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Mad Cows and Ecstasy: Chance and Choice in an Evidence-based Society

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[The Address of the President, delivered to The Royal Statistical Society on Wednesday, June 12th, 1996]

1. INTRODUCTION

It is not only a great honour to have been chosen to serve as the President of the Royal Statistical Society but also a privilege to be the first holder of the office to have the opportunity to give a presidential address in these splendid Errol Street premises.

The Society has now completed a full year's occupation of its new home and, as I remarked in my foreword to this year's annual report, the considerable advantages of having a self-contained headquarters building are already apparent. The enhanced office and meetings facilities for staff and Fellows are of obvious and direct benefit to us all, and the architectural charms of the building are a source of much pleasure and pride.

But with the merger now well behind us and the move to Errol Street completed, this seems to many Fellows to be an appropriate time to review the Society's profile and image, and to re-examine its strategies for promoting the role of statistics in our national life.

In my address this evening, I shall explore what I see as some of the key issues relating to such 'outreach' on the part of the Society—in particular, some issues relating to communication and education.

2. OUTREACH

From its very beginning, the Royal Statistical Society has sought to contribute to the development of what we might call an evidence-based society, in which informed quantitative reasoning is the dominant modality in public debate, as well as in the decision-making processes of government, business and individuals.

However, the innumerate and confused nature of so much political, public and media reaction to major issues involving uncertainty and risk continues to serve as a reminder to us of just how far we still are from realizing this goal.

So what should we be doing, as a professional and learned Society, to improve and extend our various forms of 'outreach' and to achieve greater influence on the world around us? Where do the problems lie? Is it simply our own technical and public relations failure to communicate sufficiently clearly and aggressively what we all know to be the fundamental importance and relevance of our discipline? Or are there more deep-seated, social and cultural obstacles?

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3. STATISTICS AND AN EVIDENCE-BASED SOCIETY

3.1. *The Science of Statistics*

Contributing to the development of an evidence-based society was certainly implicitly among the aspirations of our founding fathers, who saw the original purpose of the Royal Statistical Society as being to

‘collect, arrange, digest and publish facts, illustrating the condition and prospects of society in its material, social and moral relations; these facts being for the most part arranged in tabular forms and in accordance with the principles of the numerical method’.

As statisticians, we have, of course, expanded our activities enormously beyond this original, rather humble, purview. My predecessor neatly characterized this expanded spectrum of activities under four broad headings: data collection and presentation; inference from relatively small sample surveys or experiments; modelling and analysis of complex stochastic systems; and, crucially, involvement with the ‘larger stage . . . the territory of politics, management, the law, philosophy and the sciences. . .’ (Bartholomew, 1995).

An upbeat way of viewing our subject is to see statistics as ‘the science of doing science’, whose role is to provide theory and protocols to guide and discipline all forms of quantitative investigatory procedure. Such theory and protocols fall under the following kinds of heading: the framing of questions; design of experiments or surveys; drawing up protocols for data collection and recording; collection of data by sampling or observing; monitoring compliance with protocols; monitoring data quality; data storage, summarization and presentation; stochastic modelling; statistical analysis; model criticism and the assessment of assumptions; inference reporting and the use of results for prediction, decision-making or hypothesis generation.

It is part of the success story of statistics that so many people who are not primarily statisticians accept the need to work within this framework as a pre-requisite for being judged competent in their own primary fields. And the Society has long since come to accept that many such people are highly capable statisticians in their own right, and that it is not appropriate for us to claim an exclusive right to practise the science of doing science.

But our recognition that it is not appropriate to seek to restrict the practice of statistics to a ‘closed shop’ should not inhibit us from asserting, as and when necessary, the very real nature of our own expertise, or from acknowledging and exercising our responsibility to investigate, and, if necessary, to expose, perceived instances of statistical incompetence, or lack of integrity or judgment.

It should therefore certainly be a continuing part of our outreach strategy to identify and monitor areas of activity in government, science or business, which actually or potentially involve a significant statistical element, but where appropriate levels of statistical awareness and competence are currently lacking. Technical outreach in promoting the appropriate use of the tools and methods of the science of statistics will remain a major concern of the Society.

However, from the point of view of the general public, for the most part statistics impacts on day-to-day life not directly through its methodology but through the ‘evidence’ which results from its application. This gives rise to a different perspective on ‘outreach’.

3.2. *Towards an Evidence-based Society*

Most of us with rationalist pretensions presumably aspire to live in a society in which decisions about matters of substance with significant potential social or personal implications are taken on the basis of the best available evidence, rather than on the basis of irrelevant evidence or no evidence at all. Of course, the nature of what constitutes evidence in any particular instance could be a matter for significant debate. But, modulo such debate, most of us have the aspiration to live in a society which is more, rather than less, 'evidence based'.

But what, in concrete terms, is required to move society further in this direction? And what role should the Society play?

Others performing on the larger stage—albeit certainly much influenced by statisticians—have set their own agenda in respect of taking concrete steps in the direction of an evidence-based society.

