a the "Lab" (the Laboratory for Computer Graphics and Spatial Analysis that he founded), I still believe that Fisher was a great man. This is a meagre book and should not have been published.

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GRAPHICS AND GRAPHIC INFORMATION-PROCESSING / Jacques Bertin; translated by William J. Berg and Paul Scott. Berlin; New York: Walter de Gruyter, 1981. 273 p., ill., maps, some col. ISBN 3-11-006901-6 : DM 38 (pbk.). Also available bound DM 58.

Any traditonally oriented Anglo-American cartographer who reads this book without screaming – either in pain or in exultation – hasn't paid atention to what he's read. Organized, printed and bound in the manner of a handbook, *Graphics and Graphic Information-Processing*, with none of the magisterial overtones of the *Semiology of Graphics*, manages nevertheless to demolish most of the foundations of contemporary theory and practice in one breathless romp through graphic information-processing. "Cartography is above all a means of data processing," Bertin says, which means "A graphic is not 'drawn' once and for all; it is 'constructed' and reconstructed until it reveals all the relationships constituted by the interplay of the data." This implies that, "A graphic is never an end in itself; it is a moment in the process of decision-making," which suggests in turn that "The best graphic operations are those carried out by the decision-maker himself" (*i.e.*, the hotel manager, the city planner, the traffic engineer, the folk-song scholar). If the cartographer isn't reeling by now, it can only be because he hasn't yet figured out that all this means, "we should not ask the cartographer to be a designer. We ask him to resolve problems of relationships among sets," an observation that makes perfect sense given Bertin's scant regard for the problems of cartography as communication. In fact, he dismisses – in a pithy, brilliant footnote – the entire communications model:

> On the basis of these remarks we may say that graphics (and therefore cartography) does not conform to a polysemic schema: sender ↔ code ↔ recipient, but to a monosemic one: operator ↔ three relationships. Sender and recipient are identical in terms of their goals: understanding relationships. There are only 'operators.' And in fact, we note that unlike the monosemic schema, the polysemic schema does not enable us to solve graphic problems.

The twist is in that last word: *problems*. Bertin is interested in solving problems, in doing science, in making decisions; and for Bertin, graphics – and therefore cartography – are ways of *doing* that, ways of *doing* science, ways of *solving* problems, ways of *making* decisions. Only incidentally, after the fact, and *occasionally*, are they ways of communicating. The altered emphasis can be completely disorienting to one accustomed to thinking of graphics the other way around. Early on, Bertin presents three successive forms of graphic application, each corresponding to a given stage in the processes of solving problems, doing science

or making decisions: 1 defining the questions; 2 discovering the answers; and 3 communicating the answers ('if need be' Bertin adds parenthetically). To the initial stage of 'defining the questions' corresponds what Bertin terms the 'matrix analysis' of the problem. Typically developed intuitively, this stage is formulated by Bertin in a series of graphics ('the apportionment table,' 'the homogeneity schema,' 'the pertinency table') that *force* the researcher to examine the relationships among his questions and between his questions and sources of information. To the second stage of 'discovering the answers' corresponds the various forms of graphic information-processing. Much better than half the book is devoted to this stage, moving from example to example in the manner of a math text. Four major forms of graphic construction – *permutation matrices* (embracing the reorderable matrix, the weighted matrix, the image-file, the matrix-file and the array of curves), *ordered tables* (of which there are two types), *reorderable networks*, and *ordered networks* (otherwise known as topographies or maps, subdivided into four categories) – are explicated with the use of no less than thirty-five worked examples, graphic solutions to problems in Siberian hydro-meteorology, employment trends in physics in the United States, prices in thirty-one major world cities, recreational park usage, the evolution of ionic capitals, crop cycles in an African region, animal behavior, the chronology of ancient Chinese vases, sizes of farms in Provence, characteristics of factory workers, 17th century demographic movements and the distribution of ethnic groups in Upper Volta to mention just a few. Numerous other problems, or parts of problems, frequently hypothetical, are treated; and a special index to principal examples cited lists forty-five of them. To the third stage of 'communicating the answers' corresponds graphic communication. To this Bertin devotes exactly four paragraphs, and the odd sentence here and there: graphic communication is not really an issue for graphic information *processing* – and therefore not really a problem for the cartographer.

For the cartographer who has never imagined his role as other than that of graphic communicator – *illustrating* the work, the previously processed information, of others – Bertin must appear less iconoclastic heretic than complete madman; but his apparent nonsense is the simple and rigorously logical consequence of putting cartography back into the world of action from which it has been too long severed. There the issue is seldom whether a given user can 'read' the graphic before him (which is indeed a problem in graphic communication), but rather what sort of graphic would enable him to answer the question he is asking (invariably a problem in graphic information-processing). This is always the focus for Bertin – *what graphic construction will answer this question?* –, and because he sees the map (or 'ordered network') as a uniquely powerful graphic, he sees the making of maps – cartography – as a uniquely powerful graphic information-processor:

> A geographical map is a representation of the arrangement of elements on the surface of the earth. The order defined by the terrestrial surface confers two exceptional attributes to the map.
> - The map supplies *intrinsic information as to topographical proximity*, which only it can transcribe completely.

