BOOK REVIEWS

YRJÖ AHMAVAARA. *On the Unified Factor Theory of Mind.* Helsinki: Suomalaisen Tiedeakatemia, 1957. Annales Akademiae Scientiarum Fennicae, Ser. B., Vol. 106. Pp. 176.

In Part I, entitled "On the Factorial Description of Mind," the author develops his concept of a "Unified Factor Theory" and presents a short outline of his earlier "Transformation Analysis" [1]. In Part II, entitled "On the Theory of Abilities," he uses his transformation analysis for the comparison of several studies reported in the literature.

To compare Ahmavaara's "Unified Factor Theory" with similar expositions on the logic and philosophical basis of factor analysis would be a rather hopeless undertaking in that the number of such presentations is very large. It is the opinion of this reviewer that the most careful and comprehensive accounts of the philosophical basis of factor analysis remain those contained in the books by L. L. Thurstone [18] and Sir Godfrey Thomson [17]. Ahmavaara, following the terminology of Cohen and Nagel [7], places factor analysis in the domain of abstractive theories which encompass, among others, the theories of relativity, evolution, and quantum theory, in contradistinction to mechanistic theories which include field theories, the theory of atomic structure of matter, and current theories of learning. The latter are characterized by pictures or visual presentations, whereas the former describe relationships without recourse to mechanistic models. The author suggests that factor analysis represents the only example in psychology of an abstractive theory and attributes misunderstanding in this area to attempts at giving a mechanistic interpretation to the factors. He argues that the abstractive theory is a precursor of the mechanistic one which may, some time in the future, supersede it. It is not the goal of this abstractive theory of factor analysis to find a hypothetical inner mechanism to explain the results, but to identify some underlying simple order in terms of the fewest possible number of concepts.

While the usual textbooks of psychology start, according to the author, with the explanation of a mechanistic model, the abstractive theory should begin with a formal consideration of the experimental conditions. He lets the registration of some experimental fact result in a score a_{ikm}, depending on the person (index i), the trait (index k), and the situation (index m). In a graphical representation, these three bases are thought of as dimensions of infinite extension where, however, only the situation dimension is assumed to represent a time-dependent continuum. All qualitative observations must be quantized to yield scores, and the author suggests item analysis, scale analysis, and latent structure analysis as methods of quantification. He also states that all persons and traits must be numbered and arrayed along their respective axes. He then continues to argue that all traits, situations, and persons cannot be considered of equal importance in psychology, and that the psychological starting point of a unified factor theory is an attempt to discover the "most revealing situations, the principal types of personality and traits." These "Situation, Person, and Trait Factors" represent an "Information Packet" (of finite extent) with score characteristics A_{ikm}, which serve to characterize any new observation according to the "main type" to which it belongs.

In Chapter 4 of Part I, the author states the goal of his theory, i.e., to find the method of analysis by which the Information Packet can be obtained. He argues that the results of experiments constitute "highly symbolic descriptions of the object, the rules of this symbolization being . . . chosen freely so as to yield the simplest theory to fit the facts." He postulates that this symbolism must be chosen in such a way that the psychological scores can be added together to yield new psychological scores. He argues that this principle of additivity is logical in view of the experimental techniques employed in psychology; in contrast, classical physics employs a multiplicative principle (2 dynes + 3 cm. is meaningless, but 2 dynes $\times$ 3 cm = 6 dyne-cm or ergs is meaningful), and the author compares the

required additivity in psychology with the additivity of states of an atom. The additivity principle gives rise to a linear model of factor analysis, and the author brands nonlinear factor analysis as a misconception. He negates the superiority of a nonlinear model and considers it merely as an alternative. This argument, which is advanced repeatedly, becomes somewhat weakened by such statements as (pp. 38–39)

> "Nonlinear relationships between persons . . . are *not necessarily* nonlinear from the point of view of traits, and vice versa. Thus we can, by a change of the basis of analysis . . . satisfy the requirement of linear relationships in numerous ways . . .
>
> "So far, at least, there has been no real need for nonlinear factor analysis, and *I suppose* that there never will be" (italics supplied).

It is interesting to note how carefully the author avoids the logical consequence of this argument, namely, that some method of normalizing or scaling *must precede* the analysis. The simple way of normalizing experimental data, by which Laplace, according to G. Darmois's [8] beautiful formulation, "a linéarisé la théorie des erreurs," has been frequently used by factor analysts ever since the time of Thurstone's famous box problem, which would be inextricable without this device. But Laplace, Thurstone, and Darmois advocate these techniques clearly in order to represent the complex nonlinear relationship by a linear approximation, whereas Ahmavaara expressly disavows the existence of nonlinear relations.

As Ahmavaara starts an attempt to give mathematical expression to his logical postulates, the monograph becomes a nightmare. He starts out with the massive contention (p. 25)

> "If we add together two vectors, the result is again a vector (of the 'linear vector field' spanned by those two vectors). The vector is the most general mathematical symbol which satisfies this requirement."

(Even a beginning student of linear associative algebra will cringe at this.)

Thus, as a "direct consequence of the additivity postulate" he states that

> "the theory of mind, expressed in terms of the relations between psychological scores, can be constructed as isomorphic with the mathematical theory of linear vector fields."

He discusses three different linear vector fields; one each for persons, traits, and situations. Each may be considered on the basis of the other two. According to the author, these are to be "independent models of mind which complement each other." He then introduces the scalar product of two vectors (p. 26) as an "index intended to express the smallness of the angle between the vectors in question." This statement becomes grave when we recognize the author's confusion between component and factor analysis:

> "The use of communalities or the use of (11) (factor analysis model) instead of (9) (component analysis model) is promoted by an endeavor to reduce the number of factors to a minimum. This is not, however, a necessary requirement imposed on the vector model, but only a practical convention" (p. 33).

It gets more serious when we note, on the same page, that the desire for a simple structure is "prompted by the same endeavor to reduce the number of factors which dictated the use of communalities;" and it becomes entirely untenable when we read the surprising argument on page 41.

> "Factor Analysis, as it is represented in this text, is accordingly performed from covariances rather than from correlations. It is a well known fact [*sic*!] that this is the only way to create a consistent factor theory. The usual factorial procedure,

> starting from correlations, is only to be considered a practical approximation, which must be replaced before long by an analysis of covariance."

Just how consistent can a theory be if the linear vector field representing mind can be changed at will by changing units and, for instance, giving a boy a score of 10 points for a correct answer instead of 2 points? In vectors of such varying lengths as the author postulates, even in his illustrations, the relationship between scalar products and angular separation would not even suffice as a first approximation.

This leads us to the "Transformation Analysis," the central feature of the monograph, which is employed throughout Part II. The author repeatedly and emphatically rejects the criticisms of statisticians and, in fact, the legitimacy of statistics as a tool at this stage of model building; he refers to the experimental group as an experimental population. But then he must admit (p. 34) that

> "every experimental factor analysis of traits, based on some limited number of subjects, establishes its own vector model, which is different from all other models established by other analyses of traits, with other persons as subjects. If there were no connections between these factor analyses with different subjects, we could not arrive at any general factor theory of mind."