In particular, there has been the growth of a movement in recent years calling itself 'evidence-based medicine', which perhaps has valuable lessons to offer. This movement has its antecedents in the work of people like Archibald Cochrane, who, in the 1970s, were concerned at what they saw as the disappointing level of real effectiveness of medical services, and the mismatch between the resources employed and health status outcomes achieved. Cochrane and others argued that these deficiencies were mainly attributable to the lack of systematic use of scientific method, particularly in evaluating therapeutic interventions through the use of controlled trials.

Part of what the movement is about is described as follows by its leading proponents:

'Evidence-based medicine is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence-based medicine means integrating individual clinical experience with the best available external clinical evidence from systematic research. . . . Without current best evidence, practice risks becoming rapidly out of date, to the detriment of patients' (Sackett *et al.*, 1996).

From a conventional statistical point of view, what does this amount to? At one level, it manifests itself in the creation of targeted databases of systematic literature reviews of statistical evidence—see, for example, Chalmers and Altman (1995) for a recent overview from a mainly statistical perspective. But this is also accompanied by a commitment to communicating findings in a readily assimilable form to relevant practitioners. One such enterprise, the Cochrane Collaboration, is an international network of individuals and institutions committed to the preparation, maintenance and dissemination of systematic reviews of the effects of health care. The aim is that

'At the bedside or in the office, physicians should have instantaneous, up-to-date assistance from an affordable, universally available database of systematic reviews of the best evidence from clinical trials . . . data from the trials would have to be presented in a standardized, graphic, and easily comprehensible form . . . if the only information the physician received was that there was no reliable information . . . that in itself would be extraordinarily useful' (Bero and Rennie, 1995).

But what is so special about medicine? We are, through the media, as ordinary citizens, confronted daily with controversy and debate across a whole spectrum of public policy issues. But, typically, we have no access to any form of systematic

‘evidence base’—and, therefore, no means of participating in the debate in a mature and informed manner. Obvious topical examples include education—what *does* work in the classroom?—and penal policy—what *is* effective in preventing re-offending?

Perhaps there is an opportunity here for the Society—together with appropriate allies in other learned societies and the media—to launch a campaign, directed at developing analogues of the Cochrane Collaboration, to provide suitable evidence bases in other areas besides medicine, with the aim of achieving a quantal shift in the quantitative maturity of public policy debates.

3.3. *Institutional Obstacles to an Evidence-based Society*

For many people, the word evidence conjures up an immediate association with the law. It is somewhat paradoxical, therefore, that the procedures and protocols of UK law-courts seem so much at odds with the kinds of disciplined scientific reasoning that many of us would see as essential in an evidence-based society.

To us, it is a commonplace that so-called ‘common sense’ is woefully inadequate for dealing with issues involving conditional probability. The ‘prosecutor’s fallacy’—the confusion of the conditional probability of A given B with that of B given A—has often been the subject of correspondence in *RSS News*. And the kind of conundrum typified by the ‘game show problem’ can prove challenging to even the brightest students of probability.

Moreover, empirical studies have repeatedly shown that people’s intuitive processing of information tends to ignore base rates (see, for example, Eddy (1982)). There is a very real need for adherence to formal probabilistic reasoning if gross errors are to be avoided.

However, as I was finishing preparing this address, a newspaper article appeared (The Times, 1996), reporting a judgment of the Court of Appeal, Criminal Division, which included the following:

‘Evidence of the Bayes Theorem or any similar statistical method of analysis in a criminal trial plunged the jury into inappropriate and unnecessary realms of theory and complexity, deflecting them from their proper task . . . their Lordships . . . had very grave doubts as to whether that evidence was properly admissible because it trespassed on an area peculiarly and exclusively within the jury’s province, namely the way in which they evaluated the relationship between one piece of evidence and another. The Bayes Theorem might be an appropriate and useful tool for statisticians, but it was not appropriate for use in jury trials or as a means to assist the jury in its task.’

So there we have it. To hell with rationality as we know it—their Lordships have pronounced!

This is bad enough, but the legal mentality displayed here has knock-on effects well beyond the confines of the courts. A not insignificant number of Members of Parliament are lawyers. Perhaps as a consequence, the style of debate and enquiry which characterizes much of the working of the UK Parliament and its committees stresses and rewards the mastery of an adversarial style, employed for short-term effect, rather than any long-term commitment to an evidence-based approach. The discussion of our national affairs therefore takes place in an overwhelmingly superficial and silly atmosphere, which runs counter to the more dispassionate forms of evidence gathering and assessment that should characterize a mature democracy.

However, there are those—e.g. in the Parliamentary Office of Science and Technology—who seek to bring a more scientific and technical focus to bear on parliamentary debates and we should undoubtedly try to do more, as a Society, to aid and abet their efforts.

So far as the processes of government are concerned in the UK, we still remain a far from ‘open’ evidence-based society. There can be little hope for informed debate if secrecy is the norm, or if mechanisms for deliberately selective reporting become part of the government communication machine—as in March 1992, when a leaked document described the mission of the recently established National Health Service (NHS) Corporate Affairs Intelligence Unit to be that of enabling Ministers to present a ‘positive account’ of the NHS. And, apart from national security issues, why is it not standard practice for scientific advice to government to be in the public domain? Of course, it may sometimes be difficult to strike a balance between the needs of openness and confidentiality, but current practice in the UK certainly leans too far towards the latter.

