Letters

Scientific Method, Statistical Inference, and the Law

Something *other* than despair must motivate the scientist "who watches the instruments of his calling, and his reluctance to claim certainty, turned against him." Two recent editorials [*Science* **123**, 1059 (15 June 1956) and 1099 (22 June 1956)] have pointed up difficulties in the understanding of scientific method at hearings conducted by the Federal Trade Commission; the second reference included (on page 1107) an even more complete account of the utter lack of understanding of the most elementary principles of statistical reasoning by that same governmental agency. Such lacunae in intellectual armor, however, are not solely the possession of the legal talent of the FTC. It is our observation based on a limited sample but a sample of sufficiently large size, with not a single exception, to warrant at least the tentative hypothesis: the vast majority of those professionally concerned with the law are equally deficient in their understanding of those same principles of scientific inference.

Every day life is becoming more surrounded with affairs closely related to the scientific laboratory. Intimately associated with advances in technologic processes are the objective criteria by which the scientist reaches his conclusions. Similarly the lawyer, to best represent the interests of his client, must familiarize himself not only with the "technologic processes" of the situation in question but also with certain basic statistical reasoning, a primary ingredient in scientific analysis of evidence. The necessary statistical reasoning is not only intuitive and natural but also extremely useful and applicable to a broad spectrum of legal cases. An objective of this communication cannot be to present all possible examples of statistics applied to legal situations, but it can point up some ideas underlying statistical decision making and point out the similarity of these concepts with some of those concepts already accepted in the law. To this end we first outline some general analogies.

The thinking of the experimentalist, be he pure or applied, must of necessity be based on statistics: he must analyze data obtained by observation; and the only available objective methods of accomplishing this analysis are provided by the discipline of statistics. To digress for a moment, it should be mentioned that theoretical statistics, which develops the abstract logic on which the applications rest, might be considered as a branch of applied mathematics and has its foundations in the theory of probability. However, the applied statistician, dealing with the real facts of a physical world, must be more than a mathematician if he is to work on the same team with researchers in any field of investigation who have concrete problems facing them for which solutions in the real world must be discovered.

A qualitative analogy can be made between the thinking of the experimentalist and that of the lawyer in his situation. Although the lawyer may not have been aware of it, he is trained to think and reason in a manner similar to the scientist. Perhaps he has not been conscious that his processes of deducing conclusions are—in principle—the same as those of the scientist; the lawyer may have been unaware of this fact, because he has given the scientist too much credit for "precision." Take the legally familiar phrase, "beyond a reasonable doubt." The phrase very scrupulously does not say, "with certainty" or "beyond a doubt"; the legal phrase carefully includes the word *reasonable*.

The scientist, too, never proves everything "with certainty" or "beyond a doubt"; the best he can ever hope to say is that he has established a fact "beyond a *reasonable* doubt." The difference between the experimental and the legal situations is that the scientist has learned how to calculate the probability of the doubt. This has been the contribution of statistics.

We need not go into detail with the scientific measurement of experimental uncertainty. One hypothetical example will serve to illustrate. Suppose that a medical researcher comes up with a new treatment. The results of the experiments he conducts to evaluate his treatment are almost never black or white, but usually one of the shades of gray: more patients may improve with the new treatment than usually show improvement with the traditional treatment. (The key word here is *usually*: associated with any phenomenon there is almost always variation. For example, on the average, 70 percent of patients may recover from a disease inside of a week, in the long run. But given the next five groups of 100 patients each, we should not be surprised to see as few as 60 or 65 patients or as many as 75 or 80 patients recovering inside of a week in some of the groups. Almost certainly not all five groups of 100 patients will have the same number recovering inside of a week.) Here statistics comes to the rescue and aids in evaluating the experiment by analyzing the pattern of variation as follows: If there is no more merit to the new treatment than to the old treatment and if we repeated our experiment under identical conditions many times over, then by chance alone we would observe differences at least as large as those in our experiment in less than, say, one out of 10 such experiments (or one out of 20, or 100, or 1000, and so forth.) The one out of 20, or one out of 100, and so forth, is the doubt that remains. What we choose to call "reasonable doubt," or what we class as "beyond reasonable doubt" depends on the consequences of a wrong decision. Indeed, this type of reasoning is not new to the law; some philosophers of the law have implicitly set an upper limit for "reasonable doubt" for criminal actions: "Better that 100 criminals shall go free than to unjustly convict one innocent person."

Until now we have dealt with the broad analogies between decision making in experimental science and in courts of law. We now turn to a special class of legal cases to illustrate more specifically how statistical sampling procedures fit into the lawyer's "bag of tools."

More and more legal actions depend for their bases in fact on the results of experiment. Since experimental results vary, any experiment establishes a "fact" only within a certain area of doubt; and the lawyer should be aware of the existence and extent of these areas. One specifically controversial set of facts are those arising as the result of a sampling process. This particular field is one that has been given much study by statisticians, and a great deal is known about the subject. In a recent paper ["Legal aspects of sampling: recent developments." *Trans. Am. Soc. Quality Control* (1955)] Frank R. Kennedy, of the College of Law at the State University of Iowa, has given an excellent summary and bibliography of legal cases depending to greater or lesser extent on evidence obtained by sampling. Among other examples, he cites the Food and Drug Ad-

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ministration as having "had a considerable amount of experience in the courts with its sampling procedures." The facts are that the Food and Drug Administration regularly condemns products on the basis of their agents' inspection of samples of shipments. Unfortunately, owing to the lawyers' naivete concerning statistics, counsel for the defendants have too infrequently attacked the Government's cases as being based on inadequately designed samples. Kennedy points out that the burden of the proof of the adequacy of the sampling procedure is the Government's.