The entire argument here and in the sequel is a description of samples with careful substitution of the words "experimental population" to avoid recognition of the statistical nature of this argument. In the development of the transformation analysis on pp. 35-36 the author assumes two experimental populations which give rise to two factor matrices F_1 and F_2 and derives, from his principle of additivity, that (p. 35)

> "the linear relationships between the trait vectors are invariant under transformation from the vector field of the first study to the vector field of the second study."

The proof of this contention is very interesting. From his formula (16) on page 36, $F_2 = F_1L$, he obtains a unique expression for L in formula (17), i.e., $L = (F_1'F_1)^{-1}F_1'F_2$. Of course, he realizes that one cannot proceed from (17) to (16) and therefore plots the elements of F_2 versus those of F_1L hoping that the points will be on an $x = y$ line. Naturally, and to nobody's surprise, the plots on pages 54, 57, and 60, for instance, are not very convincing and dozens of other plots are not shown. How the author justifies this solution is beyond the mathematical comprehension of the reviewer. Does he assume that $F_1L = F_2+E$ (i.e., all error in the *second* study) and minimize the sum of squares of elements in E? That would yield the stated solution for L. But what if he exchanges the numbers 1 and 2? Apart from the serious objections to this kind of least-squares approach, what became of the transformation analysis,

> "the latter being the consistent comparison method of factor studies," (p. 36)

if a mere change of subscripts produces two different results?

Part II of the monograph applies this transformation analysis to 18 comparisons in the Reasoning-Closure Domain, six comparisons in the Verbal Domain, four in the Mechanical Domain, and three in the Musical Domain. A short interpretation of results based upon the comparison matrix is given for each pair of studies. Combination of results is attempted by using the sum of invariance values as a criterion. The "objective comparison" (p. 48) involves quite a number of arbitrary index numbers whose properties are not discussed.

The author makes brief mention of other techniques and examples of comparison of factor studies, especially the method proposed by Tucker [19] and the classification monograph by French [9]. To these methods and catalogues he contrasts his transformation analysis as the objective and consistent one.

Ahmavaara compares factor analysis to differential calculus and contrasts it with statistics. The first two pages of his introduction are directed strongly against statistics and statisticians. He claims on page 12 that "the validity of the whole factor theory has been questioned by statisticians;" the reviewer, who is a statistician, must take exception to that statement. If we disregard statements made by some statisticians who do not condescend to even an attempt at understanding the models of factor analysis (e.g., one discussion speaker in [13]) or who, like Ahmavaara, discuss two different types of analysis, viz., factor and component analysis, as if they were one and the same [11], the statisticians have been rather cooperative and enthusiastic about factor analysis. Shortly after psychologists like Sir Godfrey Thomson and L. L. Thurstone had explained the model, statisticians (Lawley [14], Bartlett [6]) produced solutions which, alas, are exactly obtainable only with the help of medium-sized electronic machinery. A psychologist who has understood the basis of factorial logic will probably profit by reading about the statistical and mathematical methods which are presented in a variety of studies [4, 5, 12, 15]. A problem which still awaits solution, i.e., that of an appropriate mathematical and/or statistical analysis of the "vector field of persons based upon traits," has been attacked in the last part of [10], and some operational methods were suggested by Stephenson and others.

The problem of comparing two factor studies by statistical techniques is essentially solved. If we take a covariance matrix as an approximation of the correlation matrix (and not vice versa, as suggested by the author) the test is trivial (see, e.g., [3] and [16]). The derivation of a test for the equality of two correlation matrices by the likelihood ratio method is of the order of an exercise for a student who has studied multivariate analysis (in a book such as [3]). Testing equality of two factor matrices may be somewhat more difficult, but is still amenable to treatment by a minor extension of Lawley's approach. The maximum determinant solution which L. L. Thurstone suggested in 1953 on intuitive grounds, and which was subsequently described in [5] and [12], leads to results identical with the maximum likelihood solution, and is particularly easy to handle for the comparison of two factorial studies. Statisticians do have methods of solution, and also available is the computational equipment to find them in a relatively short time. Many statisticians appreciate the ideas of factor analysis and like to help. It is sometimes difficult, however, to allay suspicions of skeptics if examples of mathematical legerdemain appear in the psychological literature.

This reviewer enjoyed reading the monograph, and while he is doubtful about the value of the author's transformation analysis, he is impressed by the clarity of the logical presentations of factor analysis as an abstractive theory. He preferred to view factor analysis as a method to identify principles of classification, and stands corrected by the author who would certainly regard even this unpretentious interpretation as mechanistic. While the reviewer would dissuade against use of the author's mathematical techniques, he would strongly recommend the monograph to philosophers, psychologists, and social scientists. He would also encourage the author to excerpt the monograph, leave out all mathematical formulation, and present such an article to a more general group of readers including, by all means, statisticians.

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Y. AHMAVAARA AND T. MARKKANEN. *The Unified Factor Model.* Its Position in Psychometric Theory and Application to Sociological Alcohol Study. Vol. 7. Helsinki: The Finnish Foundation for Alcohol Studies, 1958. Pp. 187. Stockholm: Almqvist and Wiksell, distributors.

This monograph consists of two parts. The first, by Ahmavaara, is entitled "A Treatise on Psychometric Models," and the second, authored by Markkanen, "On the Sociological Theory of Alcohol in Terms of the Unified Factor Analysis Model."

The title of the first part is misleading. It is not at all a treatise of psychometric models such as may be found in [2, 3, 10, 12]. Instead, and much to the annoyance of the reader, it represents an exceedingly poor presentation of some selected techniques of scaling with severe criticisms attached, which verge on the polemic (pages 40 to 47 on Guttman's principal components), and a eulogy on the first author's own methods. The reviewer, who enjoyed the author's earlier *On the Unified Factor Theory of Mind* because of its interesting and compelling logical development, and in spite of its grotesque mathematics (transformation analysis), was not at all impressed by the present volume. A glance at some of the chapter headings and statements,

"Sec. 5 A Critical Examination of Guttman's Principal Components"
"Sec. 7 Erroneous Imitations of . . ."

"Sec. 9 Critical Examination of the Radex System"
"A requirement of such a kind is arbitrary to the highest degree" (p. 46)
"Mathematical artifacts" (p. 46)
"lacking empirical foundation" (p. 46)
"Moreover, there occur in the afore-mentioned work (*Mathematical Thinking in the Social Sciences*) such statements of fundamental nature as are to be regarded as simply erroneous . . . " (p. 56)
"there are many equations suggested by Rashevsky which are devoid of any other significance . . . " (p. 59)
"I protest . . . " (p. 73)
etc., etc.,

and, on the other hand, where the author refers to his own methods and proposals,

"Our approach to the problem of mathematical models in sociology differs from that of 'Mathematical Thinking . . . ' in that ours tends to be a systematic one." (p. 15)
"A very fine example of the application of discriminance analysis . . . " (p. 27)
"It has recently been shown in an objective and numerical manner . . . " (the author speaks, of all things, about his transformation analysis) (p. 62)
"What essentially makes factor analysis a unified model is its third step, the transformation." (p. 80)
"A synthesis of different factor analyses could be secured for the first time in an objective manner." (p. 84)
etc., etc.,

should discourage the reader from paying any further attention to the first author's vain suggestions.

