

BOOK REVIEWS

JOHN D. TRIMMER. *Response of Physical Systems*. New York: John Wiley and Sons, Inc., 1950, pp. ix + 268.

Although this book is written primarily for workers in engineering and applied physics, the author hopes that it may be of use to workers in other sciences. It is only in the first chapter that application is made to any extent to problems other than those of applied physics. But the point of view which is developed by the author, together with the mathematical results presented, would make it worthwhile for the biologist or psychologist who is interested in formulating his own problems in a quantitative, theoretical manner, to make use of this book. The text is written in such a way that only a limited knowledge of general physics and of differential equations is required in order to follow the principal ideas developed.

In the first chapter, "A Pattern for Systems," the problem to be treated is outlined. The author considers a "system" (e.g., apparatus, organism, mind, society) upon which there is a "forcing" (force, drive, motive, stimulus) which acts according to some "law" (equation, habit) to produce a "response" (action, output, mood, thought). The types of problems one may wish to solve can then be classified by the unknown. Thus, the direct problem is to find the response from the known forcing, system, and law. The converse problem is to find the forcing, the inverse problem is to find the properties of the system, and the inductive problem is to find the law. In this chapter and elsewhere the difficulties of isolating the system and its parts are brought out. In the second chapter, "Physical Systems," is given a general discussion and a classification of systems together with definitions of terms.

In chapters three, four, and six (First-Order, Second-Order, and Higher-Order Systems) a number of problems are solved. Among these are thermal, electrical, and hydraulic models, automatic speed control, production of radio-isotopes, and the nuclear chain reactor. The stability of a response and transient responses are also discussed in detail.

Chapter five, "Sinusoidal Forcing of Linear Systems," gives the solution to a second-order system with a sinusoidal input.

Chapter seven, "Measuring Instruments," treats instruments as physical systems. Such problems as range, efficiency, and accuracy are discussed. Considerable attention is given to errors—mechanism, scale, environmental, dynamic, reading, measurement, determinate, sampling, and random errors.

In chapter eight, "Feedback Systems," thermal and electronic examples are used as illustrations of direct feedback, e.g., the response itself can directly change the magnitude of the forcing. An example of negative impedance is also given. In chapter nine, "Parametric Forcing," the system is considered in which the response is altered by a change in the value of some parameter. Examples used are the condenser microphone and the nuclear chain reactor. If the response is able to alter the value of some parameter, the result is a parametric feedback system.

In chapter ten, "Distributed Systems," problems are treated in which the values of one or more of the properties of the system are distributed continuously in space in such a manner that this fact cannot be ignored. This leads to partial differential equations which are briefly discussed. Applications are made to wave motion and to the cable problem.

The last chapter, "Nonlinear Systems," treats principally the problem of a charged particle in a force field and the problem of the oscillator.

In addition to an appendix of problems, there is an appendix on the use of the Laplace transform in the study of linear systems.

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PALMER O. JOHNSON. *Statistical Methods in Research*. New York: Prentice-Hall, Inc., 1949, pp. xvii + 377.

The reviewer wishes to congratulate Professor Johnson on the production of a statistical text that sets a new benchmark of merit in the field of statistical psychology. The author aimed to write a non-mathematical but essentially accurate presentation based on the contributions of such statisticians as R. A. Fisher, E. S. Pearson, J. Neyman, S. S. Wilks, H. Hotelling, etc. The large set of references to original articles bears witness to the diligence with which he has culled the statistical field for theories and techniques which would be of use to the research worker in psychology or education. How well he has succeeded can best be judged by examining the topics covered.

The book opens with a short discussion on the realm of statistics in which the author emphasizes that the student must be taught (1) how to choose the most effective statistical tool for the purpose in mind (2) the basic assumptions underlying the statistical tool selected (3) how to test whether these basic assumptions are fulfilled by the particular situation to which the tool is applied. The author adheres to this viewpoint rigorously in the greater part of the book; for example, all analysis of variance examples give as their first step, the testing of the assumption of homogeneity of variance.

