INTRODUCTION

Past relationships between statistics and the clinic have been, to say the least, strained if not antagonistic. Although we have seen the development of psychological statistics, agricultural statistics, medical and even geological statistics, clinical statistics is still an unheard-of combination. Apparently the bedside needs of the patient are either too urgent or too little understood to permit the objective evaluation of the concepts involved in clinical work. Nevertheless, because of the rise of interest in clinical work since World War II, and because some of the men involved in clinical work had previously been exposed to statistical thinking, a demand has arisen to bridge the gap between these two disciplines. The clinician on his part has begun to feel the need for objectifying some of his empirically gained intuitions, and the statistician on his part has begun to wonder whether his present day tools are adequate to handle the complexity of the clinical case.

In analyzing the relationship between these two areas of research, it might be well to review the gradual, perhaps unnoticed rapprochement that has occurred between them. The best indications of this process can be noted in the two recent reviews of the development of statistics. Fisher(6) in his address at the inaugural meeting of the British Region of the Biometric Society gave a kaleidoscopic review of the advances of science from the early days of the Greeks to the present. Science got its early start as a deductive process through the invention of geometry, when “men learned to reason deductively, from well defined abstract concepts, to cogent and irrefrangible conclusions.” The purpose of Euclid’s Geometry however, was not aimed at artistically unified presentations alone, but had as its initial inspiration as well as its final goal practical applications in surveying, architecture, space description and measurement. Ultimately this precise deductive thinking gave rise to the branch of logic known as noumenal or philosophical deduction which, because of its earlier development completely swamped its tender sister—scientific or phenomenal inductive logic. To Galton, influenced by his half-cousin Darwin, is attributed the rise of scientific (inductive) logic, especially in its statistical applications. As soon as modern man left his philosophically (deductively) organized world, transmitted to him from the ancient Greeks through the middle ages, and began to make observation on nature both animant and inanimate, the limitations of deductive thinking unsupported by its inductive counterpart became readily apparent. Faced with the universal variability in all biological and social data, Galton and his
generation were completely stymied in their attempt to deal with these phenomena mathematically. There were no axioms to begin with because even the simplest truth about biology seemed to be subject to exceptions. Variability was the most characteristic event in nature. Galton accepted the challenge and made a virtue of variability by analyzing variability itself to see its consistencies as well as its variation. This gave the impetus to the present almost universal use of statistical methods in the inductive sciences of today.

Weaver(12) in a more detailed analysis of present day science, points out that scientific method has undergone three phases best characterized by the types of problems it dealt with: (1) problems of simplicity, (2) problems of disorganized complexity, and (3) problems of organized complexity. Up to 1900 the physical sciences had dealt with rather simple problems in which all but two variables, an independent and a dependent variable, could be kept constant. During the same period, the life sciences had not reached even this simple level of development and had to satisfy themselves with "collection, description, classification and the observation of concurrent and apparently correlated effects." Only the sketchiest beginnings of quantitative theories were proposed, and most of the data were qualitative rather than quantitative.

The next step in scientific development was the removal of the two variable constraint and the introduction of the multi-variable problem in which the single individual or molecule is lost sight of, and only the net effect of millions of molecules, each free to move in its own way is measured in terms of such overall variables as production of heat, etc. In the life sciences, social statistics, morbidity and mortality statistics were developed to predict the general trend in a group: the single individual being totally lost sight of as an entity. The development of probability theory gave an impetus to these social and physical applications and contributed much to the establishment of generalizations that have proved useful in the physical as well as the life sciences.

The final step was taken rather recently in the recognition of problems of organized complexity. This type of problem lies midway between the problems of simplicity of the two variable type and its opposite, the problems of disorganized complexity with its multitude of variables. The number of variables is still large, but they do not approach infinity. Furthermore, they are all problems which involve dealing simultaneously with a sizeable number of factors which are interrelated in an organic whole. Despite the danger of misinterpreting Weaver's intent, I have interpreted this type of problem as one in which our concern is with single individuals or groups of like-minded individuals. We are not concerned with the general laws applying to gases, but with why a given isotope in the gas chamber behaves differently from its neighbors. We are not so much concerned with the prediction of say an election, but with why John Jones votes the way he does.

This brings the problem of the individual to the fore. We may liken the shift from problems of disorganized to those of organized complexity, to the shift in interest from the behavior of gases to the behavior of the subatomic or intra-atomic world. Off-hand, there is no reason why the laws developed for the extra-atomic world should not hold true for the intro-atomic world, and many of them do, but they were sufficiently different to give rise to new concepts in physics, e.g., quanta. The likelihood is that new concepts must also arise in the life-sciences when we begin to deal with the social atom, the single individual.