Ahmavaara, in this "Treatise," discusses ratio scales and ordinal scales; his failure to mention the nominal and, above all, the interval scales at all [9] makes the discussion rather difficult to follow. Especially in the attack upon Rashevsky (p. 58) and the use of differential equations in the social sciences, Ahmavaara's failure to mention the interval scale defeats his own purpose.

After a short description of Guttman's scale, the author suggests the use of discriminance analysis (with, incidentally, an impossible graph on page 25). The idea is not much different from that used in one of the oldest types of scales [5] and, of course, no properties of the discriminant curve are studied. How necessary such a study is may be illustrated by the loose application of Guttman's reproducibility index or Menzel's coefficient of scalability [6] which depend on the number of items. The gain in reproducibility was reported as one of the most important features of the H-technique [11]. An elementary statistical investigation similar to that of Festinger [1, 4] shows the spuriousness of such a gain. The creation of suitable indices to prove a point is one of the most prevalent types of statistical lies, and we will have to await further study of the properties of Ahmavaara's discriminance curves before using them.

The initial description of Lazarsfeld's measurement is a little sketchy but quite well done. Alas, there follow some statements regarding the applicability and restrictions of Lazarsfeld's measurement which show that the author is even less familiar with the principles than the average reader. One of his criticisms of Lazarsfeld's latent class analysis is that

"The Guttman measurement provides one with better possibilities as regards mathematical model building in psychology and sociology" (p. 39).

Considerable advances in the analysis of results based upon nominal scales [7, 8] are apparently unknown to the author. These methods deserve closer study before categorical statements are made.

The author does not distinguish between maximum probability and increasing probability trace lines, and this fact, along with his failure to mention interval and nominal scales, makes him come to the conclusion that many things need to be done

> "before it is possible to say anything definite about the usefulness of the Lazarsfeld measurement in psychological and sociological research" (p. 25).

Since the author distinguishes only ratio scales and ordinal scales, he suggests that "Guttman Measurement" is the only useful one in psychology and sociology and maintains that this is the type of scale which has been used intuitively in mental test theory. The author rejects the practice of standardization (p. 37) and is extremely critical of normalization (p. 82).

Ahmavaara's description of Guttman's principal components is no description at all. It is a highly loaded criticism, sometimes advanced with polemic technicalities. To be sure, the name *intensity function*, which Guttman used for the description of the second eigenvector, may be a little vague and poorly chosen. However, Ahmavaara's disproof by semantics, in that he disclaims connection between a subject's expressed intensity of opinion and Guttman's second eigenvector, is reminiscent of political rather than scientific controversy. Ahmavaara is very critical of the meaning of the variance ratio which Guttman minimizes; he directs his criticism not against the ideas, which are not presented here anyway, but against the final formula. Ahmavaara's counter-example is, to quote the author on page 46, "lacking any empirical foundation." One may not be too strongly impressed by Guttman's principal components, but the language and polemic of this criticism is most certainly unjustified.

In his section on the theory of mathematical model building, the author presents at some length the distinctions between Cartesian and Hilbertian analysis, and restricts the former to ratio measurements. He argues that ordinal scales find their mathematical expression in terms of the dependence between vectors in the function space, and hence concludes that factor analysis is the appropriate technique to be used with this kind of measurement. As a matter of fact he states that (p. 54)

> "Factor analysis is, indeed, but a certain simple instance of the general Hilbertian analysis."

In two theorems (p. 56 and p. 59) he states the restriction of Cartesian analysis to ratio measurement and says that the Hilbertian type of analysis can be applied also to scales on which only the order is determined. He has to admit (p. 61) that the metric has some effect upon the results of Hilbertian analysis but states that

> "whatever conventions we may make concerning the metrics of the different scales, the Hilbertian vector model may always tell us something of value about the mutual relationships of the functions" (p. 62).

The reviewer would like to remind the author that the correlation between x and x^2, two collinear variables, is *zero* if x is standard normal, but this argument may be considered unjustified in that x^2 does not monotonically vary with x. However, let x be *positive* and distributed as χ^2 with one degree of freedom. In this case x^2 is certainly monotonic with x and the correlation turns out to be $\frac{1}{2}\sqrt{3}$, *corresponding to an angular separation of 30 degrees for two vectors which, before the conventions were made on the metric, were collinear.* This does tell us something of value; it tells us that some process, like normalization, is very important before we attempt an analysis based upon correlations.

It is indicative of the author's prejudice that he describes Thurstone's box problem without mentioning the fact that all measurements were normalized before correlations were computed. Failure to do so leads to serious distortions of the nonlinear combinations.

The author's description of Guttman's simplex, radex, and circumplex is critical as indicated by the heading. Since Ahmavaara's treatise contains not a single constructive idea in this respect, his criticism lacks authority; however, the point which Ahmavaara raises regarding the indeterminancy of simplex or circumplex structures, when several of these are present, has received and may deserve further study.

In Chapter IV, Ahmavaara repeats, in abbreviated form, his description of factor analysis as an abstractive theory. This was quite well done in his earlier monograph *On the Unified Factor Theory of Mind* and discussed in an earlier review. The mathematics used by Ahmavaara in his transformation analysis is beyond the comprehension of this reviewer. How, from the fact implied by equation (43) (p. 82) that $A_1'A_1L = A_1'F_2$, he concludes any similarity between the matrices A_1L and F_2 (both are rectangular) is incomprehensible. I would suggest that the author try the column vector with elements (.3, .5) for A_1 and (.8, .2) for F_2. Here, L is the scalar 1 and, if .3 seems too similar to .8, he may try (.9, .14) which, again, by the author's reasoning, is similar to A_1. Did he, perchance, cancel A_1' on the left and right side?

We read in the summary of Part I that this treatise has been a "systematic presentation of the theoretical thinking of the 'Finnish school.' " This reviewer suggests that the author gather some more experience with existing methods and literature before aspiring to the establishment of a new school.

In part II, T. Markkanen presents the results of a very extensive analysis of data obtained by Dr. Pekka Kuusi on alcohol sales experiments in rural Finland. Dr. Kuusi, whose original work was not available to the reviewer, was interested in studying the changes in attitude due to the opening of alcohol stores in several rural communities. Ten different alcoholic beverages were listed, some available on the legal market, some illegal, and subjects were asked to state how many days ago they last drank each of these beverages. The results, coded (but not scaled) on a nine-point scale, constitute variates 1 to 10. Variates 11–15 deal with general questions related to drinking (frequency, opinion, etc.), and variates 16–25 represent other activities and concomitant information.

The first factor analysis was made for the general group which (see p. 108) represents all the interviewed persons ($N = 293$). The primary factor matrix after rotation is recorded and represents, according to the author, a satisfactory simple structure. The reviewer does not quite agree; with 25 variables and 9 factors, a total of 13 zero loadings ($\pm .10$) can be obtained in a hyperplane by a pure 50-50 chance, in the absence of any concentration. Only one of the factors (5) shows significant over-determination. This does not mean that the factors are spurious; as a matter of fact they show a fairly convincing high-low tendency. It only means that the authors may consider using some more effective rotation method to clean up and clearly define their structure. The method they used (Ahmavaara's cosine method) seems to be wanting in this respect. The authors report and interpret the following factors: (1) Physical and Mental Activeness, (2) Social Control, (3) Pastime and Passive Enjoyment, (4) Asocial Drinking (preference of illegal beverages), (5) Religion (but unassociated with the rest), (6) Form of Manifestation of Drunkenness, (7) Underdeveloped Drinking, (8) Attitude and Opinion, and (9) Legal Drinking.

