DISCUSSION

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This session marks a rebirth of serious and prominent attention in the ASA to graphics for the analysis and communication of statistics. It is extremely exciting to participate in a session organized by a Director of the Census who is reviving the tradition of his illustrious predecessors Francis Walker and Henry Gannett and their great graphic presentations of the 9th through 12th Censuses. The Census Bureau for the first time since the 12th Census is again at the forefront of statistical graphic innovation. I am similarly honored at sharing the platform with Roberto Bachi who is responsible for the revival last year of the great statistical graphic tradition of the International Statistical Institute after an unfortunately prolonged period of dormancy within that body. To Cal Schmid, I am particularly indebted for his having been the major bearer of the graphic tradition within my own field, sociology, during my entire professional life. And, not the least noteworthy representation on this panel is that of Howard Wainer, for the integral place graphics now has in exploratory data analysis as well as for his work on the essential links that will have to be sustained between statistical graphics and cognitive and perceptual psychology.

Three related tensions that have long existed in graphics are raised in this session. The first is that between establishing and adhering to a restricted set of conventional standards of graphic representation as opposed to the desire to bring the full range of one's ingenuity to bear anew on each problem's unique demands. Second, is the tension between graphic simplicity and complex reality. Finally, there is the tension in seeking rules for graphic practice between relying on deduction or intuition versus explicit testing.

Standardization vs. Innovation

First, there is a need to restrain the innovative and creative impulse, even where some altogether new departure appears clearly an improvement over standard practice. Observing conventions is valuable even if their neglect poses no peril of wasteful "reinvention of the wheel" or of one's being oblivious of important considerations that are built into those graphic forms that have selectively survived to become standard practice. At the same time there is indeed vast need and room for innovative creation in social graphics. Furthermore, such standards as we have, of any of the forms mentioned in Schmid's paper, are silent with regard to many critical points of decision regarding how to proceed with the graphic treatment of any set of data for any particular purpose. Those we do have also rest almost exclusively on deductive principles, because, despite spurts of experimental activity, the sum total of experimentally-based knowledge is small and, as often as not, misleading.

Simplification vs. Oversimplicity

The second tension arises from the social scientist's desire to use graphics to convey the full complexity of his subject matter--a desire that we hope is matched by a resistance among his audience to patent oversimplifications. In social science, the importance attached to telling (and being told) the whole, complex and frequently messy story conflicts with the fact that the virtues of graphs usually vary directly with their neatness and simplicity.

Vincent Barabba and his colleagues at the Census Bureau, are exploring possibilities that the state of the art now opens up for coping with what previously have been hopelessly complex and intractable problems. Realizing these possibilities will benefit from graphic innovation--new graphics adapted to new forms of statistical analysis, as well as the mutual adaptation of modes of graphic representation and new computer-graphic reproduction technologies. The very design and production of statistical series undoubtedly have been restricted by implicit acceptance of the limitations of the media available to display the final product. If there can be radical improvements in how social statistical knowledge can be presented, perhaps they can be matched by increased sophistication in the knowledge reports attempt to present. In addition, those engaged in the production of statistical series may find new and greater degrees of order in the facts with which they deal, as they come to work with displays of these data that mobilize more of the potentialities of modern communication modalities.

Wainer has elsewhere contributed to this objective by both deductive design and experimental testing. His present experiment, however, is trivial in ways in addition to those he has discussed in his paper. As a criterion, he chose: "the amount of time that it takes a person to extract a particular bit of information from the display," that is, to reach the correct decision that a complex declarative sentence was true or false (his sentences are "complex" in the grammatical sense, although fairly simple in the sense of cognitive difficulty). Such a test, first of all, would be a useful one for graphics that have the purpose of a reference table--a convenient device, such as a railroad time table, for locating a given datum or subset in a larger data collection. (Actually, the subjects in Wainer's experiment were given an hypothesis to look-up in the display to determine whether the display agreed with it.) The graphic representations Wainer sought to test for their "goodness" are indeed ones designed for a book of "general purpose" statistics that its principal author found does have some such reference table uses--for example, by political speech-writers. But the major intent of "social indicators" chartbooks is different: it is to present data which hold within them a pattern of many patterns, that can be appreciated and learned as wholes. They are there to figure in the active work of the mind of the user, mobilizable for stimulation of and assimilation to other patterned information in that great storage and retrieval

system, the nervous system. While it would not be accurate to say that Wainer asks his S's to see the trees, rather than the forest, he does ask them to report only the relative sizes of clumps and not the forest's patterns. I would like to see tests of the richness and veridicality (or even plausibility) of the stories about important social realities that subjects are able to construct while studying various sets of displays, or after they have studied them. Such tests would be closer the purposes which have led to the investments in equipment and software being made by the Census Bureau to aid the work of capturing ever more complex features of social reality in graphical displays.