In the Government Statistical Service itself, there has obviously been much progress, and welcome shifts of emphasis, since the dark days of the Rayner report. But the continuing decentralization of the service and the close involvement of many statisticians with the narrowly focused policy needs of their departments is still a worry to many in the Society. Is decentralization a hindrance to obtaining a unified statistical perspective on issues which cut across the responsibilities of any one department? Is the dispersion of statisticians conducive to the maintenance of a high level of continuing, professional statistical development? In such a system, can individual statisticians really be sufficiently protected from local departmental pressures?

The Society wishes the new Head of the Government Statistical Service—and the newly created Office for National Statistics—well for the future. We shall watch developments with interest and judge them by how well they ultimately serve the purposes of an open, evidence-based society.

3.4. *Sociological Obstacles to an Evidence-based Society*

An underlying premise in much of what I have said is that being ‘scientific’ is good and being ‘unscientific’ is bad. However, it is important for us to be aware that—in one manifestation of ‘post-modernism’—an increasing number of people are coming to see science more as part of the problem than as the pre-eminent way of finding solutions (see, for example, Beck (1992)). For example, risks from the use of nuclear power and chemical manipulation in the production of food-stuffs loom large in many people’s thoughts. Typically, the scientific and technical response is to claim that all would be well but for ‘human error’ (reactor operators’ faults at Chernobyl; farmers’ faults in using herbicides under inappropriate conditions, thus causing the production of dioxins). This kind of response is ultimately alienating. The problem is compounded by the fact that scientific experts are increasingly perceived to be closely associated with government and industry and thus no longer seen as disinterested seekers after truth. And these perceptions are unlikely to diminish. Academics are pressured into such relationships by the current funding climate in higher education. And various plans have been mooted to privatize many of the government-funded, but currently independently operated, research agencies in the UK.

Where do we fit into all this as statisticians? I think that we have positive things to contribute that distinguish us from mainstream science and technology, and provide us with opportunities to offer the public a different perspective.

From a technical point of view, the kind of thinking that comes naturally to us in the context of the Taguchi approach to experimental design is highly relevant to the robust design of complex technological systems and to considerations of robustness in the conditions of use of herbicides. In this latter context, for example, scientific studies of the toxicology of the relevant chemicals, conducted under carefully controlled conditions in the laboratory, established beyond any doubt that a certain class of herbicides, used under the correct specified conditions, posed no danger of producing dioxins. But this is of monumental irrelevance to actual usage in the field, where instructions for use are mislaid, or become illegible after rain or are ignored because of time or economic pressures. An aware, statistical design perspective, with an eye to robustness in use, would have suggested building these externally varying factors into the laboratory studies.

So far as the dangers of close relationships between scientists and government and industry are concerned, there may be valuable lessons to be learned from the conduct of clinical trials. Here, there are often close associations between the pharmaceutical industry and individual scientists and statisticians working in the area. But the existence of a regulatory framework, and the statutory need for monitoring and ethical committees in the conduct of trials, seems to provide sufficient checks and balances to maintain public confidence in the process.

In summary, I believe that, when necessary, we should use the perspective of statistics as the science of doing science to distance ourselves somewhat from the insensitive excesses of single-minded science and technology, and to assert rather more strongly our potential role as a resource for disinterested comment and advice.

4. COMMUNICATION

4.1. *Relating to Other Constituencies*

An evidence-based society requires not just evidence—and some form of consensus about what constitutes evidence—but also open access to and communication of that evidence, in a form which can be understood and acted on, either by individuals, institutions or public policy makers. The evidence must be communicated in a form which is meaningful to the intended audience.

This seems to me to be an issue which we need to take much more seriously. Communication only takes place if people are listening and the message is understandable. Of course, it is important to retain the honest core of whatever message it is that we wish to convey, but it is essential to find the appropriate style and language if there is to be real impact.

Even when the attempted communication is with educated peer groups, such as lawyers or journalists, the cultural barriers can be considerable. This is well illustrated by the following contribution from a lawyer, given at a meeting between lawyers and statisticians, which the Society organized several years ago:

'I am the idiot boy here today . . . large parts of the things that have been said here are absolute gobbledegook to me. I could not make head nor tail of most of it. Bear in mind . . . that the average lawyer cannot even work out figures with a computer. We are dealing

in a field which we simply do not understand. It therefore behoves you, if you want us to accept your views, to put them in a simple language which we do understand . . . it is not a question of the lawyers coming to terms with your field of expertise. Do not go along with the idea that we ought to conform to what you want. You . . . are coming into our field. If you are coming to us, unhappily, it is for you to adapt to us, and not for us to adapt to you . . . lawyers, in general, tend to distrust expert evidence . . . for the same reason that most people also distrust expert knowledge — because they do not understand it. When we do not understand something it is very difficult to accept it as the basis for forming judgement' (Napley, 1982).

I have already made clear earlier my rejection of the extraordinary presumption that the court is the private domain of the lawyer, in which statisticians (and other experts) are, at best, temporary guests, who should mind their manners, or, at worst, are trespassers, to be seen off the premises at the first sign of insubordination.