There follows the transformation analysis of the two groups, and the agreement between the two patterns (graph on page 116) looks quite extraordinary. Equally extraordinary, however, is the agreement between the two correlation matrices (pp. 178 and 180). Most extraordinary, alas, is the composition of the two groups, for one of them ($N = 254$) represents the users of alcohol, whereas the other represents the general group ($N = 293$). Thus, the two groups which are compared in the "consistent and unique" transformation analysis, *have all 25 responses of 254 subjects in common* and differ only in that the general

group has 39 subjects added to it. A beginning student in some scientific discipline may be forgiven for making this kind of error of comparison. It is less easy to be tolerant of the promoters of new, systematic, scientific theories.

The authors make more comparisons, on the basis of age, employment, etc.; as an index of comparison they use the mean score on each factor. It apparently does not occur to them that a straightforward comparison of the results of each variable would be much easier and considerably more meaningful. Perhaps they might even condescend to use a t, F, or multiple-range test to show whether such group differences are significant.

In conclusion it must be said that this monograph places the users and defenders of factor analysis in an embarrassing position. Theirs is a mathematical model, well related to the real world, soundly formulated and, for the last 25 years, extensively studied. The results of many demonstration studies, starting with Thurstone's box problem, constitute strong evidence in favor of the method. The statistical methods connected with factor analysis have been well developed and known for more than 25 years—only the exact numerical solutions are quite hard to find, and are only now feasible with the aid of electronic machinery. But how can anyone convince skeptics of the usefulness of factor analysis if authors, like the present ones, make a travesty of it?

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SOLOMON KULLBACK. *Information Theory and Statistics.* New York: John Wiley & Sons' Inc., 1959. Pp. xvii + 395.

Information theory may well be a blood relative of the law of large numbers. At least the famous coding theorem and the famous law seem to share a direct interest in estimation processes based on fluctuating observations, and both settle the estimation

problem by the simple expedient of taking a nearly infinite sample. So it is easy to think of both as bypassing statistics.

What then are we to make of the provocative title of this book? Information theory seems to mean many different things, and the author is apparently not talking about the coding theorem or about channel capacity. In fact, a statistician like Kullback cannot get himself into a lather of excitement over the main results of the theory, reflecting as they do a type of asymptotic process already familiar in statements like the law of large numbers. On the contrary, the part of information theory that intrigues him is the arithmetic, the $p \log p$ formula.

The book is best described as a treatise on the inequality

$$-\sum p_1 \log \frac{p_2}{p_1} \geq 0,$$

where p_1 and p_2 are any two probability distributions over the same set of categories. The inequality is easily proved, and it immediately generates nearly all the attractive features of information measures. For example, only a few additional steps are required to show that information is maximum when the values of p_2 are all equal, or that conditional probabilities yield a smaller amount of information than marginals, or that transmitted information is always equal to or greater than zero, and so on. Actually Kullback's statement of the inequality is more general, and the reader will have to pay for the generality with increased effort, but the many interesting and occasionally remarkable properties of the inequality put the price within reason.

In any event Kullback converts the formula to legitimate statistics by considering p_2 as a probability that emerges from a "null" hypothesis, and p_1 as an analogous probability based on an alternative hypothesis. When sample estimates are substituted for p_1 and p_2, the formula becomes a random variable and its size measures the divergence of the two hypotheses as seen in the data. This is a picture of divergence almost identical to the one given by the likelihood ratio, and Kullback demonstrates that information measures in the form of the inequality are in fact negative logs of likelihood ratios. This is not a new idea but the detail of Kullback's treatment surpasses the earlier literature on the subject by a wide margin.

The idea is carried through a succession of null hypothesis tests based on several different assumed populations extending from the simple binomial to the multivariate normal. These rubrics, tests and populations, furnish the structure for much of the writing as Kullback analyzes the divergence formula under each heading. Perhaps the most interesting set of tests is found in the chapter on contingency tables where the asymptotic chi-square distribution of the likelihood ratio is linked to a surprising array of contingency tests. It is worth noting that likelihood ratio tests are essentially equivalent to the more familiar chi-square tests. The only important difference is that, with a suitable table of $n \log n$, the likelihood ratios are much easier and faster to compute. Kullback provides an excellent table in an appendix.

Columbia University WILLIAM J. MCGILL

R. D. LUCE AND H. RAIFFA. *Games and Decisions*. New York: John Wiley and Sons, 1957. Pp. 509.

The preface of this book would serve as an excellent review. In three printed pages the authors set out their scope and objectives. The reviewer would need only to comment that they have fully achieved their goals.

The purpose of the book is to communicate the central ideas and results of game

theory and related decision-making models in such form as to minimize the mathematical prerequisites. In principle the main test is mathematically self-contained and no specific mathematical preparation is assumed. In the authors' words, "neither the calculus nor matrix algebra as such are required, but neither will hinder, for probably the most important prerequisite is that ill-defined quality: mathematical sophistication." However, the final quarter of the book is devoted to mathematical appendices which require considerably more mathematical knowledge.

The book might well have been subtitled "15 years after" since it provides the first general sequel to the von Neumann-Morgenstern treatise (*Theory of Games and Economic Behavior*, Princeton: Princeton University Press, 1944, 1947). The emphasis is almost totally on the concepts of game theory from the point of view of their appropriateness in social science contexts. Although little attention is given to the mathematical details of solutions to specific games, the appendices and references to the bibliography provide an excellent guide to a solid and complete mathematical treatment of game theory. The authors have not sacrificed preciseness in the interest of easy reading. If a concept is difficult they carefully introduce it with well-chosen illustrative examples and instructive description, then provide a full formal treatment.

The first three chapters provide a general introduction to the theory of games including utility theory. Chapter 4 treats two-person, zero-sum games. Chapters 5 and 6 treat two-person, nonzero-sum games and present concepts developed in an attempt to meet some of the deficiencies in the von Neumann-Morgenstern theory, and Chapters 7–12 treat n-person games beginning with the von Neumann-Morgenstern theory and reaching into many newer developments. The last two chapters, 13 and 14, treat individual and group decision making and again report progress largely since von Neumann-Morgenstern.

Although the book is directed primarily toward the general scientific reader and is colored by a social science point of view, its comprehensive and critical review of game theory makes it required reading for any person doing mathematical research in the field.

The exposition is uniformly excellent. The careful interplay among (1) illustrative and provocative examples, (2) instructive analyses, and (3) formal developments makes for easy reading. The book is well adapted (1) for general reading, (2) for reference, and (3) for seminar study. The reviewer's main regret is the absence of exercises; if these were available the book would make a fine text for an introductory course in game theory directed toward students who have had an introduction to mathematics at least equivalent to the Social Science Research Council sponsored summer institutes of 1953 and 1955 or to one of the one-year courses in mathematics for social scientists such as those initiated at Michigan and Illinois in 1952 and which have since spread across the nation. The authors indicate several groupings of chapters to make the book most useful to various classes of readers.

