

Hardy's wit and amusement statistics

Statistics and Truth: Putting Chance to Work (Ramanujan Memorial Lectures). C. Radhakrishna Rao. Council of Scientific and Industrial Research, New Delhi, 1989. 143 pp.

C. R. Rao is, to many, India's greatest statistician. During his most productive phase (1945-75) several results of great beauty and depth flowed from his pen: the Cramér-Rao inequality, the Rao-Blackwell theorem, the contributions to multivariate analysis, linear estimation, generalized inverses of matrices. In fact, such was the surge of his contribution that his mentor, P. C. Mahalanobis, is rumoured to have asked the Royal Society of London to delay the award of its fellowship to Rao lest he turn complacent (Rao eventually became FRS in 1967). Rao is also a very prolific writer; he is the author of a dozen books, including that great classic, *Linear Statistical Inference and its Applications*, an epitome of rigour and presentation.

It is therefore a pleasant surprise to find Rao taking an excursion away from linear manifolds and unbiased estimators and talking about more mundane affairs: how to date a literary work, how to resolve a controversy involving Shakespeare and Bacon, how to prove that Mendel (and even Newton) probably faked some of their data, how to resolve a case of disputed paternity, how to correctly estimate the mean sojourn time of tourists in Morocco. All this promises to be rollicking reading, but there is a small problem: Rao appears a trifle uncomfortable; his writing lacks the abandon and the flair that must accompany such narratives. But never mind. The Master has condescended to pronounce, and we must be grateful.

Consider, for example, what Rao has to say about randomness and chance. Many of us grew up with the belief that you could unravel the secrets of the universe by tossing a coin, or rolling a die. All this new talk of mathematical chaos and determinism is therefore very frightening. Is randomness dying? Has the theory of chance suddenly lost its virtue? Is Albert Einstein chuckling away to himself, reminding us that he always held that 'God does not play dice'? 'No', Rao

reassures us. 'God continues to toss a coin. In fact, He is probably tossing a more perfect coin because the best random binary sequences are provided by birth statistics in India.' As for Einstein, let him be! After all, 'did he not accept the chance behaviour of molecules embodied in the Bose-Einstein theory'? But, we persist, how do you reconcile chaos with chance? 'Chance', says the Master, 'deals with order in disorder, while chaos deals with disorder in order. Both may be relevant in modelling real-life phenomena.'

Being an elder (Rao turns 70 in September 1990) and a veteran, he provides a fair sprinkling of anecdotes and encounters with other statistical giants who have now passed into the infinite. Karl Pearson, the inventor of Monte Carlo simulation techniques (now enjoying unprecedented popularity with the advent of computers), once advised Rao that 'the record of a month's roulette-playing at Monte Carlo can afford us material for discussing the foundations of knowledge'. Rao, ever the good pupil, took this advice seriously, and contributed to the foundations of statistical inference. Rao is also puzzled with new attitudes: 'Thirty years ago, when we submitted papers containing simulation studies to journals, the editors were reluctant to publish them. Now, even when we have exact solutions, editors still want a simulation study!'

The implication that Mendel probably faked some of his data is also made gently and without malice. Rao writes: 'The overall probability of such good agreement is $7/100,000$, which is very small. It is therefore likely that Mendel was deceived by some assistant who knew too well what was expected.' Very charitable indeed, but then Rao belongs to the era of grace in mathematics and science. And how do statisticians prove that Mendel and Newton were cheating? By looking for what Haldane used to call 'second-order faking'. If a theory is looking for a 3:1 ratio, Rao says, 'it is always possible to choose two numbers whose ratio is neither too close to, nor too far from' the sought ratio. But consider the sequence of numbers averaging to this ratio and look at, for example, clusters of five in this sequence. Subject

them to the chi-square test, and one will find 'unusual uniformity'! There are several other examples of statistical deceit, including Lazzarini's incredibly accurate computation of π , which was reported with great fanfare in 1901.

So the book goes along, with eye-catching anecdotes to break the monotony. An example (of G. H. Hardy at a Trinity high table; quoted by Sir Ronald Fisher):

'Do you mean, Hardy, if I said that two and two make five, that you could prove any other proposition you like?'

'Yes, I think so.'

'Well, then, prove that McTaggart is the Pope.'

