tion that a microscopic image is for many reasons not strictly a picture in his sense. The direction for generalization to such images is indicated but, understandably, is not fully explicated.

In contrast, the term "processing" is construed far more broadly by Rosenfeld than it would be by most problem-oriented workers in the field. Processing to him includes coding, enhancement, segmentation, and other such operations as well as recognition or analysis. Lastly, the word "computer" in the title is actually equivalent to "algorithmic," so that the title might be paraphrased as "useful and interesting algorithmic transformations of two-dimensional optical density arrays," but this would not attract as wide an audience as the book deserves.

Thus far I have dealt with Rosenfeld's main concern—what might be termed picture information of the first kind, or *inherent* information. This information, expressible as relations among the various possible subsets of resolution elements and their respective gray values which together constitute the picture, must be distinguished from picture information of the second kind. The latter, which might be termed *added* information, is that information which the human brings to the picture in fulfilling the task of detecting, analyzing, describing, or classifying images or objects within images. The added information simply cannot be evoked or isolated no matter how the picture or image is processed or transformed. It does provide a structure upon which parts of the inherent information may be organized. Indeed, such structures would seem to be required even before systematic rather than pragmatic information reduction can take place.

Systematic treatment of added information is not easy. The added information is relatively inaccessible, residing as it does in the intellect of the picture analyst and elicitable usually only by linguistic informant technics. However, creation of useful structures of added information becomes increasingly feasible as the picture class is increasingly constrained, or, in other words, as problem orientation plays an increasingly large role. Even here formal picture descriptions which are generative, in the same sense as linguistic grammars, remain (except in relatively trivial cases) theoretically possible but unrealized objects.

Rosenfeld's final chapter ("Picture description and picture languages") is a brief characterization of the research on the use of added information for primarily picture analysis. Its brevity is regrettable but understandable. However, if picture processing is ever to transcend mere pragmatic employment of mathematical tools (no matter how elegant) much more attention will have to be paid to the use of formal models of classes of images. This may mean that picture processing may make greatest progress in those problem-oriented areas where the user is willing to defer immediate results—until powerful logical structures can be developed to drive, as it were, the picture analyses.

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## Significant Measures

**Statistical Power Analysis for the Behavioral Sciences.** JACOB COHEN. Academic Press, New York, 1969. xvi + 416 pp. $13.50.

"A lady declares that by tasting a cup of tea made with milk she can discriminate whether the milk or the tea infusion was first added to the cup. We will consider the problem of designing an experiment by means of which this assertion can be tested." Thus Sir Ronald Fisher begins his chapter on hypothesis testing in *The Design of Experiments* (ed. 4, Edinburgh, 1947). Suppose the claim is tested by presenting to the lady two cups of tea, one made by each method, and asking her to indicate which is which, this trial being repeated 15 times. Presumably the lady will get some pairs correct even if she is just guessing. Therefore, to establish her claim, she must do substantially better than chance. In the language of statistical hypothesis testing, the hypothesis that she is guessing is called the null hypothesis; and we assume that the probability of any set of outcomes can be correctly calculated on the basis of this hypothesis. To evaluate the lady's actual performance, we calculate the probability (under the null hypothesis) that a chance mechanism could have done as well as or better than she did. If this probability is small, the experiment is said to be statistically significant. The value of this probability, called its significance level, is often used to summarize how convincingly the data disprove the null hypothesis. The idea is that, since a result as good as or better than that observed would only rarely occur by chance, a causal mechanism is the more reasonable explanation.

Assume that our lady has some ability to discriminate correctly between the cups, without being perfect. We know that her score will vary from one set of 15 trials to another. We now ask, if her true (long-run) batting average is known, what is the probability that a single experiment, of 15 trials, will yield a result significant at a specified significance level? This probability is called the power of the test, and answering this question for a variety of experimental situations is the purpose of the book under review. For example, Cohen's tables show that if her true average is 70 percent, only about half the time would a 15-trial experiment be significant at the 5-percent level of significance. On the other hand, if her true average were 80 percent, then about 84 out of 100 such experiments would meet the criterion.

In general, assuming the model and the calculations to be correct, the factors determining the power of a test are the significance level, the sample size, the inherent variability of the data, and the actual, though unknown, size of the effect the experimenter is trying to demonstrate. Without losing generality, Cohen measures the size of the effect in terms of the data's variability.

For each statistical test considered, Cohen presents two tables. One gives the power as a function of level of significance, effect size, and sample size; the other gives the sample size required to obtain a given power as a function of effect size and level of significance. (Since this latter quantity can be easily obtained by scanning the columns of the first table, the second is largely only a convenience.) The book covers most parametric tests likely to be found in an introductory or intermediate textbook, including approximations for the power of the test for interaction in the analysis of variance. Except for the sign test, no nonparametric or sequential tests are covered.

Choosing an appropriate effect size to use in assessing the power of a test is often difficult, since the true value is, of course, not known. Cohen works hard on this problem, using both examples and a generalized concept of small, medium, and large effects, which will be both understandable and useful to many social scientists. While a rigorous handling of a prior distribution is beyond the scope of the book, the idea of taking a weighted average of the power against several alternatives would

add a Bayesian touch that might help some workers who have only vague ideas about the actual size of an effect.