In inaugurating this symposium, the starting point was the third level of development, namely organized complexity. To be sure, clinical psychology has hardly passed the first level of development, namely, that of collecting and classifying observations, but the second level of development, that of disorganized complexity is uniquely unsuitable for the treatment of clinical data. While individual differences and generalizations about average performance have proved useful in social, general, and experimental psychology, clinical psychology eschews these approaches and is concerned more
with the deviations in performance which characterize a given individual. For this reason, perhaps, the clinical sciences may be able to dispense with the intermediate stage and proceed directly to the study of organized complexity.

Present day statistical treatment of clinical data is primarily group-centered rather than individual-centered. The clinician who attempts to apply statistics in the classification of his cases or the evaluation of his results has to adapt the group-centered methods to the individual-centered material. Many such adaptations have already been suggested and utilized in various clinics and clinical research programs. But no concerted effort has ever been made to bring these methods together. The purpose of this symposium is to collect the adaptations of group statistics and provide the clinician with examples of their application to his problem. The following types of problems are frequently encountered by clinicians: (1) integration of test or observational data into patterns or profiles, (2) determining whether a given change in performance or behavior is significant or due to chance, and (3) determining the degree of consistency or variability or scatter that a given performance exhibits. There are numerous more specific problems, but most of them could be classified into the above categories.

Regarding the first type of problems, that of patterns or profiles for the description or classification of a series of observations or test scores on a given individual, several methods have been proposed. Stephenson(10) describes an application of factor analysis to this problem. Cronbach(27) describes a method which might be designated as a pattern analysis approach. In general, the problem seems to reduce itself to finding individual similarities between the various cases under study and classifying those cases who show the greatest similarity into one group or type. A type of this variety might be defined as a group of individuals who exhibit a common pattern in their scores or behavior, and whose frequency is such that it is greater than chance expectancy(14).

The second problem, of determining the significance of an observed change in a single individual is one which has received attention only recently(2, 9).

**Basic Assumptions**

In the usual study of normal individuals with psychological tests, once the universe under investigation is specified, a random sample can be drawn and estimates of the parameters characterizing the universe can be obtained to any degree of accuracy desired. The changes in score of the selected sample after a certain period of time, or after the application of the experimental factor, can also be compared to the expected chance or systematic variation in a control group selected from the specified universe to see whether the change is significant. Certain assumptions underlie this approach. First, that the score obtained for a given individual is a random sample of his true score distribution. Second, that the score variability (variation around the true value of the score) is constant for each individual in the sample. The variability of the entire sample can therefore be regarded as a basis for estimating the variability of each individual. In the case of abnormal individuals, several important requirements that are prerequisites for the above-mentioned treatment are lacking. The universe from which the sample is drawn can not always be accurately specified, the usual standard error for evaluating changes is untrustworthy, and the whole method of ordinary group statistics fails because its assumptions are not fulfilled. Consequently a modification or a new approach is required. In order to develop this new approach certain axioms and postulates are necessary:

1. In the study of a single individual, especially of a so-called abnormal individual, we must treat each case as an independent universe. Later when the characteristics of each of these universes become known we may be able to classify them into groups of like structured or similar universes. Until such knowledge becomes available, it is unwarranted to classify individuals as equivalent even if they have made identical scores on a series of tests.
2. Every individual is characterized by a given level of performance, of which the observed test score is a random sample.

3. Every individual is also characterized by a given degree of variability around the level of performance. This variability is characteristic of the individual and varies as much or more from person to person as does the level around which this variation occurs. This variability or its opposite, consistency, may be likened to the physiological consistency which goes under the name of homeostasis. The behavioral field as well as the internal environment of the individual is subject to the influence of slight alterations in the stimulation of the organism internally or externally, to which it responds by changes in performance, but this change in performance follows a characteristic pattern dependent upon the individual's characteristic variability or homeostatic pattern.

4. The effect of change in stimulation, internal and external, is to bring about an alteration either in the level of performance, the variation in performance, or in both.

These axioms constitute the basis on which treatment of an individual's data differ from the treatment of group data. Essentially the differences stem from the fact that the clinician is unwilling to regard his cases as constituting a meaningful universe. Consequently he must resort to considering each case as a universe unto itself.

The consequences of these axioms are significant for the treatment of clinical data as follows:

1. In addition to obtaining a sample of a given individual's performance, it is necessary also to obtain a sample of his variability. This necessitates taking 4 or more readings of observations on each case under study, for each of the states that is under investigation.

2. It is necessary to determine the types of influences exerted by variables other than those which the clinician may be attempting to vary. As a result of our dependence on repeated measurements or observations, practice effects are bound to occur. Since these practice effects are probably uniquely determined, it becomes impossible to evaluate those effects on a group basis, and methods for determining practice effects must be invented for the single individual.

In addition to the experimental variable under investigation at least two additional variables must be investigated. Some patients tend to improve (or get worse) spontaneously, regardless of the variables manipulated by the experimentally-minded clinician. The mere attention paid to the patient who may have previously felt hopeless or neglected, is sufficient to alter his performance temporarily or permanently, e.g., "total push" effects. Care must be taken not to attribute changes produced by the "total push" to the workings of the experimental variable. In addition to the externally apparent changes which may affect the individual, certain less apparent changes may be at work such as mood swings, cooperativeness, level of motivation, etc.