Finally, and crucially, if we are to use simple prose as the criterion against which to judge the efficacy of various displays, should we not include prose as one of the display forms against which we test others?

It may be important for this matter of detail versus pattern to make explicit what I think is implicit in Wainer's rationale for making rapidity of recognition of particular relationships his criterion. Without being at all familiar with psychological research on the matter, I find it plausible that the ability to discern larger patterns is a function of the ease (which perhaps equals rapidity) with which their components can be discerned. We know from experience, for example, that if it takes too long (involves too much effort) to learn the legend of a chart thoroughly, the patterns in that chart will not be understood. But how much time or effort is too much and what range of time makes any important difference for pattern comprehension? Where on such scales do the mean times Wainer found (about 16 seconds) fall?

There is a feature of graphics that differentiates it from the verbal language and makes us more dependent on experiments in order to estimate what displays will be unduly complex for some or all of a given audience. We have poor sense of people's graphicacy because graphic communication does not afford the feedback we get with verbal communication. Indeed, most communication about graphics, as in the case with the present discussion, proceeds verbally, not graphically.

People are able to make judgments about others' literacy from listening to talk--that is, from others' linguistic fluency. They are not similarly exposed to graphic productions of others such as would allow them to make judgments of others' graphicacy. One also can form judgments, although with some degree of error, of the command of the language others possess by their reactions to what one says--signs of comprehending, not comprehending, miscomprehending--in conversations, From an accumulation of impressions of others' fluency, one forms judgments as to the general distribution of ideas and for which classes of people.

Fluency is an imperfect test of literacy; the ability to gain comprehension from prose may be greater than the ability to articulate that comprehension. Fluency is an even more imperfect measure of graphicacy, particularly so because of the limits of language about graphic form. Tests may confuse the vocabulary at a person's command for naming properties of graphics with his facility and accuracy of understanding. Good tests of graphicacy might involve asking subjects to draw patterns rather than to check words. Since the ability to draw a form that one can mentally comprehend may be limited, however, tests might best be by multiple choice among presented figures. Interactive computergraphics holds forth promise of graphic conversations that may be illuminating with regard to graphicacy.

One's ideas about what others will see in a chart, what will be clear or obscure, be attractive or not, have this meaning or that--derive mostly from projection. We think others will see as we see, although possibly not as well. Some of us may choose to employ a "test idiot" to try out a chart--"If my secretary (wife, office partner, janitor, etc.) can understand it, anybody can." Prof. Bachi used his grandchildren, possibly a large group of subjects but a suspect one if there is even the tiniest bit of genetic or intrafamilial cultural transmission of graphicacy. There is considerable warrant for the belief that all human minds are similarly constructed, and also for that fact that those likely to be an audience for a particular chart have had their minds trained in similar ways by a body of common cultural experiences. There is also warrant for the idea that some graphic forms are more pictorially literal and hence "specific-culture free" than is the case with linguistic productions. After all, we can "dig" ancient Chinese graphics and even prehistoric cavemen's drawings, but we would be lost in the corresponding verbal languages. But, at the same time, the fit of graphics to minds and cultures also varies widely. We are very apt to be surprised by what others stubbornly misperceive in a chart as by what gets perceived as intended. How are we to know what to expect of all people or of some particular set of people? What forms depend only on universal or near-universal innate ability for their comprehension; which ones on merely the knowledge expected of any reasonably educated person in modern civilization; which ones on specific training?

One of the truly remarkable lessons of the history of statistical graphics is the leap in the inventions of just one man--William Playfair--from a situation in which there was, to all intents and purposes, no such thing as a statistical graphics to where a major portion of all the basic forms most commonly used at present came into being and with remarkable similarity to current usage. They received immediate, wide acclaim. Should we page Chomsky?

Reviewing the field of experimentation on the comprehension of statistical graphics, a fairly fashionable line of endeavor a few decades back, leads me to suspect low promise from experiments like Wainer's because little generalization is possible with any confidence from the specific subjects, displays, and criteria to the larger classes each purports to represent. Most past experiments have hardly more generalizability than does advertisement copy testing. The major pertinent exceptions in our field are low-order psychophysical kinds of inquiries on grey scales,

line thickness, and color valuing, as done particularly by cartographers. (See, Feinberg and Franklin, 1975.)

The graphs Wainer used, for example, all embody much more information and much higher levels of precision than required for answering the questions he put to S's. They contained high redundancy, for example, graphic and alphanumeric representations of the same quantities. With regard to each form he tested, questions might be raised whether these particular graphs are either ideal or representative of all possible designs of that general named form for conveying the data; for example, positioning and typefaces used for labels, color choices (singly and combinations), use of rulings, scale proportions. Next, we have to ask whether the particular uses, for which that form is ideal. In a forthcoming paper, Macdonald-Ross of the British Open University cogently criticizes past experiments on the effectiveness of graphs and tables on these grounds.