A short discussion of 'Probability and Likelihood' which follows contains a brief account of Bayes Theorem and maximum likelihood. Maximum-likelihood estimates are used with great frequency in the latter parts of the book.

The next chapter, on 'Sampling Distributions,' gives us the sampling distributions of such frequently used statistics as the mean; the variance, Student's t ; the correlation coefficient; Fisher's z ratio; the binomial distribution; etc. This chapter characterizes the approach of the author to advanced problems in mathematical statistics. Exact formulas are given, but not derived if unfamiliar mathematical concepts like Gamma functions are involved, or mathematics beyond differential calculus is necessary. All of these sampling distributions are used in a later chapter which summarizes the simple useful tests of significance. These chapters include some relatively unknown tests such as the L_1 for the homogeneity of variances and Hotelling's test for the equality of two correlation coefficients from the same sample. It is of interest to note that Hotelling's test can be generalized to test for the equality of correlation coefficients in any column of a correlation matrix.

A short explanation of the Neyman-Pearson theory of testing statistical hypotheses precedes the chapter giving examples of tests of significance. The

modern statistical theory of inference is competently summarized in terms of the concepts of the null hypothesis, Type I and Type II errors, critical regions, and the power of the likelihood ratio. In accordance with the author's principles, the presentation is on a verbal level, relying on logical formulation rather than rigorous mathematical derivations. Illustrative examples and empirical demonstrations are given at many points in the exposition. The mathematical symbols are used mainly for clear, concise, and correct formulations of these concepts.

The next chapter deals with the techniques of estimating population parameters by means of statistics. The maximum-likelihood method is used for point estimation; both Fisher's fiducial method and the Neyman-Pearson method of confidence belts are used for interval estimation. Maximum-likelihood methods are applied to such novel problems as Jackson's estimation of the reliability of a test, and Wilks' test for the equivalence of two forms of a test with respect to means, variances, and covariances. The treatment of reliability follows Jackson and Hoyt in using the analysis of variance assumptions of additivity of components and equal error variances. To the reviewer, the analysis of variance probability model seems distinctly inferior to the regression probability model for the estimation of true and error variance. Also, the assumption of homogeneity of the observed variances is unnecessarily restrictive.

The next section, on testing the hypothesis of normality, includes some useful advice on how to normalize the set of observations in those cases where the distributions can be shown to be certain non-normal types. Then there is a unique chapter on those tests of significance which are 'distribution-free' or 'nonparametric,' i.e., which make no assumptions about the distribution of the observations in the parent population. For most psychologists, the analysis of variance using ranked data, Kendall's W coefficient of concordance, and the use of paired comparisons for calculating the agreement and consistency of subjects, will be new techniques. This chapter is a good idea and the reviewer hopes it will be expanded in the next edition to take in Kendall's rank-order coefficient τ , simple devices like Tchebycheff's inequality, and G. W. Brown's analysis of variance using medians instead of means.

A discussion of sampling is followed by a detailed mathematical presentation of the analysis of variance. The probability models for single classification and double classification (rows by columns) are set up, and the maximum-likelihood derivation is given. (Incidentally, neither here nor elsewhere is it explicitly pointed out that the maximum-likelihood method is equivalent to the least-squares technique only because of the assumption of normality.) A number of examples of the analysis of variance and covariance are presented.

Two chapters are devoted to the principles and applications of experimental design with examples of experiments in psychology using randomized blocks, Latin squares, and factorial designs. It is gratifying to note that the probability model for each example is given in full for all applications in analysis of variance and covariance. This method of teaching Fisher's techniques far surpasses Fisher's own presentation of his methods. By explicitly designating which parameters are being tested for their deviation from zero, it allows the student to do his own reasoning instead of forcing him to follow some blind, rule-of-thumb handbook. To leave out the probability models, as most textbooks do, is to ensure that a certain proportion of students will go thru the ritual of analysis of vari-

ance with the religious conscientiousness of a devotee of number magic, and for the same mystical reasons.