In the reviewer's judgment *Games and Decisions* is and will remain for a long time the definitive work in the conceptual side of game theory; every quantitatively oriented social scientist could profit by reading it carefully and having it available on his working bookshelf.

University of Michigan R. M. THRALL

RAYMOND B. CATTELL. *Personality and Motivation: Structure and Measurement.* New York: World Book Company, 1957. Pp. xxiv + 948.

This book, according to the author, is a progress report on factor-analytic research on basic personality dimensions. It is intended chiefly for applied psychologists, university

teachers, and students with a sound grasp of statistics and principles of psychological measurement. The book is arranged in six parts, which range from some fairly elementary concepts of measurement, through measurement techniques as applied specifically to the area of personality, to theory and findings with respect to personality and motivation. Twelve appendices cover various subjects more or less peripheral to the book itself. A bibliography listing more than 700 references and a glossary defining nearly 500 terms complete the book. It is recommended that the latter be studied thoroughly before the book is read since the author is quite adept at using familiar terms in unfamiliar ways and has developed many new descriptive words for his factors and techniques.

Part I, Basic Principles in Personality Research, sets the stage for the remainder of the book by presenting reasons why measurement and theory must proceed hand-in-hand, by describing the three media of personality observation (observation by others through use of rating scales; observation by the self through use of questionnaires; and observation by use of objective tests); and by a rather thorough discussion of the role of factor analysis. The author's customary distinction between clusters (which he states to be surface traits) and factors (which he states to be source traits) is elaborated as is his contention that factors represent measures of the underlying dynamics of personality which result in observed clusters of manifest behaviors which intercorrelate highly.

In Part II, findings from a number of factor analyses of personality measures based on ratings, questionnaires, and objective tests are summarized. Part IV presents similar findings in the areas of attitude and motivation, and Part V contains the results of several factor analyses of personality change. Interpretations of and speculations concerning these factors are present in great abundance. However, the book itself does not present sufficient data concerning factor loadings, correlations between factors, and stability of findings across samples to permit evaluation of these interpretations or of the factor analyses themselves without a tremendous amount of "library research" on the cited references.

Part III continues the discussion of measurement theory commenced in Part I, but at a somewhat more sophisticated level. Of special interest in this section are results of second-order factor analyses of the author's primary factors. These second-order factors are practically orthogonal, in contrast to the substantial correlations frequently found among Cattell's primaries, and appear to be similar both in meaning and number to the first-order factors found by other investigators.

The final part is concerned with the application of personality measurement in the clinical, educational, and industrial fields. The use of the "specification equation," with its attendant factor profiles for people and requirement profiles for job or classroom situations, is discussed at length. A number of common clinical and industrial measurement situations are touched upon and a test battery (usually one published by the Cattell's Institute for Personality and Ability Testing) is recommended for each.

Although presented as a progress report, this book appears to be basically an exposition of Cattell's theories of personality, which are considerably in advance of the experimental data necessary to confirm them. Viewed as such it contains a wealth of ideas and suggestions for research, but does not appear suitable as a textbook, at least at the undergraduate or first-year graduate student level.

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ERNEST C. TUPES

D. R. Cox. *Planning of Experiments.* New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958. Pp. vii + 308.

A. E. Maxwell. *Experimental Design in Psychology and the Medical Sciences.* London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1958. Pp. 147.

Each of these books bears the Wiley imprint, concerns the conduct of experiments, and was written at the University of London. (David Cox, a statistician, is reader in statistics in Birkbeck College; Maxwell, a psychologist, is lecturer in statistics in the Institute of Psychiatry, Maudesley Hospital.) Aside from these superficial similarities, there are considerable differences between the two volumes.

Cox's *Planning of Experiments* is significantly titled; this excellent book concerns the broader aspects of design—and not analysis—of experiments. Further, it adds markedly to already available books in this field, being much more concerned with the planning stages than most books incorporating the word "design" in their title. For example, it treats in some detail the nature of treatment factors—qualitative and quantitative, and the choice of their number and level. Techniques for effective design—randomization, grouping of experimental units into homogeneous blocks, use of covariates, etc.—are presented in their intuitive reasonableness to the experimenter, for whom the book is written. Justification for these techniques is not made to depend upon the analysis of variance. Continual reference, however, is made to standard sources for the analyses; Cox is careful to point out that the benefits of efficient design are only realized if correspondingly efficient analyses are used. On the other hand, no amount of analysis can completely compensate for lack of good design; this is the reason this book is important.

Planning of Experiments aims to make the experimental scientist aware of the possibilities in experimental design, and for simpler designs, to enable him to construct them. Very little quantitative background is presumed; concepts (but not rigorous definitions) of standard error, significance, confidence interval, and power are developed in a persuasive fashion. Although basically a reference, this book could be used as a supplementary text for a course in experimental design or research methodology (it contains no exercises, however).

The style of the book is lucid and well fitted to independent study. Each chapter starts with an introduction and ends with a concise summary. Recommendations are made as to certain sections to be omitted, depending upon the reader's interest. Self-help suggestions are made, e.g., in discussing response curves, the reader not familiar with the properties of second-degree equations is invited to sketch a few. In presenting numerical examples of the presence and absence of interaction, Cox first gives instances where residual error is zero, a useful device making the interaction and main effects more apparent. The concept of residual error is articulated by the notion, carried out in numerical examples, of successively substracting out the various estimated effects from the original observations. It would be well, however, at some point to introduce the general model in the following form (using Cox's notation and style):

$$\text{observation} = \begin{matrix}\text{over-all}\\ \text{mean}\end{matrix} + \left[\begin{matrix}\text{mean}\\ \text{observation}\\ \text{for that}\\ \text{treatment}\end{matrix} - \begin{matrix}\text{over-all}\\ \text{mean}\end{matrix}\right] + \left[\begin{matrix}\text{mean}\\ \text{observation}\\ \text{for that}\\ \text{block}\end{matrix} - \text{mean}\right] + \text{res.}$$

As a text *or* reference, the lack of exercises as such is offset by the abundance of good examples in considerable detail, well integrated with the exposition. Examples cover a wide range of fields, and nearly all represent actual experiments. Several examples are from psychology, principally experimental and educational.

In terms of content, the book may be divided into two parts: Chapters 1 to 9, giving

in fairly complete detail certain basic designs, and Chapters 10–14, introducing and outlining the standard cases of the more complex designs. Chapter 1 gives a general introduction, indicating when experimental designs are useful, in contrast to survey techniques, and enumerating five requirements for good design—unbiasedness, precision, ability to generalize, simplicity, and measurable error. Next, the concept of reduction of error is introduced, first by allocation of treatments to experimental units (randomized blocks, Latin squares) and second by use of concomitant variables. Adjustment of treatment means for concomitant variation is given considerable attention and illustrated graphically.

Randomization receives an unusually extensive treatment, including its methods, properties, and justification. (A minor flaw: one of the methods suggested for entering a random number table is to think of some numbers to designate page, row, and column; such a nonrandom start might, of course, lead to bias or dependence in continued applications.) Randomized assignment of treatments to experimental units is compared with systematic or subjective assignment. Occurrence of extreme permutations as a result of randomization is considered, and recommendations are made for preventing or dealing with this case.