However, the fact remains that, if we do not appear relevant and do not make ourselves clearly understood, we will not be listened to and will not have the influence that we rightly seek. We must take this on board if we wish to have more effect on the media. If there is a Society point of view which we wish to convey in the context of breaking news, we must be prepared to distil it into the form of a brief and readily understandable press release. If we identify material which is to appear in our journal and we feel has the potential to provide the basis of an interesting feature which would raise the profile of statistics, we must be willing to draw it to the attention of appropriate journalists and to facilitate any resulting follow-up.

4.2. *Relating to the Individual*

I believe that an important aspect of appearing relevant involves taking seriously the problem of relating our subject to the individual.

When individual members of the public are confronted by arguments about health or environmental issues, the question most likely to be asked is 'how does this affect me or my immediate family?'. In so far as the statistician's answer is couched in terms of 'averages', or frequencies of occurrence calculated by reference to membership of a 'population' with which the individual does not readily identify, there will be a lack of perception of relevance on the part of the individual and a failure of communication on the part of the statistician. There are no doubt contexts in which the unavailability of disaggregated data makes this inevitable, but even when — let us say — careful studies have made it possible to identify a risk factor taxonomy of a population are we really able to communicate this in a meaningful way?

In part, of course, communication is bedevilled by problems of the basic lack of the requisite mathematical education — of which more later. But it is not just a matter of mathematics. I think that there is much more that we could do to have an effect — both in terms of formal education and in the realm of communication to the general public.

Returning for a moment to evidence-based medicine, although many would see systematic reviews as the key element, it is interesting to note the insistence in the movement's basic credo on

' . . . thoughtful identification and compassionate use of individual patients' predicaments, rights and prejudices in making clinical decisions about their care' (Sackett *et al.*, 1996).

I am not clear how this translates into practice in the evidence-based medicine context, but I want to pick it up here to flag several important issues which I suspect are at the heart of many of the difficulties we have, as statisticians, with our public image and with impacting effectively on public policy debates.

First, there is specific concern with relevance to the *individual*; secondly, there is an explicit reference to *decision-making*; thirdly, there is an implicit commitment to taking into account individual *utilities*. In the next section, I shall argue that, if we aspire to more effective outreach to the general public, we need to pay more attention to individual psychology, and individual perceptions of chances and choices.

5. CHANCE AND CHOICE

5.1. *The Psychological Dimension*

People are fascinated with people, particularly with themselves. By comparison, even the fascination of Bayes theorem pales into insignificance! But, as statistical educators and communicators, we do not acknowledge or exploit this sufficiently.

For example, people are fascinated to learn how population responses to questions can be affected by the order in which alternatives are presented. Responses, in a poll in the USA, to the two forms ‘Should divorce in this country be easier to obtain, more difficult to obtain, or stay as it is now?’ and ‘Should divorce in this country be easier to obtain, stay as it is now, or be more difficult to obtain?’ resulted in 36% replying ‘more difficult’ to the first form and 46% to the second, with 41% replying ‘stay as it is now’ to the first form and 29% to the second (Schuman and Presser, 1981).

Plous (1993) has provided an entertaining survey of the role of this and other psychological factors in activities such as perceiving randomness, interpreting evidence and making decisions. Greater concern with these issues on the part of statisticians would, I believe, have two benefits. First, it would make us more aware of how people actually think and behave — and this is surely a necessary prerequisite for learning how to communicate more effectively. Secondly, the introduction of more of the psychological dimension into our teaching would both humanize the project and emphasize the relevance of the material to the individual.

5.2. *Decision and Utility*

Psychological and technical elements combine particularly effectively in the context of individual decision-making in situations of uncertainty. However, despite the clear pedagogical opportunities which this offers, decision-making and utility are topics which play little role in the dominant statistical paradigms as they are taught to most students. Instead, they are topics that are more likely to be found in psychology or operational research courses.

I think that this is a major mistake on our part — not just because the ideas are central to my own view of how to provide a disciplined framework for the effective use of statistical evidence, but also because they enable us to engage the attention of the general public and of students — at all ages and stages — in a way that standard presentations of statistical analyses do not. In particular, they emphasize the direct individual relevance of what can otherwise seem individually irrelevant.

For example, the discussion of whether or not it is rational for an individual to participate in the lottery makes no sense whatsoever unless embedded in a decision

framework. Such a discussion requires an explicit reference to the person's utility function for money, or perhaps to a multiattribute utility function, which allows for trade-offs between monetary outcomes and the value of participation in the gamble. High-minded condemnation of the general public for 'not understanding the probabilities' seems to me rather to miss the point.

Everyone has an interest in money, and a discussion of chance and choice in the context of monetary decisions has an obvious appeal. However, most people are also obsessed about their health. Several years ago I was involved in a project in Nottingham to evaluate the use of decision analysis in clinical decisions (for a detailed discussion of concepts and applications, see Spiegelhalter and Smith (1981)). Outreach activities took the form of open days for the general public and we were astonished to find that people would queue patiently for hours for the privilege of receiving an individual probabilistic diagnosis of their stomach problems. They would also queue to get to the computer to respond to an interactive questionnaire aimed at assessing their utilities for remaining life expectancies in the contexts of risky operations. The attention of individual physicians was also readily engaged. In the setting of a clinical unit, treating severe liver disease, utilities elicited from physicians provided consensus values which were then used in a decision analysis to derive an operating strategy for the unit.

