Selected Papers of C. R. Rao. S. Das Gupta *et al.* (eds). New Age International (Pvt) Ltd, 4835/24, Ansari Road, New Delhi 110 002. 2001. vol. 5. 496 pp. Price: Rs 750.

The book under review contains 32 selected papers by C. Radhakrishna Rao, the most distinguished Indian statistician, published during 1986–1999. The first four volumes covered the periods 1945–1953, 1954–1965, 1966–1974 and 1975–1985 respectively.

Rao has been a dominant personality in statistics for more than fifty years, first in the Indian Statistical Institute (ISI) and later in USA, after his retirement from ISI. His philosophy of research in statistics is best summarized in his own words: 'Since statistics is essentially the science, technology and art of solving problems in all investigations, scientific or otherwise, it is imperative that a statistician should work in collaboration with research workers in other fields, understand their problems, suggest necessary experimentation to collect data and devise appropriate statistical tools for solving them. This is how expansion of statistics takes place. There is nothing like a statistical problem which statistics purports to solve. Problems belong to the basic disciplines' (cf. p. 458).

Research papers in this volume amply demonstrate this approach and almost every paper has its origin in a real-life problem. At the same time, Rao makes use of very powerful mathematics, including probability theory to solve statistical problems.

Rao has been consistently interested in multivariate analysis. In this volume, he deals with pattern recognition based on discriminant functions (paper no. 5), selection of covariates in growth curve models (no. 14), principal component analysis of familial data and multivariate measures of interclass and intraclass correlations in familial data (nos 15 and 16). These papers clearly bring out Rao's urge to develop new methods of analysis of multidimensional data.

In paper no. 25, he deals with the problem of predicting/estimating positions of multiple targets (signal processing and tracking of targets) whose motions are governed by certain dynamical linear equations in vector random variables and suggests simple implementation procedures.

Paper no. 10 deals with characterization of distributions within the class of elliptically symmetric distributions based on constancy of certain conditional expectations. It also extends to characterizations based on independent and identical distributed random variables to sequences of exchangeable random variables. These results have potential applications in modelling multivariate data as well as in Bayesian analysis.

Some of the characterizations obtained by Rao and his colleagues are related to problems where what we can record is affected/damaged by the very process of observation or by some other physical process. For example, the number of eggs laid by an insect (x) may get distorted or damaged and the actual record (y) would be the number of eggs that hatch into larvae. (Such situations are known as 'Damage models'.) Rao and his colleagues have come up with many interesting characterizations of probability distribution based on the inter-relationships between the distribution of the actual record y and the original value x. Such characterizations are statistically very relevant, particularly when the distributions of x and y are of the same type and the observer has to be careful in interpreting and analysing such data sets. Characterizations are obtained using solutions of the Cauchy and Choquet-Deny type functional equations (paper nos 1 and 6).

In another paper (no. 2), Spitzer's integral representation for stationary measure of a discrete branching process is obtained and the result is used to provide a complete solution of a problem in damage models. This is another instance where Rao exploits probability theory in studying statistically relevant situations.

Least square (LS) theory is one of the fundamental and popular methods of estimation of unknown parameters. Throughout his career, Rao has made very significant contributions to this theory. The estimates obtained by this method are affected when one has data from a distribution having longer tails than the Normal Probability Law. In the least absolute deviation (LAD) of L_1-norm-based methods, we minimize the sum of the absolute values of the differences between the observed and the expected. Rao initiated a research programme on L_1-norm and related techniques with the group at the Center for Multivariate Analysis, University of Pittsburg. This volume contains a review paper (no. 6) on statistical methodology based on L_1-norm. Paper no. 20 establishes asymptotic properties of LAD estimators in censored regression models. The multivariate analogue of the LAD method is called LD (least deviance) estimation. Paper no. 12 investigates the asymptotic properties of LD-estimators and suggests analogues of classical LS procedures. Both LS and L_1-norm-based methods date back to the seventeenth century; however the latter have not yet become popular in statistics as they involve tedious calculations and unlike the former, use asymptotic distribution theory. Also, they may be less efficient than some other robust procedures like the rank-based methods for one-dimensional data.

With the computing advancements and modern statistical techniques such as bootstrap, methods suggested by Rao and other statisticians may become more popular. Rao also discusses how to use bootstrap for L_1-based methods. He further discusses a Poisson bootstrap which removes some of the anomalies in the standard bootstrap procedures. In the suggested bootstrap, the number of distinct observations can be controlled unlike the standard bootstrap. To prove that suggested bootstrap procedures are superior to the standard normal approximation, Rao employs techniques based on Edgeworth expansions which have become a very prominent tool in bootstrap theory.

Distances between observed and their expected values can also be defined by using convex discrepancy functions, besides the two discussed above. Minimizing these to obtain estimates of the parameters leads to M-equations and M-estimators. Three papers (nos. 17, 21 and 22) in this volume discuss properties of M-estimators and develop multivariate ANOVA-type tests for the standard linear model.