Factorial designs are considered at some length. Careful distinction is made between quantitative, ranked qualitative, and qualitative factors; the latter are further designated as specific (Model I) or sampled (Model II). (It is asserted that quantitative factors are nearly always Model II.) Response curves and response surfaces are developed and illustrated by numerical examples. In the chapter on the choice of the number of observations, five bases are presented for estimation of precision (or equivalently, error); observed variation between experimental units, higher order interactions, theoretical considerations, within-unit variance, and past experience.

Chapters 10 to 14 cover a wide range of additional techniques of experimental design, among them Graeco-Latin and higher order squares, balanced incomplete blocks, Youden squares, lattice squares, partially balanced incomplete blocks, fractional replication, confounding, cross-over designs. For use of these designs, Cox recommends consultation with a statistician or reference to more advanced works. These chapters, however, serve well in giving the experimenter a concept of the possibilities. In the final chapter, Cox considers briefly a collection of techniques: search for optimum conditions (experimental conditions under which a particular quantity is maximized); assays, especially bioassays; trend-free systematic designs (small experiments where precision under an assumed trend is achieved at the expense of randomization, and hence, estimation of error); and the case in which certain treatment arrangements are inadmissible.

The book contains extensive author and subject indices, tables of random digits and random permutations, references for each chapter, and a useful general bibliography, briefly annotating eleven standard references on the design and analysis of experiments.

In summary, the coverage, style, and level of this book recommend it highly for independent study in the planning of experiments.

Maxwell's *Experimental Design in Psychology and the Medical Sciences* is quite a different book from Cox's. As early as the preface, one is put on guard against this slim volume; there the curious statement is made that this book "differs from the general run of statistical textbooks for psychologists and medical men, *which tend to concentrate on descriptive statistics*" [italics mine]. In psychology, at least, this remark seems more historical than contemporary, considering such widely used psychological statistics texts as Walker and Lev, McNemar, or the experimental design texts of Lindquist and Edwards.

This book, directed to psychologists and medical researchers, assumes no prior statistics; a sketchy introduction is given in the first chapter. Following that, separate, brief chapters are accorded randomized blocks, Latin and Graeco-Latin squares, factorial designs, cross-over designs, balanced incomplete blocks, linear regression and product moment correlation (five pages), analysis of covariance, inadmissible treatment arrange-

ments, systematic designs, and relative efficiency. Coverage of Cox's development of systematic designs and inadmissible treatments is comparatively excessive for a book which does not even mention the more common topics of fractional replication, split plot, partially balanced incomplete blocks, lattice designs, and merely makes reference to confounding. (Cox himself allots the two topics only seven pages in his much more complete book.) No consideration is given to such basic concepts as fixed and random effects, expected mean squares, or power. The underlying model for an analysis is seldom explicity stated.

There are instances of passages which are at best misleading. For example, on page 50 it is stated that "When randomization, too, has been properly carried out in an experiment, analysis of variance procedures and the use of the variance ratio test are valid whether or not the variate being sampled is normally distributed in the population. . . ."

Nor is the book redeemed by the mode of presentation. The first chapter institutes a precedent for jumping into the middle of things by treating a test for the difference in means of two samples, but never the one sample case. References are scanty. Many standard works are omitted, and several of the books are cited in outdated editions.

In general, the book presents somewhat the impression of a personal handbook or set of notes, competently prepared for the use of the compiler, but of little use to others in that form.

University of Chicago JACK SAWYER

ANNE ANASTASI. *Differential Psychology.* (3rd edition) New York: Macmillan, 1958. Pp. xii + 664.

This is certainly the outstanding text in differential psychology in both its thoroughness of coverage and the level of sophistication of its treatment of research findings. Some idea of its comprehensiveness may be gained from the distribution of the numbers of references at the ends of the chapters—ranging from 27 to 150, with the median between 93 and 96.

Despite the increase in volume of literature cited, this edition is smaller in size than the second edition. There are 18 chapters instead of 24 and 631 pages of text instead of 867. Some of the economy has been effected by omitting or shortening discussions of statistical and measurement techniques, and by reducing the detail in the discussions of the researches presented. These changes may be regarded as good or as bad, depending upon one's view of what the proper function of a textbook is. It has long been my opinion that on the college level a textbook for a course of the "survey" type should serve primarily as a source and reference book for the student, with free rein given to the author to state his own interpretations of the material presented. Anastasi's book meets these criteria well. The findings of investigations on a given topic are well integrated, and critical evaluations of particular studies are in many cases made with enough generality that students with interests in the details of experimental design and data analysis might be stimulated to read some of the references in the original.

I think I am not alone in detecting in Anastasi a tendency to be lenient in criticising researches whose conclusions place heavy weight on environment as a determiner of human abilities. The most flagrant example probably is her treatment of Bernardine Schmidt's famous study. Although she is a bit more severe in this edition than in the previous one, Anastasi's summary statement in this connection is, "Whether the specific procedures utilized by Schmidt can be expected to produce gains as large as those claimed, however, must remain an unanswered question for the present. In any event, it appears evident that the effectiveness of many of the techniques would be restricted to certain types of cases"

(p. 405). It should hardly be necessary to justify a categorical *No* to the "unanswered question."

All in all, however, Anastasi's position on the heredity-environment question, as she herself formulates it, is a reasonable and defensible one, and certainly the most practical. For example, "The question should be reformulated in terms, not of how much, but of how. What we need to know is the *modus operandi*—the way in which specific hereditary and environmental factors operate in producing specific differences in behavior" (p. 83). Her most extreme statement, perhaps, is in the final chapter: "It is not the race, or sex, or physical 'type' to which the individual belongs by heredity that determines his psychological make-up, but the cultural group in which he was reared, the traditions, attitudes, and points of view impressed upon him, and the type of abilities fostered and encouraged" (p. 604). One must admit that this statement has not yet been proved false, and the point of view Anastasi assumes is one that college students should be able to evaluate, and have fun in the process.

In decided contrast to the general maturity expected of students who use the book is the plane of some of the discussions of elementary statistical measures. There seems to be scant justification for including in a text of this sort a description and explanation of frequency distributions, frequency polygons, histograms, and the like (pp. 24 ff.). These materials add unnecessary bulk to the book, and it is doubtful that students who need this kind of rudimentary work can profit from the rest of the book anyway. Why not assume adequate command of statistics, or leave it to the instructor to supply it?

The attempt to present, and yet condense, statistical methods is likely to lead to oversimplification, errors, and misleading statements. Anastasi's fairly elaborate discussion of the basis for statistical regression (p. 204) is inadequate because it fails to mention that the direction of the regression depends upon the shape of the true-score distribution. In a U-shaped distribution, for example, regression would be *away* from the mean.

In the section on factor analysis the following statements appear (pp. 330, 331): "If by factor analysis we find that five factors are sufficient to account for all the common variance covered by these twenty tests, we can substitute these five new dimensions for the original twenty in describing each individual. . . . In any event, the number of necessary scores required to cover the behavior domain surveyed by the original test battery would be reduced from twenty to five in the process." Although factors are limited to accounting for common variance in the first part of the first sentence, the rest of that sentence and the second sentence seem to imply the inclusion of unique variance also.

The objections I have just enumerated are relatively minor and easily remedied. When the book deals with the main topics of differential psychology it is excellent. Students and teachers alike should find courses in which it is used stimulating and provocative.