Kennedy, in addition to other references, cites certain actions involving the Federal Trade Commission wherein sampling devices were used in order to better arrive at the facts. One of us has recently been involved as an expert in hearings of an organization before an examiner of the Federal Trade Commission. The case in point was an antitrust action, and the basis of the charge depended in part on the size of the total market of the product involved; this fact could not be definitely ascertained from any source, governmental or private. Other than estimates which were admitted to be sheer guesswork, there were no public "statistics" on the size of the market. It so happened that the respondent, in the usual course of business, had made market research studies on a random sampling basis. Along with the expert knowledge of company employees in the use of the collected data, these could be projected to a rather precise estimate of the total market. The point of interest here is that the very competent legal counsel available to *both* sides in the case were out of their depth when it came to understanding the testimony concerning these relatively simple statistical techniques.

As Kennedy concludes, "The use of sampling in the courts is increasing." The use of statistics is increasing in many areas where the legal expert must be at home. Statistical methodology and theory, tied up as it is in all scientific investigation, is becoming a more important technique to have at one's command.

It is especially important that the lawyer, if he is to represent properly his client in any of a host of civil or criminal actions, make himself familiar with this basic logic which, in essence, is similar to his own. The lawyer who does not is falling behind the pace of his times and failing the clients who place their confidence in him.

Be it understood that we have no intention of suggesting that lawyers must become technically proficient in scientific and/or statistical method. But some concerted effort, by responsible individuals and groups of scientists, is in order to get these ideas across to similar individuals and groups in the legal profession. The single most evident group on each side seems apparent. The AAAS, as the largest and most influential organization of scientists in the United States, might well consider the possibility of approaching the various bar associations with a fixed objective: the aiding of the members of the legal profession in becoming acquainted with the elements of scientific method and reasoning. Such a *rapprochement* could lead only to better understanding of science in the courts, better hearings, better decisions; it could be the beginning of the end of such farcical exhibitions as those in the hearings to which allusions were made in the editorials in *Science* mentioned earlier. Indeed, this could be the alternative to despair.

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Of Books and Reading

Many persons were greatly shocked at the conclusions of the American Institute of Public Opinion which were referred to in the editorial "Of books and reading" [Science **123**, 703 (27 Apr. 1956)]. In an effort to become better informed on the subject, I have on four occasions requested additional information from the institute.

Points covered in these letters were as follows:

1) Have background studies been published on how the statistics were compiled, and are detailed tables available to the general public or libraries?

2) Has Gallup written a general article describing the techniques that would be applicable to a better understanding of the results?

3) Has the information contained in the institute's releases been expanded, commented upon, or amplified in any published work?

4) How many people were interviewed and what mode of sampling was used?

In response to my first inquiries, two news releases were received without comment and, finally, a brief letter from one of the editors, which indicated that to his knowledge the information in the release had not been expanded or commented upon. A letter sent for the personal attention of Gallup elicited no response. None of the information provided by the institute gave a definite answer to any of the questions raised.

It seems to me that an institution which is so widely regarded as an authority in the field of public opinion has a responsibility to provide its readership with at least some basic facts on how such a poll is conducted. If the institute is unwilling or unable to do so, it is my opinion, and that of many of my business and professional associates, that the institute's methods, perhaps unjustly, are open to criticism. I am taking the liberty of communicating this information to *Science* because the aforementioned editorial had, no doubt, great weight with readers and might be considered an endorsement of the findings. Should the matter be permitted to rest?

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Periodically we study the book-reading habits of the American public and those of the people of other countries where we have affiliated organizations.

In the studies which have been reported, the results were based on this question put to all persons interviewed: "Do you happen to be reading any books or novels at present?" Those replying "yes" were then asked: "Which one(s)?"

In the tabulations we exclude reading of the Bible. In the most recent of these studies, we found that 17 percent were reading a book.

To find out how long it has been since the respondents have read a book, we have asked: "When, as nearly as you can recall, did you last read any book other than the Bible?" And then: "Can you recall the name of the book you last read?"

Every sample has been based on a true cross-section of the adult population of the country. These samples are based on from 1500 to 3000 personal interviews. In the language of statisticians, we use a "modified probability" sample.

Our standard procedure is to ask each respondent a great many "control" questions: education, age, sex, and religion, and so on. It is possible in this way to make certain that each cross-section is representative of all segments of the population, and it is possible to discover the reading habits of each segment.

Our methods have been described *ad nauseam*.

A few years ago the Survey Research Center of the University of Michigan undertook a national survey which provides data on book reading. The findings are contained in a book *The Library's Public* by Bernard Berelson. I strongly urge Wallerstein to consult this report.

One of the unfortunate features of our work in the Gallup Poll is that we do not have the time or the money to incorporate our findings in magazine or book form. Someday we hope we can interest a foundation in providing the funds for this purpose.

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