To even begin to replace deduction with induction as a footing for the basic graphic repertoire, and for systematic and effective testing of the rapid innovation of new and complex graphic forms now taking place, it would be hopeless to attempt to proceed in a naive empirical fashion. For experimentation to contribute would appear to require relating psychological and psychophysical theories to a more generalized conceptualization of the problems of graphic communication. Before the standards handbooks Schmid recommends would profit much from such research there would remain considerable bridge-building to relate such general knowledge to the concrete problems of graphic design confronted in any given case.

Standards and Conventions

Although innovation can be valuable, and much innovation will be essential, I agree with the arguments implicit in Schmid's paper for caution in attempting innovation of graphic forms. Funkhouser describes vast labors toward invention of new devices and elaborate systems that were in vain. Some work has been idle in that it failed to take account of the versatility of the basic standard repertoire of representational forms, and, where innovations represented any improvement at all, these were often quite marginal relative to the new learning the innovation demanded of basically lazy users and audiences. I am sure Prof. Bachi has encountered barriers to the acceptance of his Graphic Rational Patterns, even though the symbols of his system can be learned in minutes.

An equally great hazard in innovations stems from the ready possibilities for communication error and failure in graphics. An advantage of the highly familiar forms has been the accumulation of experience in how many things can go wrong with them, and, to the extent that such experience has been integrated into formal rules of standard statistical graphical representation, it figures in general caveats in manuals and in the working knowledge of regular users.

The same two types of problems beset attempts at technological innovation and the adoption of new technology for generating and transmitting graphic statistics. The problems are aggravated in that specialists who are at work in such fields as the development of computergraphics hardware and software are rarely intimately conversant with the field of statistical graphics. Not only are wheels painfully reinvented, they often turn out to be somewhat square. This fact adds urgency to the need for establishing working relationships of technological innovators with those statisticians and other scientists who have made statistical graphics a special object of their attention. This has been as objective of our Graphic Social Reporting Project (graphs) at the Bureau of Social Science Research and of the Council on Social Graphics.

There is another reason for cautions about innovation. For graphicacy to develop, both among producers and audiences, there must be the cultivation of familiarity with a restricted, durable broadly applicable set of graphic conventions and standards for social statistics. The same basic forms must be used regularly to establish them as readily drawn-upon repertoires. In the repertoire of the producer, there must be thorough appreciation of statistical-graphic forms, and the ready, economical means for producing them that frequent use generates. In the repertoire of consumers, there must be the ready and accurate comprehension that comes with the familiarity Wainer suspects affected his results.

Staying within the bounds of conventions ordinarily need not prove highly constraining. Even the most familiar basic forms are adaptable to the expression of a rich array of meanings.

Scope of Innovation

Until there is widespread familiarity with the basic statistical-graphic equivalents of orthography, vocabulary and syntax of the verbal language, innovation of new graphic forms might well be restriced to enabling one to do things that would otherwise be nigh infeasible. As a test to be applied within our project to any proposed departure from standard forms of graphical representation, I have recommended the following principle: "Does the innovation have such strong virtues and broad applicability that it has some real chance of becoming a standard--a graphic convention?" The innovative potential of the new development may derive from its elegance as a new semiotic tool of principle or its adaptability to new developments in the environments of graphic technology and uses. Exceptions to the caution against unique forms admittedly exist where an ad hoc graphic solution elegantly mobilizes for its problem the properties of "self-evidence" that some iconic devices can have. Exceptions may also exist where the statistical solution must be unconventional. I think the Census Bureau's work is embodying this strategy. The broad audience for its publications and its central role as statistical institution gives it the potential of rapidly moving innovations such as Bachi's to the status of conventions.

For all the caution in my discussion and in each of the other paper's, including Barabba's, I trust the latter's audio-visual show convinced you that the statistical graphics revolution is

already here. We may not all be able to rush out to place orders for many items in the Sear's catalog Barabba put on the screen, but just a few of these systems alone have voracious appetites for the ideas we can generate to feed them and will have prodigious outputs requiring appraisal.

Here's an anecdote revealing with regard to the nature of the graphic revolution. I receive the Federal Statistics Users Conference Newsletter which, as one of its attractive features, gives me very prompt information each month on the availability of new Federal statistical publications. In the most recent issue, it contained information on new releases of school enrollment and educational attainment studies. But four days before I received my newsletter, I had already had access to these data in the multicolored chart formats of STATUS. It won't be long before they will also be available on my CRT by pushing a few keys.

REFERENCE

B.M. Feinberg and C.A. Franklin (eds.) Social Graphics Bibliography, Washington, Bureau of Social Science Research, 1975.