The book concludes with a succinct summary of multiple regression problems. Unfortunately Fisher's computational technique is used, which means that the complete inverse of the correlation matrix is computed each time. Even worse, it is not stated explicitly anywhere that it is the inverse of a matrix which is being computed. Tests of significance for the multiple correlation and the multiple regression weights are given and illustrated. The two-group linear discriminant function is derived using Mahalanobis's D^2 . The relation of D^2 to Hotelling's T^2 is mentioned but not explained in detail. Wherry's proof that Fisher's linear discriminant function is exactly proportional to the regression of the dichotomous criterion of group membership on the independent variables is not mentioned. Consequently, it is not pointed out that testing D^2 or T^2 for significance is algebraically identical to testing a multiple correlation for significance.

The book is designed for a year's course of advanced statistics, and assumes that the student will have a knowledge of descriptive statistics and elementary calculus. The reviewer has been able to use the chapters on the testing of statistical hypotheses as the basis of the third term in a year's course in statistics. The students were clinical psychologists and for the most part knew no calculus. Yet, with Johnson's treatment, it was possible to give a firm rational foundation to all tests of significance by using such concepts as maximum likelihood, null hypothesis, Type I and Type II errors, critical region, etc.

However, the instructor will probably find the book of more use than will the student. Johnson has undertaken the arduous task of listing every reference that he has used. We thus have a compilation of almost all those articles which would be of interest to a statistical psychologist both from a theoretical and applied point of view.

There are several points on which the reviewer finds himself in disagreement with the author. The difference between a one-tail and a two-tail test is never made explicit and apparent errors occur in the applications. For example in Problem V.1 (pp. 69-70) the question is asked 'if the mean ability of the class is the same as that of the population.' This question seems to call for a two-tail test since the direction of the difference is not specified. But a one-tail test is used. Johnson has stated (in a personal communication to the reviewer) that the one-tail test must be used because the population mean is known in this problem. This does not seem to be adequate. If the one-tail test were used on each such case at, let us say, the 5% level, then, when the null hypothesis is true, 10% of the differences would be rejected as non-null differences. It seems to the reviewer that the Neyman-Pearson theory demands that the level of confidence correspond exactly to the per cent of Type I errors.

A similar case arises when the F ratio is used to test the homogeneity of two variances (p. 82). The tabled value of the F ratio gives a one-tail test. But since the direction of the difference is not specified, a two-tail test is necessary. We must find the probability that an F ratio would exceed s_1^2/s_2^2 or be less than s_2^2/s_1^2 (where $s_1^2 > s_2^2$). The L_1 test for homogeneity of the two variances gives this same two-tail F test. A. M. Mood demonstrates the point very clearly in his recent text (*Introduction to the Theory of Statistics*. New York: McGraw-Hill Book Co., 1950, p. 268).

The treatment of chi-square is utterly inadequate. This is all the more sur-

prising in view of the care taken to define other basic sampling distributions, such as t and Fisher's z . The first mention of chi-square comes on page 37 in the middle of a discussion on the goodness of fit of sampled means to a known normal distribution. The inquiring student is referred to page 96 where he will find an example of the use of chi-square, but not a word of its meaning, or the basic sampling distribution it illustrates. But as Lewis and Burke have pointed out, statistical textbooks for psychologists seem to universally fail when the chi-square test is discussed (D. Lewis and C. V. Burke, *Psychol. Bull.*, 1949, 46, 433-489). Their article, however, should go a long way towards rectifying this deficiency.

In spite of these defects, the book remains unexcelled in its field. Author Johnson has managed to pack more good statistics into his book than appears in any other comparable text. *Statistical Methods in Research* is definitely required reading for all teachers of statistics in the fields of psychology and education.

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HOWARD W. GOHEEN and SAMUEL KAVRUCK, *Selected References on Test Construction, Mental Test Theory, and Statistics, 1929-1949*, Washington, D. C.: United States Civil Service Commission, 1950, pp. 209.

This is an exceedingly valuable index of much of the literature in the fields of test theory, test construction, and statistics. Recommended for all members of the Society.

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