- The map constructs a constant and universal reference shape, constituting the most powerful means of introducing into the problem *the extrinsic information necessary for interpretation and decision-making.*

It is for these reasons that Bertin insists that:

Cartography is above all a means of data processing... It can serve either in the discovery of characteristics corresponding geographically to a given characteristic or in the discovery of a geographical distribution defined by a given set of characteristics.

Note that the emphasis in these quotations (Bertin's own) is on *interpretation, decision-making, discovery*, on the active solution of problems, on science: "We should not ask the cartographer to be a designer. We ask him to resolve problems of relationships among sets." Bertin restores the cartographer to his rightful position among the sciences, a position that the cartographer's overt – and yet namby-pamby – commitment to design has imperilled. Instead of having him concern himself with 'balance' and 'harmony,' with 'elegance' and 'handsomeness,' Bertin would have him exploit the graphic capabilities uniquely his to the solution of problems otherwise intractable. When the time comes to communicate these solutions to others..., time enough to call in a designer.

The last phrase is mine, not Bertin's, and is meant in derision. No designers need apply to gussie-up the products of genuine cartographers. Though Bertin does not bother to make this point, it is evident throughout, in the way, for example, to quote Edward Tufte (in *The Visual Display of Quantitative Information*), "Bertin's crisp and elegant line allows the display of 17 small-scale graphics on a single page along with extensive text." It's a point well taken. No one has ever dared to shrink graphics as small as Bertin does, yet so incisive is his line, so unerring his sense of the hierarchy in the information he displays, so well positioned his graphic vis-à-vis his text, that the whole is an emblem of balance and simplicity, of clarity, of powerful expression. Yet never once does he so much as nod in the direction of such precepts: the beauty of his graphics flows directly from his principles regarding the processing of information and its importance in the dynamics of decision-making, problem-solving and the doing of science. The allusion to Edward Tufte was not entirely adventitious, for he and Bertin hew closely to similar principles. For both, the primary interest in a graphic lies in its data. Not, *is it pretty?* but, *does it say something worth knowing?* That is, they look at graphics as scientists, not interior decorators. Their secondary focus is on efficacy and efficiency. "The efficacy of a graphic construction is revealed by the level of question which receives an immediate answer," writes Bertin, but good graphics allow viewers both to *see* a distribution *as a whole* and to *read* elementary *bits of information*. Bertin notes:

We utilize graphics to save time and consequently memory; in order to SEE, that is to perceive immediately. Accordingly, a graphic which must be READ, that is perceived over time, does not solve the problem. Moreover we observe that such a graphic is usually not even read. The reader prefers the written text, since it generally yields a much better ratio of information received to time spent.

Yet the best graphics actively encourage interactive seeing-reading, permitting users the luxury of validating for themselves the cartographer's highest level resolution of the data. Good graphics have high information-to-ink ratios. Tufte and Bertin both insist that good graphics can be shrunk way down, if only because good data, usefully organized, have such inherently clear structure. Tufte and Bertin have strong theoretic orientations, yet both share a concern for the veritable nitty-gritty of procedure: Bertin even illustrates the manner in which a strip of cardboard – specified as one mm thick and four cms high – should be folded for the permutation of the image-file. "The fold should not be creased," he cautions. In all these ways, Tufte and Bertin treat the graphic as engineers, not Boutique Designers. A third commitment relates to the *role* of the graphic. Both insist that the graphic function in a text as any other paragraph, goes where it *logically fits in the exposition*, not somewhere else, on the back of the next page, or on the back of that previous. In fact, Tufte agrees with Bertin that, "If the text is more than one page, the image must appear again on the following page"; and he organized *The Visual Display of Quantitative Information* as though he subscribed to Bertin's prescription that, "If the text does not cover the entire page, the bottom part should be left blank. And one begins again with the next image." In these ways, Tufte and Bertin accord the graphic the dignity a novelist reserves for his prose, not as he regards an illustrator fobbed off on him by his publisher. Finally, both share an understated commitment to beauty, understated not because this is something scientists, engineers and novelists don't gush about, but rather because, being more than skin deep, beauty is understood as inherent in the quality of the data, its organization, its ability to be handled at many levels, its efficiency, its efficacy, its role: a good graphic is not a greeting card.

Because he practises what he preaches, Bertin has produced a book that returns as much information per time put into reading it as any I have ever read. Yet as intensely packed as it is, because of its clear organization, because of its simple relationship of text to graphics, because of its useful method of referencing and cross-referencing, because of its *hundreds* of graphics, it was also a dream to read. Some credit is doubtless due the excellent translators, but much of it is a direct function of the structure of the book itself, which, endlessly absorbing at the most elementary level, has a profound and obvious superstructure:

> Graphics is a very simple and efficacious sign system which anyone can put to use. A graphic is not only a drawing; it is a responsibility, sometimes a weighty one, in decision-making. A graphic is not 'drawn' once and for all; it is 'constructed' and reconstructed until it reveals all the relationships constituted by the interplay of the data. The best graphic operations are those carried out by the decision-maker himself. A graphic is never an end in itself; it is a moment in the process of decision-making....

And so is *Graphics and Graphic Information-Processing*. Bound in an impregnated cloth bonded to paper, sized to the grip, and not unduly heavy, it is not the handsome book that Tufte's is. This is a handbook, meant to be read, not once and for all, but again and again, consulted and reconsulted until the graphics path it points toward can be unerringly followed. I can scarcely imagine a better guide.

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