'Well, if two and two make five, then five is equal to four. If you subtract three, you will find that two is equal to one. McTaggart and the Pope are two; therefore McTaggart and the Pope are one.'

The book also contains examples of Indian ingenuity of which I shall only mention one. During the communal riots in 1947, a large number of people of one community took refuge in the Red Fort. It was obviously the Government's responsibility to feed these refugees, and the task was entrusted to a contractor. This contractor, predictably enough, was a crook. He submitted food bills that appeared to be inflated, but which nobody could verify since the Red Fort was out of bounds. The question was: how many refugees were there inside? A clever statistician found the answer: Let R , P and S represent the quantities of rice, pulses and salt listed in the contractor's bill. Let r , p and s represent the per capita requirements of rice, pulses and salt. It is therefore clear that R/r , P/p and S/s are equally valid estimates of the same number of persons. But while rice was expensive, salt cost almost nothing. The wily contractor was therefore expected to inflate R while retaining the correct value of S . The Government therefore paid only for S/s persons, instead of a figure closer to R/r , and the contractor was left wondering how he had been caught in this one!

Rao goes on to recount many such examples of Indian ingenuity and then poses a worrying question: where is In-

dian statistics now headed after its blazing performance in the fifties and sixties? Elsewhere he asks why Indian statisticians are still not embracing the computer when it is such an indispensable tool. Sadly, Rao has himself to do some of the answering. Why did he quit the Indian Statistical Institute in the seventies when he was its unquestioned supremo? Even today he is perhaps the best choice to restore Indian statistics to its old glory. Will he assume this mantle?

But we must not persist with such questions. We must instead rejoice that Rao is still in full possession of his faculties. When S. K. Joshi, director of the National Physical Laboratory in Delhi, asked him if, as someone past sixty, he was not doing science more harm than good, Rao replied with stiff pride, 'Thomas Huxley's assertion is probably *statistically* true, but I am trying to follow Lord Rayleigh by being an active scientist throughout my life.' A wonderfully positive sentiment this, and we must salute the man. Many years ago, when I was a first-year student at the Indian Statistical Institute in Calcutta, Rao walked into the class and gave a most inspiring impromptu lecture on the foundations of statistics. That day many of us secretly decided that we would emulate the great man. Most of us have failed, as we were perhaps destined to, but it is reassuring to note that the great man is still around, and that the sheer magnitude

of his achievement continues to be a source of inspiration to all of us.

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Astronomy reviews

Annual Review of Astronomy and Astrophysics 1989. Vol. 27. G. Burbidge, D. Layzer and J. G. Phillips, eds. Annual Reviews Inc., Palo Alto, USA. 1989. 773 pp. \$51.

Any serious student of astronomical sciences is familiar with the *Annual Reviews*. They contain authoritative, state-of-the-art reviews on various timely topics. The authors are commissioned by the editors; and the reviews are not refereed so that the authors do not have to try to anticipate what the referee would say.

The 1989 volume contains 16 articles by 29 authors. They scan a wide spectrum of topics, starting with a computer model of light pollution at US observatories due to projected increase in city population. Other articles cover the Sun, the stars, interstellar space, the Milky Way galaxy, the Local Group, and galaxies in general. Then there is a review on the astronomer's delight, su-

pernova 1987A, based on 376 published articles and preprints.

A minor suggestion: provide the contents of the article at the beginning, as is done by *Reviews of Modern Physics*.

A noteworthy regular feature of the *Reviews* is a charming autobiographical essay by a distinguished astronomer. Given the rather ugly appellation 'prefatory', the essay brings alive the persona behind the small-print name that appears at the end of articles. Lyman Spitzer, talking about the offer of a professorship at Princeton and also the directorship of the Observatory, says disarmingly: 'I soon accepted; ever since my graduate student days I had felt this would be an ideal position. For this offer I am grateful to three of this country's greatest astronomers—to Russel for his support, to Chandrasekhar for not accepting the earlier offer..., and to Shapley for informing Princeton of my longstanding interest in this particular post....'

A handful of recent *Reviews* would provide the reader with an up-to-date survey of recent research work in astronomy. If there is one periodical in astronomy that needs to be brought out in an inexpensive Indian edition, it is this series.

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