University of Michigan JOHN E. MILHOLLAND

R. OLAVI VIITAMÄKI. *Personality Traits Between Puberty and Adolescence.* Annales Academiae Scientiarum Fennicae, Ser. B, Tom. 104, Helsinki: Suomalainen Tiedeakatemia, 1956. Pp. 183.

This is a report on the relationships between scholastic achievement and "certain ability, temperament and dynamical traits." A battery of ability tests, the Wartegg drawing completion test, and the Zulliger shortened variation of the Rorschach test were given to a sample of high school boys and girls, some of whom took the projective tests again at college three years later. Almost everything that could have been done with the data has been done. Reported for the sexes separately are multiple correlations with high school and college achievement, combined and separate factor analyses, and differences between the

means and correlations between the two testings with the projective devices. There is also a Q-technique analysis for those with the best matriculation results.

The ability tests are too restricted in content and too inadequately described for the factorial results to be of any interest outside Finland. Projective testers may be able to understand the interpretations given the factors obtained, but even they may be disturbed to find that over three years boys change to become both more introversive and more extraversive! To those who don't speak the projective language or who lack the necessary intuition, the results will have little appeal. Some developmental psychologists may find merit in the evidence concerning personality changes between ages 15 and 18, provided they can interpret and justify the changes and disregard that out of enough differences considered some must turn out to be statistically significant. Consistently overlooked are the need for cross validation in such a fact-finding study, and the role of experimental dependence between variables in the use of factor analysis. Interpretation of factorial differences between boys and girls and between ages 15 and 18 in terms of *differentiation* is questionable, especially considering that methods of communality estimation and of deciding the number of factors are not given.

Too much of the report consists of mention of material for its own sake rather than for its relevance. There are chapters on the nature of personality, on the constancy of personality traits, on measurement in psychology, on factors in the Rorschach, and on the prediction of scholastic success from ability and personality tests, but their content is never related to what follows. For example, Viitamäki insists that factor analysis is a hypothesis-testing technique, yet uses it in a fact-finding way.

Perhaps of most interest is the application of a method of rotation suggested by Ahmavaara, but not elsewhere reported, though it is implied in Ahmavaara's writings. The primary factor axes are located through those tests which have the lowest ratios of their first centroid loadings to the lengths of their vectors, that is, along those vectors furthest from the first centroid. Rotation is made directly to oblique primary factor pattern. In the analysis reported, this method of rotation yields a fair simple structure. But it may overemphasize single variables in the location of hyperplanes and might better be used for selection of the first trial vectors in the single plane method of rotation.

The translation is quite fair, though there are some strange terms (e.g., prestations), and some oddities, such as: "Marking done by the teachers is also incoherent!"

All in all, there has been a lot of busy-work and much being wise after the event. One gets lost in the wealth of data, and this is aggravated by the highly intuitive interpretations. The report is below the standard of others in the *Series* and will interest a limited audience only.

University of Sydney J. A. RADCLIFFE

D. H. STOTT. *The Social Adjustment of Children. Manual to the Bristol Social Adjustment Guides.* London: University of London Press, 1958.

The Bristol Social Adjustment Guides, developed by D. H. Stott and E. G. Sykes, "offer a method for detecting and diagnosing maladjustment, unsettledness, or other emotional handicap in children of school age." There are separate forms for The Child in School (Boy), The Child in School (Girl), The Child in Residential Care, and The Child in the Family. Each form consists of groups of descriptive phrases in various categories. The observer's task is simply to underline the phrases which are appropriate. For example, the forms for The Child in School include (i) Attitude to Teacher, (ii) Attitude to School Work, Games, and Play, (iii) Attitude to Other Children, (iv) Personal Ways and Physique. Each of these forms has groups of phrases such as

Greeting teacher: Over-eager to greet / greets normally / sometimes eager / etc.

Categories and content are pertinent and coverage is good; phraseology is clear. Scoring is by template, awkward for any large number of cases; the summary forms, although effectively designed, seem unnecessarily large.

The authors consider children's problems in terms of a number of diagnostic categories, each falling along a continuum from mild "unsettledness" to severe "maladjustment," except XC which does not extend into the maladjustment end. These categories are: U-W, unforthcomingness-withdrawal; D, depression; XA, anxiety or uncertainty about adult interest and affection; HA, hostility to adults; K (for knavery!), an attitude of unconcern for adult approval; XC, anxiety for approval of and acceptance by other children; HC, hostility to other children; Restlessness (at the maladjustment end this becomes psychosomatic disorder or physical defect); and a miscellaneous group.

The author's basic concept is that maladjustment results from over-readiness of the "executive reactions" (i.e., normal responses to unfavorable situations) as a result of excessive or prolonged activation. His discussion of the patterns which tend to occur is insightful, but in places this discussion is somewhat more dogmatic about causal sequences than the present state of our knowledge would seem to warrant.

The long chapter on the development of the Guides is introduced by a general discussion of epistemological and methodological problems, as background and justification for the largely nonstatistical technique followed in the construction. The extremely laborious and somewhat naive procedure is open to technical criticism, but it must be noted that the criteria for each step were in terms of psychological sense—a standard sometimes lacking in studies with more statistical sophistication. Unfortunately, in this description some essential data are omitted, e. g., adequate description of the subjects on whom the Guides were tried out. It would also appear that there was contamination of the criterion classes by the test scores. There are no data on reliability and no norms.

From the general nature of the scales, their content, and their coverage, they might well meet their author's intent to provide "a clinical instrument by which a comprehensive report of how the child behaves and reacts in real life can be furnished to the psychologist or psychiatrist, and a system for the interpretation of the behaviour . . . a means of judging whether a child is suffering from emotional difficulties, such as might be the cause of failure in school-work, or which might act as a warning sign of the possibility of delinquent breakdown . . . in the training of teachers as a framework for the observation and study of children. . ." From the Manual, however, there is no way of judging whether or not they are likely to be effective.

Harvard University ANNE ROE

ALPHONSE CHAPANIS. *Research Techniques in Human Engineering.* Baltimore, Md.: The Johns Hopkins Press, 1959. Pp. ix + 316.

In 1956 Chapanis published a monograph entitled *The Design and Conduct of Human Engineering Studies* (San Diego, Calif.: San Diego State College Foundation, pp. iii + 73). The present volume is an expanded version of the monograph, with the addition of one new chapter. As before, the author continues reluctantly to use the phrase *human engineering* rather than some more desirable but less popular term such as *engineering psychology, biomechanics, human factors engineering,* or *ergonomics.* The aims of the author are (1) a description of the methods available to the human engineer, and (2) a presentation of "principles and guide lines about ways of doing dependable studies on people." Although elementary in nature, the book is intended to provide background information to individuals who are concerned with experiments relating men to machines. Thus the audience should include those engaged in industrial engineering, operations research, experimental psychology, systems engineering, and scientific management.

The introductory chapter proposes that the tactics and strategy of science can be learned from a book—thus justifying the present work—and states that research on people is the most difficult kind of experimentation. After dismissing common sense as a reliable standard for design decisions, some common pitfalls in studying people are reviewed.