The use of graphs to illustrate the concept of population overlap and to show power as a function of effective size would have helped the discussion of these concepts.

The book is presented as being both a handbook and a supplementary text for an intermediate course in statistics. As a supplementary text the book is very good. It contains almost 100 examples which illustrate both the use of the tables and some of the problems investigators face in planning their research. The most common problem is that the sample size required for reasonable power is larger than the experimenter can afford.

It is disappointing that a book dealing with a matter so close to the heart of science as how one proves the existence of a hypothesized or predicted effect gives the student so little of the philosophical or broader statistical issues involved. In particular, there is no attempt to relate tests of hypotheses to either confidence-interval estimation or more general forms of decision theory. Situations in which these ideas are relevant occur in the examples, and surely an intermediate student should be acquainted with both these concepts. In fairness to the author, it is the richness of his examples that seems to cry out for a broader basis of discussion. Cohen clearly is alive to these issues, but he never seriously discusses them with the reader man to man.

Those who know statistics and simply want to look up the power of the test they have in mind are not going to find their answer quickly. This is true even though each chapter is organized on the same general plan. The minimum information required, for example, to look up the power for a $t$ test with equal variances but unequal sample sizes is so scattered that one must skim the whole chapter. This problem is aggravated by the way the book is set in type. The illustrative examples are interspersed throughout the material explaining the use of the tables and are numbered in a boldface type more prominent than the heading of the substantive section, with the result that these important sections are hard to find by leafing through the chapter. They can best be found by looking in the table of contents, rather than the index.

The way the headings of the tables themselves are set in type is a classic example of what not to do. The title of the table, which tells the type of test and the level of significance, is in a lightface of the same size as that used for references in *Science*. The level of significance is not labeled as such but is called "a," presumably for alpha, the usual statistical notation. The "a" has a subscript which is the only clue to whether the table is for a one- or a two-tail test. Mistaking a one-tail for a two-tail table produces a serious error. When a table is continued onto a second page, not even this microscopic information is reprinted.

Despite these typographical roadblocks this book should have a widespread and beneficial effect upon the social sciences. By putting power tables for so many common statistical tests into one book with a unified treatment, Cohen will save many experimenters from trying to prove too much with too little.

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## The Rise of Native American Civilization

**A Comparison of Formative Cultures in the Americas.** Diffusion or the Psychic Unity of Man. JAMES A. FORD. Smithsonian Institution Press, Washington, D.C., 1969 (available from Superintendent of Documents, Washington, D.C.). xviii + 214 pp. + plates. $7.75. Smithsonian Contributions to Anthropology, vol. 11.

This posthumous book is a monumental and scholarly synthesis of its author's life's work. Here the results of his broad and active participation in the archeological investigation of New World culture history come finally to bear upon major problems of culture theory. So do his concerns with archeological methodology and theory.

The book has two main foci: the definition and delineation of that part of native American culture history that gives the book its title—the Formative—and a test of one of culture theory's most important problems, the extent of human creativity.

For Ford the Formative was more a culture-historical process than a chronological period:

> . . . it is preferable to define the Formative more loosely as the 3000 years (or less in some regions) during which the elements of ceramics, ground stone tools, handmade figurines, and manioc and maize agriculture were being diffused and welded into the socio-economic life of the people living in the region extending from Peru to the eastern United States.

This culminated in the appearance of the first American civilizations. Ford eschews the traditional tripartite division of the Formative into Early, Middle, and Late phases. Instead he proposes a "Colonial Formative," 3000 to 1200 B.C., during which ceramics were being distributed over the Americas by seafaring colonizers, and a "Theocratic Formative" "rather sharply defined by the first appearance of mound structures and other appurtenances of political-religious control" between 1200 and 400 B.C.

Through a detailed analysis and comparison of data and chronology Ford comes to the conclusion that the main stimuli giving rise to both the Colonial and the Theocratic Formative were of trans-Pacific origin. At this level the work constitutes an exploration of theoretical problems of long standing in anthropology and history. As I have mentioned, the most important of these lies in the delineation of human creativity, its incidence and nature. Adjunct to and illuminative of this are the factors of parallel invention and discovery, cultural determinism of human behavior, and the role of diffusion in culture growth, all hoary with age as concepts and problems, faddishly in and out of style with students of human behavior, but incessantly providing a background dissonance to our attempts to understand ourselves. It has long been the hope of anthropologists and culture historians of the American tradition that the rise of native American civilization would provide an independent "laboratory" test of cultural evolution through which universal principles and laws of human behavior could be formulated. Only when the results of the "busyness" of synchronic investigations of human behavior are assessed can the importance of this hope he evaluated. But Ford's conclusions amount to a major challenge to all theorists of human behavior.

The test of the two opposing views lies in the interpretation of available data. The presentation here is the most serious challenge so far to the thesis that prehistoric American civilization