**Currently Available Methods**

It is needless to say that answers to all of these problems are not yet available. But the description of the problems facing the study of the individual ought to provide the clinical research worker with a program for measuring the quantifiable factors and circumventing those that baffle measurement.

In examining the field of available methods, the methods of analysis of variance and covariance for the single case are found most satisfactory in setting up experimental designs for dealing with the above data. Within the universe of the single individual, the readings may be regarded as more or less independent. In this way an analysis of variance can be made of each case separately, apportioning the total variability into its components. These component parts can then be studied in groups of contrasted individuals (treated and untreated), and the significance of the results noted. This
procedure may be applied not only to the changes in level of performance, but also to changes in variability of performance. In order to remove the influence of variability when considering changes in level, analysis of covariance may be resorted to. Similarly, the effect of level of performance may be removed when changes in variability are under consideration.

The analysis of the individual case has been stressed thus far because it seems uniquely suited to clinical data. It must be remembered that the clinician asks not only how does this case differ from the other cases that he has seen, but also asks in what way does this case resemble his previously observed cases. Hence both integrative as well as differential methods are of use to the clinician. Among the tools which serve both a differential as well as an integral purpose is the method of the discriminant function which serves to integrate a group of variables into a total score such that the maximum differentiation from a contrasted group is effected. A recent improvement of the discriminant function is the development of the partial discriminant functions. These bear the same relationship to zero order discriminant function that partial correlations bear to zero order correlations. Such a partial discriminant function would be especially useful when two groups are compared postoperatively on a test for which they were not equated preoperatively. Perhaps the mathematical statisticians can provide a tool for fractionating a given population into subgroups such that the difference between the means of these subgroups would be a maximum. This would be the converse problem of the discriminant function, and may turn the technique into a method for discovering types.

The analysis of individual similarities finds its apex in the inverted factor analysis or Q technique. Here each subject is correlated with all the others and the matrix of intercorrelations subjected to a factor analysis to determine the types inherent in the data.

The sequential analysis method provides the experimenter with a means of determining how many observations are required for testing a given hypothesis. In the study of intra-individual variability, a suitable derivative of sequential analysis ought to prove very useful to the clinical statistician.

In all of these attempts, the underlying problem is that of finding a mathematical model for the phenomena before us. Without such mathematical models we can never hope to develop rigorous tests of the adequacy of a given conclusion. To be sure the mathematical models are rigid and do not permit even slight deviations to go unnoticed. But that is the very purpose of the mathematical model, and as soon as the deviations get to be too troublesome, the model can be modified accordingly. As an example of such a mathematical model, the J-curve hypothesis of F. Allport might be mentioned. The J-curve hypothesis states in essence that when social customs and mores affect a population differentially rather than in a uniform manner, the resulting distribution of behavior will be J-shaped rather than symmetrical. Most of the data which have been analyzed under this conformity hypothesis are in discrete rather than continuous steps. A mathematical model that suits such a hypothesis is the binomial distribution which can represent discrete as well as continuous variables and furthermore produces symmetrical distributions for $p = q = 0.50$ and unsymmetrical and even J-shaped distributions when $p$ approaches 1.00 or 0.00. By fitting a binomial to the conformity data, the value of $p$ itself is found to be useful as an index of the degree of conformity.

In applying this model to various sets of data it soon became apparent that some conformity data do not lend themselves to a binomial fit. This occurred in the analysis of the behavior of motorists at cross streets. A careful scrutiny of the data revealed that they could be divided into two parts—data for 3 p.m. when children leave school, and data for non-school hours. Upon the assumption that two conformity trends characterized this material (greater conformity to traffic rules at 3 p.m. and lesser conformity at
other times), two binomials were fitted to the data which corresponded to the different conformity levels and the combined results fitted the total data adequately.

Summary

The purpose of this symposium was not to initiate a new type of statistics but to adapt as much as possible of the current group-centered methods to the purposes of clinical research. The needed adaptations of group methods to the problems met in clinical research was stressed by several contributors. The theoretical reasons why present-day methods are not fully applicable to the understanding of an individual case were outlined and the ground was prepared for the presentation of individual-centered methods.

One outcome of this symposium was a demonstration of the possibility of treating each clinical case as a separate universe. Such stress had formerly been made only by the idioGraphers. They have won their point, but their claims that the idiographic method can never be handled statistically is not shared by the author. In fact, some of the papers in this symposium show the way for quantifying the idiographic approach.

Another outcome has been the demonstration of the desirability of collaboration between clinical research workers and mathematical statisticians. Many of the problems facing the clinical research worker have already been adequately solved by statisticians. Others promise to lend themselves to solution as soon as the basic problem becomes clear. Indeed, it becomes quite apparent that as soon as a given clinical problem is specified adequately, a solution soon becomes available.

References