The remaining seven chapters present the methods available to the practicing human engineer who might be called upon to perform research in order to solve some man-machine problem. Under methods of direct observation we find operator opinions, activity sampling, process analysis (including link analysis), and micromotion techniques. A chapter on accidents and near accidents describes the critical-incident technique. Raw data are used to describe and illustrate statistical methods which include (in 51 pages!) tabular and graphic distributions, measures of central tendency, measures of variability, measures of relationship (Pearson r only), and significance of differences (t test and F test). The chapter on experimental methods also uses raw data to illustrate single- and multi-variable designs (including the Latin square); ten pages are devoted to how much realism is needed in experiments. The psychophysical methods discussed are average error, limits, and constants. The eighth (and new) chapter is on techniques of articulation testing for speech communication applications. Chapanis wisely includes an earlier chapter on special problems in experimenting with people in which he discusses experimental variables, control of motivation, selection of subjects, and apparatus.

The nonpsychologist reader of this book should gain the level of sophistication about experimenting with human beings that the psychology student receives in his basic course in experimental psychology (both types of students should, of course, have additional laboratory exercises). In fact, as a methods book, this volume could well serve as a text for an experimental psychology course if suitably supplemented by contextual lectures and outside reading. The real contribution made by this volume, however, is its successfully clear and timely account of research techniques to a growing audience of physical and engineering scientists who have become concerned with the human factor in man-machine efficiency.

Tufts University LEONARD C. MEAD

F. F. STEPHAN and P. J. MCCARTHY. *Sampling Opinions.* New York: John Wiley and Sons Inc., 1958. Pp. 451.

This book presents one of the few sound and comprehensive treatments of sample survey methodology. There are available volumes which give a more complete treatment of particular phases of survey methodology, e.g., Hansen, Hurwitz, and Madow's treatment of sampling or Hyman's books on interviewing in social research, but the book under review is one of the few which attempts to cover the entire area of survey research and succeeds in doing so without degenerating into a collection of pious admonitions. In addition, the authors present a good deal of hitherto unpublished data which will be of considerable value in actual practical sample design.

The great strength of this book is its emphasis on the multiplicity of problems encountered in sample surveys and the need for considering all of these problems in survey design. The weakness of the book is its overemphasis of quota sampling and particularly of the type of quota sampling which was popular seven or eight years ago. With the exception of this overemphasis, the volume is a very careful and scholarly treatment of the field of sample surveys. It is well suited as a text for a general introductory course in the techniques of sample surveys and, with supplemental readings (e.g., from Hurwitz, Hansen, and Madow or from Hyman) could also be used in more advanced courses since it does bring in a good deal of original research material.

There are a few statements with which the reviewer would take issue but these are extremely minor. For example, in referring to the ratio of two random variables, the statement is made that "only an approximation can be obtained from the probability model for its variance" (p. 202). While the formulas usually given for the variance of such ratios are approximations an exact formula is, of course, available. Since a ratio of two random variates is itself a random variate, it has a variance which can be defined and which can be estimated by repeated samplings, the exactness of the variance estimate being limited only by the number of repeated samplings it is feasible to make.

Chapter 10, on the variability of quota sampling, glosses over the main point that the mean square error of a quota sample estimate is of primary interest. However, even if one takes this treatment in its own terms and considers only the variance, the treatment is somewhat misleading. There is a comparison of the variance of quota sampling with the variance of random binomial sampling which concludes that the variance of a quota sample result "can be approximated in a rough fashion by the variance of the binomial model for random sampling when it is multiplied by a suitable factor by the order of 1.5" (p. 233). Actually the data are insufficient to support any definitive conclusions—even as cautious a conclusion as the one just quoted. In addition, it would be more appropriate to compare the variance of quota sample estimates with the variance of estimates based on a clustered probability sample rather than with the variance of simple random sampling. I strongly suspect that a comparison between quota sampling and clustered random sampling (with the same size and geographic distribution of interviewers' assignments) would show that quota sampling gives a *lower* rather than a *higher* variance.

A particularly valuable feature of the book is Chapter 12 on analysis of field operations. While the analysis was carried out on a quota sample, a good deal of it is applicable to surveys which use probability sampling. This chapter is especially valuable in emphasizing some of the factors leading to high and low costs and to high and low biases and sampling variances.

The publication of this book emphasizes again the great methodological improvements in survey design which have occurred in the past 20 years—improvements to which the authors of the book have made substantial contributions. As Hyman notes in his book on interviewing, an awareness of defects in methodology is a sign of sophistication and of progress rather than of weakness and, in this respect, the survey field is well ahead of other areas in the social sciences and of many areas in the natural sciences as well.

National Analysts Inc. ELI S. MARKS

S. N. ROY. *Some Aspects of Multivariate Analysis.* New York: John Wiley and Sons, Inc., 1957. Pp. viii +214.

This monograph is the first of a series to be published by the India Statistical Institute. The main body of the book is a collection of journal papers by the author, his students, and colleagues, slightly rewritten for uniformity of style and presentation. Several chapters, one on the general theory of tests of hypotheses and two on properties of the multivariate normal distribution and related sampling statistics, have been added providing background for the notation used throughout the book. The final 77 pages are taken up by nine appendices containing proofs of various theorems needed in the body of the work.

Professor Roy sets for himself the task of obtaining confidence bounds for certain functions of the parameters of one or several multivariate normal distributions, where the functions are chosen to be natural measures of deviation from the usual null hypotheses. The approach is novel. He first defines a class of statistical tests which have "good" prop-

erties. One property is that the tests can easily be inverted to obtain confidence bounds. Another is that the method of test construction leads naturally into a set of simultaneous confidence bounds; that is, in 95 percent (say) of such experiments each confidence bound in the set will contain the true value of its corresponding parametric function. Then he discusses the power of the tests (and thus the "shortness" of the confidence bounds) and obtains lower bounds for the power functions, and finally, develops the confidence bounds associated with the class of tests. These include confidence bounds on means and linear functions of means, on the characteristic roots of variance-covariance matrices, and on regression functions.

In the last chapter Roy discusses the application of the same class of tests to multivariate categorical data. Here he makes the important but often neglected distinction between a classification whose marginal totals are fixed in advance and one whose marginal totals are random variables. The distinction does not affect the test criterion but rather determines the class of alternative hypotheses to be considered. It is also useful in pointing up analogies between contingency table problems and analysis of variance problems.

The proofreading of the book is less than adequate, particularly considering the small amount of redundancy in a mathematical equation. The reader who, like the reviewer, is annoyed to find that he is reading a continued story will hope that the wait for the "later monograph" which is promised so often throughout the book will not be too long.

It is not likely that the ultimate consumer of statistical methods will find this book worth his while. But the psychological statistician interested in multivariate problems will profit from a careful study of this work.

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CORRECTION

An erratum which appeared in *Psychometrika*, Volume 24, p. 404, December, 1959, unfortunately included a typographical error. The final symbol should read q_2 , not p_2 . Thus the erratum would read as follows.

In Cureton, Edward E., Note on $\phi/\phi_{\max}$. *Psychometrika*, 1959, **24**, 89–92, the first sentence of paragraph 2, page 89, should read "It is well known that ϕ can equal $+1$ only if $p_1 = p_2$, and that it can equal -1 only if $p_1 = q_2$ ([1], p. 324; [2], p. 342)."

The editorial staff joins the William Byrd Press in promising more diligently to "mind our p's and q's."