7 *Multifunctioning Graphical Elements*

The same ink should often serve more than one graphical purpose. A graphical element may carry data information and also perform a design function usually left to non-data-ink. Or it might show several different pieces of data. Such *multifunctioning graphical elements*, if designed with care and subtlety, can effectively display complex, multivariate data.[1]

Consider, for example, the multifunctioning blot of the blot map. It simultaneously locates the geographic unit on a two-dimensional surface, describes the shape of the geographic unit, and indicates the level of the variable displayed by color or intensity of shading. That is a great deal of information for a small patch of ink—and the different pieces of information are not confounded and mixed together.

In contrast, the conventional graphical frame performs only a modest design function, the separation of the grid and data measures from the labels. And it is a place to hang the grid ticks. With all that ink doing so little, it is a prime candidate for mobilization as a double-functioning graphical element. Hence the range-frame, the quartile frame, and the dot-dash-plot.

The principle, then, is:

> Mobilize every graphical element, perhaps several times over, to show the data.

The danger of multifunctioning elements is that they tend to generate graphical puzzles, with encodings that can only be broken by their inventor. Thus design techniques for enhancing graphical clarity in the face of complexity must be developed along with multifunctioning elements.

[1] The idea of double-functioning elements appears in architectural criticism; see Robert Venturi, *Complexity and Contradiction in Architecture* (New York, second edition, 1977), ch. 5. Venturi in turn cites Wylie Sypher, *Four Stages of Renaissance Style* (Garden City, N.Y., 1955).

Data-Built Data Measures

The graphical element that actually locates or plots the data is the *data measure*. The bars of a bar chart, the dots of a scatterplot, the dots and dashes of a dot-dash-plot, the blots of a blot map are data measures. The ink of the data measure can itself carry data; for example, the dots of the scatterplot can take on different shadings in response to a third variable.

Building data measures out of the data increases the quantitative detail and dimensionality of a graphic. The stem-and-leaf plot constructs the distribution of a variable with numbers themselves:

0 | 9 = 900 feet

0	98766562
1	97719630
2	69987766544422211009850
3	876655412099551426
4	9998844331929433361107
5	97666666554422210097731
6	898665441077761065
7	98855431100652108073
8	653322122937
9	377655421000493
10	0984433165212
11	4963201631
12	45421164
13	47830
14	00
15	676
16	52
17	92
18	5
19	39730

Stem-and-leaf displays:
heights of 218 volcanoes, unit 100 feet.

19 | 3 = 19,300 feet

The idea of making every graphical element effective was behind the design of the stem-and-leaf plot. In presenting his invention, John Tukey wrote: "If we are going to make a mark, it may as well be a meaningful one. The simplest—and most useful—meaningful mark is a digit."[2]

Here, too, the data form the data measure. Note the bimodal distribution in the histogram of college students arranged by height.

[2] "Some Graphic and Semigraphic Displays," in T. A. Bancroft, ed., *Statistical Papers in Honor of George W. Snedecor* (Ames, Iowa, 1972), p. 296.

Brian L. Joiner, "Living Histograms," *International Statistical Review*, 43 (1975), 339–340.

A distinguished graphic that builds data measures out of data was designed by Colonel Leonard P. Ayres for his statistical history of World War I, a book with several notable graphics all done by typewriter and rule. Constructing the data measures out of each American division's name (a numerical designation) turns what might have been a routine time-series into an elegant display. (Note that the cumulative design depends on the fact that none of the divisions returned before October 1918.) The triple-functioning data measure shows: (1) the number of divisions in France for each month, June 1917 to October 1918; (2) what particular divisions were in France in each month; and (3) the duration of each division's presence in France.

Leonard P. Ayres, *The War with Germany* (Washington, D.C., 1919), p. 102.