I would not wish to underestimate the problems and pitfalls in implementing these procedures in clinical and other settings. The point that I am emphasizing here is more a pedagogical one, namely that we should pay more attention to the fact that probability and statistics come to life in these kinds of decision settings, in a way which engages people's interest and makes clear the relevance of the ideas to individual lives.

5.3. *Risk*

Perhaps the main way in which members of the general public engage with the evidence-based society is in seeking guidance on 'risks'. There is certainly a growing public concern about the ways by which risks are identified, quantified and managed. Statistics is by no means the only discipline involved here, but it certainly plays a key role. Should the Society be more directly involved in the 'risk business' — and, if so, how?

An overview of problems associated with the analysis, perception and management of risk is given in a recent Royal Society study group report (Royal Society, 1992). In particular, the report draws together some estimates of risks derived from observation on humans. Some typical examples are shown in Tables 1–3. But are these kinds of numbers easy to use? Do they facilitate the informed engagement of the individual with an evidence base that helps to provide a guide to action?

An obvious question to raise is the appropriateness of the form of quantification presented. Table 1 is calibrated in terms of kilometres travelled. But, at different stages of our lifetime, we might engage with the different modes of transport in rather different proportions and, in any case, the travel speeds differ enormously. The combination of these factors makes it less than obvious how we could use these figures directly if we were concerned about risk per time exposure.

There also appears to be no systematic updating of these risk estimates over time. Since some of them are extremely out of date (see Table 2) and others clearly change quite significantly over time (see Table 3), this is an important problem.

TABLE 1
*Travel: deaths per 10⁹ km travelled
(1986–90)*

Rail	1.10
Air	0.23
Bus or coach	0.45
Car or taxi	4.40
Motorcycle	104.0
Bicycle	50.0
Pedestrians	70.0

TABLE 2
Sport: deaths per 10⁶ participant-hours

Amateur boxing, UK, 1946–62	0.5
Canoeing, UK, 1960–62	10
Rock-climbing, UK, 1961	40
Scuba diving, UK, 1970–80	220
Hang-gliding, 1977–79	1500

TABLE 3
Medical procedures: deaths per 10⁶ cases

Vaccination	1
Anaesthesia, 1970–73	40
Anaesthesia, 1986	5
Childbearing, 1974–76	100
Childbearing, 1987–89	69
Needle biopsy of liver	200

It would appear that, currently, no specific agency is charged with the task of developing and maintaining an appropriate database.

Perhaps the Society should consider initiating a debate about the need for appropriate forms of national ‘riskometer’, to provide easily understood operational guidance to the public about everyday risks, and to enable new risks as they arise to be calibrated against familiar ones.

6. EDUCATION

6.1. Numeracy

The Society has a clear and obvious interest in numeracy and I see most of this address as being concerned with numeracy in one form or another, going well beyond just the problems of numeracy in the context of school mathematics. However, in considering education, this context is vital and I wish to discuss it at some length.

6.2. Tackling the Mathematics Problem

In his 1989 presidential address, Sir John Kingman discussed the dual role of statisticians as guardians of a mathematical theory relating to uncertainty and as

collectors and commonsense interpreters of data (Kingman, 1989). He concluded — and I entirely agree with his conclusion — that ‘responsible statistical practice requires the support of a strong theoretical infrastructure’.

Further concern about the general problem of mathematical education in the UK was expressed by Peter Moore in his 1990 presidential address (Moore, 1990). This concern has not gone away. In higher education there is a worry both about the numbers of prospective students in the mathematically based disciplines and about their mathematical preparedness when they enter university.

In the light of such concern, the Society joined the London Mathematical Society (LMS) and the Institute of Mathematics and its Applications (IMA) to produce a report entitled *Tackling the Mathematics Problem* (London Mathematical Society, Institute of Mathematics and its Applications and Royal Statistical Society, 1995), which analysed these concerns in detail and suggested some actions.

The report noted that, although recent changes in school mathematics may have had advantages for some pupils, they have failed to lay the necessary foundations to maintain the quantity and quality of mathematically competent school-leavers. In particular, the changes have greatly disadvantaged those who need to continue their training beyond school level.

Serious problems perceived by those in higher education include a lack of ability to undertake numerical and algebraic calculation with fluency, a marked decline in analytical powers when faced with simple problems requiring more than one step and a changed perception of what mathematics is, in particular of the essential place within it of precision and proof.

The report identifies as a major cause of these problems the flawed method of planning changes in school mathematics over the past decade. It notes that there has been no representative, authoritative, continuing national forum for mathematics in the UK, bringing together mathematicians, scientists, engineers, employers and teachers. Instead, increasing power has been assumed by the bureaucrats of the Schools Curriculum and Assessment Authority (SCAA), with debate and consultation degenerating into a one-sided dialogue between the SCAA and individual bodies, with agenda setting and decision-making controlled by a small and necessarily unrepresentative group within the SCAA.

In recent years, English school mathematics has seen a marked shift of emphasis, with a variety of time-consuming activities, including project investigations, data surveys, etc., introduced at the expense of core technique. At first sight, it might be expected that this Society would welcome the exposure of pupils to topics such as data surveys, which have obvious intrinsic educational value. However, in the context of competing for limited time within the core curriculum, priorities must be set, against a realization of the harm being done to core competences.

