promote fear of the unknown." T. Corcoran, *The Toronto Globe and Mail* • "I want to know, from those more knowledgeable than I, where a steak stands alongside an oyster, a North Sea mackerel, a boiled egg and running for the bus. Is it a chance in a million of catching CJD or a chance in ten million? I am grown up. I can take it on the chin." Simon Jenkins, *The Times,* quoted by J. Durant in *Times Higher*, 5.4.96 • " 'Possible' should not be changed to 'probable' as has happened in the past." S.H.U. Bowies, FRS, *The Times* 12.8.96 • "It is clear to all of us who believe in the invisible hand of the market place that interference by the calamity-promoting pushers of the precautionary principle is not only hurtful but unnecessary. Cost-conscious non-governmental institutions are to be trusted with the protection of the public interest." P. Sandor, *Toronto Globe and Mail* 27.3.1996 • "I shall continue to eat beef. Yum, *yum*." Boris Johnson, *Weekly Telegraph*, no 245.	**Egalitarian** • Feeding dead sheep to cattle, or dead cattle to sheep, is "unnatural" and "perverted". "The present methods of the agricultural industry are fundamentally unsustainable." "Risk is not actually about probabilities at all. It's all about the trustworthiness of the institutions which are telling us what the risk is." (Michael Jacobs, The Guardian, 24.7.96) • "The Government … choose to take advice from a small group of hand-picked experts, particularly from those who think there is no problem." Lucy Hodges, *Times Higher* (5.4.96) • "It is the full story of the beginnings of an apocalyptic phenomenon: a deadly disease that has already devastated the national cattle herd … could in time prove to be the most insidious and lethal contagion since the Black Death." "The British Government has at all stages concealed facts and corrupted evidence on mad cow disease." "Great epidemics are warning signs, symptoms of disease in society itself." G. Cannon in the foreword to *Mad Cow Disease* by Richard Lacey • "My view is that if, and I stress if, it turns out that BSE can be transmitted to man and cause a CJD-like illness, then it would be far better to have been wise and taken precautions than to have not." Richard Lacey ibid.

Source: J. Adams, Cars, Cholera and Cows: virtual risk and the management of uncertainty, *Science Progress,* 80 (2) 1997

experts cannot agree about BSE, there is no basis upon which central authority can act; the risk should be spread by letting individual shoppers decide for themselves. The *egalitarian* instinct in the face of uncertainty is to assume that authority is covering up something dreadful, and that untrammelled markets will create something dreadful. They favour democratising the balancing act by opening up the expert committees to lay participation and holding public inquiries to get at the truth - which, when known, will justify the intervention in the markets that they favour.

Conclusions

Science has been very effective in reducing uncertainty, but much less effective in managing it. The scientific risk literature has little to say about virtual risks - and where the scientist has insufficient information even to quote odds, the optimising models of the economist are of little use. A scientist's "don't know" is the verbal equivalent of a Rorschach Inkblot: some will hear a cheerful reassuring message; others will listen to the same words and hear the threat of catastrophe.

Science has a very useful role in making visible, dangers that were previously invisible, and thereby shifting their management into the directly perceptible category. Where science has been successful it has reduced uncertainty, and thereby shrunk the domain of risk perceived through science; now that its causes are well understood, cholera, for example, is rarely discussed in terms of risk. But where the evidence is simply inconclusive and scientists cannot agree about its significance we all, scientists included, are in the realm of virtual risk - scientists usually dignify the virtual risks in which they take an interest with the label hypothesis. Figure 8 indicates the relative significance that I suggest hypotheses should be accorded in risk debates.

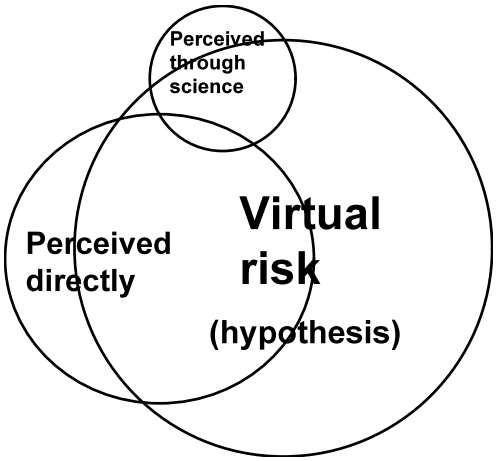

Figure 8. Reality?

The role of science in debates about risk is firmly established; clearly we need more information and understanding, of the sort that only science can provide, about the probable consequences of "balancing behaviours" for both "rewards" and "accidents". But equally clearly we must devise ways of proceeding in the absence of scientific certainty about such consequences - science will never have *all* the answers - and in so doing we must acknowledge the scientific elusiveness of risk. The clouds do not respond to what the weather forecasts say about them. People do respond to information about risks, and thereby change them.

In the presence of virtual risk even the precautionary principle becomes an unreliable guide to action. Consider the ultimate virtual risk, discussed from time to time on television and in our newspapers. Edward Teller and NASA invoke the precautionary principle to argue for the commitment of vast resources to the development of more powerful H-bombs and delivery systems to enable the world to fend off asteroids - *even if the odds of them ever being needed are only one in a million*. But we are also told by Russia's Defence Minister that "Russia might soon reach the threshold beyond which its rockets and nuclear systems cannot be controlled."[21] Which poses the greater danger to life on earth - asteroids or H-bombs and delivery systems out of control?

[21] Quoted in *The Times*, 8 February 1997.

Debates about BSE, radiation and asteroid defences are debates about the future, which does not exist except in our imaginations. They are debates to which scientists have much to contribute, but not ones that can be left to scientists alone. An understanding of the different ways in which people tend to respond to uncertainty cannot settle arguments. It does offer the prospect of more coherent and civilised debate amongst all those with a stake in such issues.