Mahalanobis had considered situations where it is more meaningful to compare quantile regression (QR) functions between populations rather than the regression functions based on the conditional mean. For example, suppose X is income of a family and Y records

the per capita consumption of milk in a family and we want to compare the pattern of milk consumption over different economic levels of individuals in two populations. The income distributions of families may be quite different in the two populations. The families in the population can be ranked by income and the regression of milk consumption on the income rank in the two populations can be compared. This leads to the QR function. Papers nos. 28 and 30 respectively, deal with the weak convergence in the Skorohod metric and the law of the iterated logarithm for the empirical cumulative QR function.

In publishing selected papers of Rao, the editors aimed at 'reaching the broad spectrum of theoretical and applied statisticians to generate new ideas and promote research in the various fields to which Professor Rao has contributed'. Undoubtedly, this goal will be achieved. The editors have done a very commendable job in compiling these volumes.

The editors also rightly thought that Rao himself is the best person to explain the context and motivation for the wide variety of problems on which he has worked for the last sixty years. Thus, the present volume includes 'Three score years of research in statistics' by Rao. This article is a must for every research student in statistics and the editors may consider bringing it out as a separate booklet.

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The Human-Brain: Essentials of Behavioural Neuroscience. Jackson Beatty. Sage Publications India Pvt Ltd, M-32 Market, Greater Kailash-I, New Delhi 110 048. 2001. 505 pp. Price not mentioned.

'The human brain is special both as an object and as a system – its connectivity, dynamics, mode of functioning and relation to body and the world is like nothing else science has yet en-

countered', stated Nobel Laureate Gerald Edelman. Others have called brain as the last frontier of ignorance. Recognizing the immense significance of improving our understanding of structure and function of the brain in health and disease, the 1990s was declared 'The decade of the brain' world over. This prompted intense scientific activity globally. It was no doubt facilitated by the emergence of a host of new techniques and technologies, ranging from molecular biology and recombinant technology and genetic engineering and real-time non-invasive imaging technique to visualize neuronal activity in conscious, cooperative human beings performing a variety of behavioural tasks. Advances in electronics, computers and information technology accelerated these developments. Parallel developments in psychology and behavioural science, till recently regarded as distinct disciplines, demanded a better integration with brain sciences, fully recognizing that the ultimate aim of all neuronal function is behaviour and with recent advances it was possible to explore the neural basis of behaviour. Thus, study of the brain was no more the restricted domain of neuroanatomists, neurophysiologists, neurochemists or neuropathologists, but it emerged as a truly multidisciplinary activity which seamlessly embraced all these and acquired the designation – neuroscience.

Not surprisingly, newer subdisciplines like cognitive neuroscience, computational neuroscience and artificial intelligence emerged. It has been stated that the sum total of the knowledge gained about the brain during the last decade or so, is more than what was learnt in the previous fifty years. It is becoming difficult for any individual to keep abreast with the voluminous new information being generated virtually on a day-to-day basis, and worse still, to access this gainfully. It is hoped that the new discipline of neuroinformatics which is currently being developed, will help in this respect.

Keeping all these developments in mind, it was timely that Jackson Beatty decided 'to provide a clearly focused, concise and coherent introduction to human brain from the perspective of contemporary integrative neuroscience'. The author has not attempted an encyclopaedic work, yet has managed to

summarize a vast amount of new information from the viewpoint of a behavioural neuroscientist. It is therefore, not surprising that the first chapter summarizes the various approaches to study the brain and mind, discussing the relative merits of reductionist and holistic approaches, the contributions of philosophical and empirical studies and enumerating the various techniques used for this purpose. Beginning with the contributions of the late 19th and early 20th century neuroanatomists like Camillo Golgi and Ramón y Cajal, progressing to electron microscopic and histochemical exploration of the structure of the brain, and to the more recent brain imaging – computerized tomography positron – emission tomography and magnetic resonance imaging, the chapter introduces an uninitiated student to the variety of approaches used to study the brain. This includes reference to electrophysiological and other investigations and even lessons one can learn from brain lesions. One would have wished that the students were also introduced to current molecular biology and genetic approaches.

The next three chapters elaborate the gross anatomy, electrophysiology and neurochemical aspects of the brain, its building blocks, the neurons and glial cells, the modes of their communication and the electrochemical processes involved. While providing an outline of all these, based on current knowledge, one is spared the tiring details which are the favourites of classical textbooks on the subject.

This is followed by an exposition of neural basis of the various functions of the brain, e.g. vision, hearing, movement, leading on to more complex behaviour like sleep and waking, emotion and stress, hunger, thirst and sex, language and cognition, learning and memory. Each one of these is a comprehensive account, written 'much the same way as ... Lecture'.

The last chapter introduces the reader to various disorders of the brain, thus bringing home the need for better understanding of the normal brain and at the same time summarizing some of the recent advances that have either already helped or suggest the future directions which may provide therapeutic approaches.

The book is well illustrated and provides enough references to recent