During the same period, there has been implicit advice — from Her Majesty’s Inspectorate (1985) and the Office for Standards in Education (1994) — that teachers should reduce their emphasis on and expectations concerning technical fluency. The associated jargon asserts that ‘*process* is at least as important as technique’, but fails to recognize that a detailed understanding of any process is dependent on having acquired a robust technical fluency.

Clear evidence exists of the increasing inability of English pupils to solve problems involving decimals, fractions, ratios, proportions and algebra (Hart *et al.*, 1981; Assessment of Performance Unit, 1985). But this has been interpreted by those

responsible for defining national curricula as demonstrating that the topics are 'too hard' for most English pupils in their lower secondary years and hence need to be postponed.

This outrageous interpretation ignores two key facts: first, that many of the topics postponed or eliminated are fundamental to subsequent progress in mathematics and cannot be neglected without serious knock-on consequences; secondly, that many countries—including some whose pupils start schooling at a later age than in England—manage perfectly well to teach these topics to a far larger percentage of pupils than we do. And, while on the topic of international comparisons, it is surely a matter of considerable concern that the Department for Education (1994) report includes no data that enable us to calibrate our national performance with that of other countries.

We are faced with a situation where double A-level mathematics entries in England and Wales have dropped from 14200 in 1970 to 5400 in 1994, with single entries increasing slightly from 50200 to 56900 (the cohort of 18-year-olds dropping from 628000 to 557000 over the same period). This makes a sorry comparison with the situation in France, where the number obtaining the Series C Mathematics and Physical Sciences Baccalaureat has increased from 21443 in 1970 to 66438 in 1993 (whereas arts entries only increased from 64502 to 74431 over the same period).

Following the publication of the report, representatives of the Society, the LMS and the IMA have had a series of exchanges with the Secretary of State for Education and with officers of the SCAA, including a meeting with Sir Ron Dearing shortly before the completion of his report on education in 16–19-year-olds. However, although we may have persuaded some people in the current government that there is a problem, we have not thus far been successful in our key aim of achieving a rethink of the current organizational structure, which leaves policy-making power in the totally inappropriate hands of the SCAA. We have now had the opportunity to put our case to senior education policy representatives of the main opposition party. We await subsequent developments with interest. In the meantime, we will continue to press the case at every opportunity and to reiterate the two major proposals that the joint working party has made to the Department for Education:

- (a) first, that a standing committee be established, including, after consultation with professional and learned societies, substantial representation from higher education—the committee would provide an overview, from primary school through to university, and ensure that sound advice and adequate support are provided to those involved in the organization and delivery of mathematics education;
- (b) secondly, that a committee of enquiry on the curriculum be established, to examine the current situation and to make proposals in time to allow for carefully considered action at the end of the current moratorium on change.

7. MAD COWS AND ECSTASY: OUTREACH REVISITED

In the main, the Society's contribution over the years to raising the profile of statistics and statisticians, and to improving the quantitative standards of national debate, has not been achieved by high profile public statements, but rather by the educative, trickle-down effect of our mainstream activities. Historically, in the case of

the Society, this has largely been through its regular discussion meetings and the work of its Sections and Local Groups; in the case of the Institute of Statisticians, this was largely through concern with education and professional accreditation — areas of activity receiving ever-increasing attention in the merged Society.

However, recent forays by the Society into the more high profile territory of direct contributions to topical public debate have certainly alerted Fellows to our potential to influence national policy decisions.

The report of the Working Party on the Measurement of Unemployment in the UK attracted much media and political attention in 1995 — and there is continuing debate in the new Office for National Statistics about the possible implementation of the Society's proposals. Similarly, the Society's meeting on 'league tables' was extremely successful in bringing together academic and government statisticians, pro-actively setting the agenda, and generally informing the national debate about problems associated with performance measures for public institutions in health and education.

Such interventions have clearly whetted the appetites of Fellows for more such public involvement. The Society must therefore think carefully about appropriate strategies for deciding when and how we should seek to become involved.

In the first place, we need to consider carefully the nature of the issues and the context of the debate. In the case of unemployment measures, the main issues are self-evidently statistical, and this is also true to a large extent in the case of league tables. It is clearly right and proper in such cases for the Society to seek to make a major contribution. Moreover, the timescales for the debate in these two cases have permitted detailed investigations to be undertaken and working parties or meetings to be set up by the Society. This has enabled detailed conclusions to be drawn and requirements for further research and debate to be identified.

In sharp contrast, many of the key issues relating to 'mad cows' and ecstasy — whose topicality and high profile in the UK at the time of preparing this address I have shamelessly exploited in choosing my title — have not been perceived as being primarily statistical in nature by government Ministers, the public or the media. In the case of links between the cattle disease bovine spongiform encephalopathy (BSE) and Creutzfeldt-Jakob disease (CJD) in humans, the issues have been seen as essentially the province of laboratory scientists and veterinarians. In the case of deaths related to taking the recreational drug ecstasy, the issues have been regarded as the province of doctors and policemen. Also, discussion of BSE-CJD and ecstasy, at least initially, has taken place in rather panic-stricken political circumstances, where the media sound-bite has been the primary form of access to debate.

These two contrasting contexts clearly pose very different problems when it comes to invoking the name and authority of the Royal Statistical Society in putting forward contributions to the public debate. These are problems both of substance — what can we say that can be legitimized as a Society view? — and of logistics — how do we arrive at that view, particularly when a relatively rapid rather than a longer-term considered response is required? Further problems arise in making judgments, at any given stage in a debate, about the extent to which a statistical intervention *per se* is appropriate. Does the problem have a sufficiently significant statistical component? Is a statistical view possible at all without closer and deeper immersion in non-statistical scientific or other issues? Where can or should the boundary be drawn between statistical and policy analysis and advice?

In particular, how could or should the Society react to mad cows and ecstasy?

In the case of BSE–CJD, many Fellows—to judge from electronic mail correspondence on ALLSTAT—clearly felt that the Society should be ‘doing something’ and there were some signs of frustration that we had not made a high profile public statement. In fact, the Society was asked directly by the government’s BSE advisory committee to comment on certain specific statistical issues and this we did, making a fairly forceful statement about the needs as we saw them. Once our World Wide Web pages have been set up, it will be possible to inform Fellows immediately of such involvement and perhaps to avoid such feelings of frustration. However, I have to say that, apart from the possible abuse of Ministers for their nonsensical assertions of ‘no risk’, there was little scope in this case for achieving anything by making public statements. Several Fellows of the Society have been involved in various aspects of the problem in their individual scientific capacities, and the Society is inevitably reliant on advice from such experts within its ranks if it is to comment in very specific terms. But, in a rather fast moving situation, with enormous scientific complexity, such experts do not necessarily agree on solutions, and perhaps the most useful role that the Society can then play is to press, behind the scenes, for greater awareness of the statistical issues and to encourage open debate. The Parliamentary Office of Science and Technology’s (1996) report acknowledges the Society’s contribution in this form.

In the case of ecstasy, there has not been any call for the Society to make public statements. This seems to me rather interesting, since, from a statistical point of view, it would seem *prima facie* easier for us to make clearer statements in this case than in the case of BSE–CJD. Imagine, then, that we have been successful in selling the concept of the national ‘riskometer’ and are being put on the spot to calibrate the risks of taking ecstasy against the risks from taking other drugs—e.g. aspirin—or following other recreational activities—e.g. canoeing. How should the Society react? An honest analysis might well result in shock–horror headlines of the form ‘Royal Statistical Society says ecstasy is safe’. But prudent reticence would seem at odds with our desire to promote an evidence-based society, where open and informed numerical debate is the norm.

We clearly need, as a learned and professional society, to debate these issues carefully before we rush to conclusions about how we attempt to raise our profile. An asymmetric loss function awaits our public utterances. Silence lays us open to the charge of being pusillanimous and may temporarily frustrate some of our Fellows; but ill-considered, instant ‘rent-a-stat’ opinions could do our public image great and lasting harm.

8. EPILOGUE

Karl Pearson said this of Florence Nightingale.

‘Florence Nightingale believed—and in all the actions of her life acted upon that belief—that the administrator could only be successful if he were guided by statistical knowledge. The legislator—to say nothing of the politician—too often failed for want of this knowledge. Nay, she went further: She held that the universe—including human communities—was evolved in accordance with a divine plan. . . . But to understand God’s thoughts, she held we must study statistics, for these are the measure of his purpose. Thus the study of statistics was for her a religious duty.’

In a more secular age, many of us would doubtless express this differently — but I hope with no less conviction. Our discipline is vital to the honest and decent conduct of public affairs and to promoting an informed perspective on chance and choice in an evidence-based society.

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VOTE OF THANKS

D. J. Bartholomew (London School of Economics and Political Science): On first reading the President's address I was much attracted by the idea of establishing a Society record for brevity. It appeared that nothing more was called for than for me to rise, to utter a fervent 'Amen' and then to resume my seat. On further reflection, and noting that I had not been given the usual caution about length, it seemed that nothing short of a page-by-page analysis would suffice. In the end, discretion triumphed over valour and I offer, instead, a more traditional vote of thanks.

I strongly agree that the Society should champion the cause of reason by encouraging the creation and maintenance of a base of information so that decisions, public and private, can be based on the way that the world actually is. Since evidence needs to be interpreted, we must provide a lead and ally ourselves with all those who seek to match our education system to the demands which a new millennium will bring. But enthusiasm must be tempered with caution. There is only one thing worse

than failing to shoulder our responsibilities, and that is falling down under their weight. Our successes will soon be forgotten but one spectacular failure, like the episode of the Meteorological Office and the great gale of October 1987, will dog our steps for a generation. The Society's outreach must be *selective*, *informed* and *sustained*. It is not the number of media appearances which ultimately counts but effecting change by the slow winning of the argument.

Let me make two further points. The first is a suggestion for overcoming one of the difficulties which the President pin-pointed. The truth about 'he who pays the piper' is acutely felt in academic circles and beyond. It is becoming increasingly difficult to maintain independence and objectivity in what were once the bastions of free thought and opinion. But not all are so constrained. Statisticians, like everyone else, are tending to retire earlier and to live longer. There is a growing pool of experience among those, still many years short of senility, who are beholden to no one. This 'retired' or, more euphemistically, 'senior' college is something which the Society could co-ordinate and service.

My second point touches deep and difficult issues relating to collective decision-making and risk taking. It is interesting that a recent issue of *The Times Higher Education Supplement* contained a supplement about risk in modern society. This was linked with the annual meeting of the Society for Risk Analysis—Europe. I note, in passing, that this supplement seemed untouched by statistics or statisticians and ask whether this Society should be a target for joint meetings. But to return to the point, the President rightly points out that decision-making needs utilities as well as probabilities. But different people have differing utility functions and many of today's important public decisions must be made in the face of irreconcilable divisions.

'*The Higher*' supplement already referred to provides a good example. Suppose that a developed country does a deal with a less developed country on the following lines. The less developed country agrees to take toxic waste from the other in return for payment that is sufficiently substantial to reduce the risks to its own population from other sources significantly. The effect of such a transaction could be a net reduction in the level of risk in *both* countries. To the statistician this might seem to be a text-book example of the 'sure thing' principle but a majority of Austrians do not see it that way. They believe that any country has a responsibility to take care of its own rubbish. This view does not necessarily result from a misunderstanding; nor is it a view which could be changed by the production of more data or by compulsory classes in decision theory. It arises from a rationally held view about the nature of human society and responsibility. It needs no imagination to see similar dilemmas arising over nuclear power, abortion or drug taking, to which the President alluded.

I mention this, not in any sense to discourage outreach, but rather to encourage us to think hard about how far we can go together, as statisticians, and where we may have to part for reasons which lie beyond our common professional concerns. The means by which conflicting aspirations and philosophies can be peacefully accommodated within a pluralist society is an internal as well as an external problem.

It is clear, I hope, how much I have enjoyed this address and, on behalf of us all, I warmly thank the President for the lead which he has given. I look forward to interesting times. More formally, it is with pleasure that I propose the vote of thanks.

T. M. F. Smith (University of Southampton): Before responding to the President's address I would like to add my appreciation of Peter Diggle's contribution to the Society over the last 6 years. We are all indebted to our Honorary Officers.

I share with the President not only a surname and a confusingly similar set of initials but also the fact that both of us have used the term post-modernism in our presidential addresses. In his thoughtful address the President rejects the anarchy of much post-modern thinking in favour of an evidence-based society in which decisions are made after rational debate using scientifically collected information. True to his Bayesian credentials he presents us with an ideal towards which the Society should move. His final quotation about that eminent Victorian statistician, Florence Nightingale, reminded me of the fact that at one time Gladstone had in his Cabinet five Fellows of the Society, including himself. In contrast today's Cabinet is dominated by lawyers!

I particularly liked the definition of statistics as 'the science of doing science, whose role is to provide theory and protocols to guide and discipline all forms of quantitative investigatory procedure'. Despite enormous ethical difficulties progress is being made in medicine, and there is no reason why the standards adopted in epidemiology should not be applied to social enquiry. There will be no simple answers but at least simplistic solutions will be demonstrated to be false. The examples of the risks from the use of nuclear power and the application of herbicides remind us that laboratory protocols are not

adequate for social enquiry; external factors which cannot be controlled should feature in the design. The Taguchi approach to social studies is long overdue.

A more rational society requires citizens who can appreciate arguments based on quantitative analyses. Such citizens should be numerate. Mathematics has never been well taught to the majority of English school-children. My parents complained about their inability at mathematics, and many of my contemporaries boasted about their lack of mathematical knowledge. There is no easy solution but one of the contemporary methods, making mathematics appear relevant, fails dismally in the teaching of probability, as the following examples from national examination papers demonstrate.

- (a) John cycles to school on average 3 days out of 5. Bill cycles to school on average 2 days out of 5. Find the probability that on a certain day they will both cycle to school.
- (b) If the probability of there being a drop in temperature tomorrow is 0.8 and the probability of it raining is 0.5, what is the probability of neither event happening?

The implied assumption of independence in these examples is both mathematically naïve and scientifically wrong. It undermines good teaching in both areas and instead of being relevant is misguided and misleading. Teaching probability through the old-fashioned medium of balls in urns would at least give our citizens an appreciation of their chance of winning the lottery, as well as the potential to understand that scientific models of uncertainty are analogues of these simple systems.

I have to admit that I was disappointed with the President's analysis of 'mad cow' disease and ecstasy. In the spirit of the title I had hoped to see a display of the relevant evidence. There were no tables of data and even more surprising no posterior distributions of the expected numbers of deaths. From his discussion it is clear that for Creutzfeldt-Jakob disease the President believes that the posterior distribution of the number of deaths is rather flat, whereas for ecstasy it is sharply peaked at a surprisingly low number. This corresponds to my own prior belief but I would value some hard evidence to enable me to modify my purely subjective prior. In the search for some relevant facts I turned to the Internet. My surfing skills are poor but I managed to find an entry for 'factsheets about BSE' from the Ministry of Agriculture, Fisheries and Food (MAFF). I was both surprised and annoyed to discover that an MAFF fact is a public relations press release, and so I retired dataless and demoralized. The Society should heed the President's message, and that of our founders, and have as the mission for at least one of its publications the presentation of numerical facts about contemporary issues, not just for the benefit of Fellows, but also for the benefit of society at large.

I have great pleasure in seconding the vote of thanks.

The vote of thanks was passed by acclamation.