The language of graphics

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CHAPTER 4

Classification of Graphic Representations

Various proposals can be found in the literature concerning **classifications** of graphic representations. Although both the exact way of categorizing as well as the terminology that is used are always different, it is nevertheless possible to identify certain distinctions that tend to be made when graphic representations are divided into different types.

The main criteria in most existing classifications of graphic representations seem to be based on combinations of:

- the type of *syntactic structure* that is involved in the representation, and
- the type of *information* that is expressed in the representation.

The concepts proposed in this thesis can serve to give a principled description of commonly distinguished types of graphic representation. The full list of types of graphic representation that we are proposing here consists of:

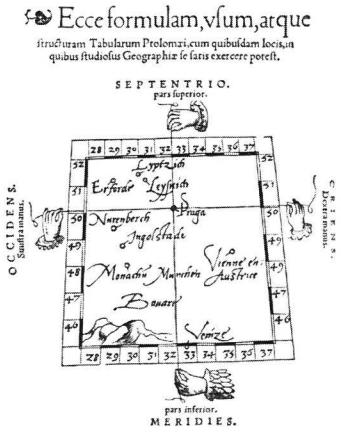
- ten **primary** types: *map, picture, statistical chart, time chart, link diagram, grouping diagram, table, (composite) symbol, written text,* and
- six **hybrid** types: *statistical map, path map, statistical path map, statistical time chart, statistical link diagram,* and *chronological link diagram.*

The figure captions of all example figures contained in this thesis (the boxed figures) include, as their last item, a classification of the concerned figure regarding these types of graphic representations. In this chapter we will first give brief descriptions of the proposed *primary* types, then discuss the proposed *hybrid* types, and finally examine and compare classifications of graphic representations that can be found in the literature.

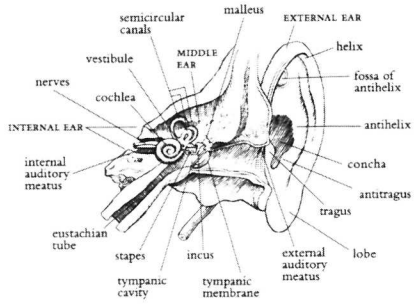
PRIMARY TYPES OF GRAPHIC REPRESENTATION

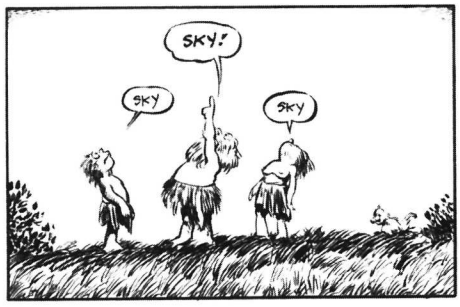
We will now look at the characteristics of each of the proposed *primary* types of graphic representation.

A **map** is a graphic representation in which the syntactic structure is based on an *integral metric space* (see subsection 2.5.2) that serves to represent a physical arrangement on a geographical surface. This integral metric space may be *distorted*, involving a more or less *literal* correspondence to the represented physical arrangement. The graphic objects that a map consists of are usually free in their *mode of expression*: they may be *non-pictorial* - such as abstract shapes as symbols for cities, and words or numbers as labels - or *pictorial* - such as pictorial symbols. Examples of maps (figures 3-12 and 2-28):



A **picture** is a graphic representation in which the syntactic structure is based on an *integral metric space* (see subsection 2.5.2) that serves to represent the physical structure of physical objects. Like in a map, the integral metric space of a picture may be *distorted*, involving a more or less *literal* correspondence to the represented physical structure. While the graphic objects that a map consists of are usually free in their mode of expression, the main graphic objects that a picture consists of involve a *pictorial mode of expression* (*realistic* or *schematic*). However, a picture may also include *labels*, which are free in their mode of expression. Examples of pictures (figures 2-16 and 3-11):

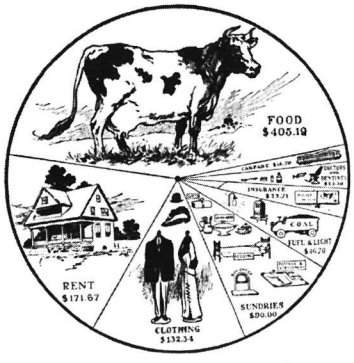


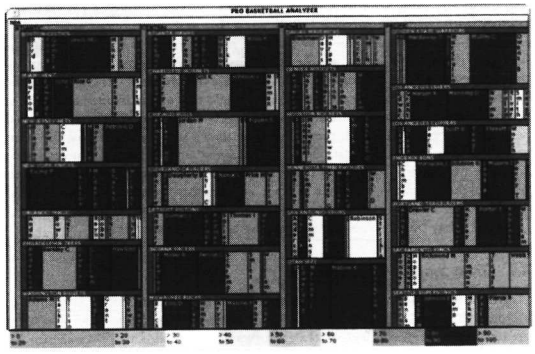


A **statistical chart** is a graphic representation in which the syntactic structure serves to show (and allows to compare) quantities. In order to do this, such a syntactic structure uses:

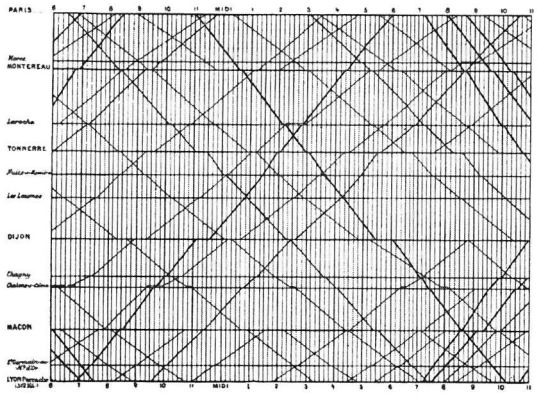
- *metric axes* (see subsection 2.5.2), such as in a two-axis chart, and/or
- *proportional division* of graphic objects (see section 2.4), such as in a pie chart, and/or
- variations in *visual attributes* (see section 2.4), such as variations of *size* or - much less precise in their interpretation - variations of *brightness*.

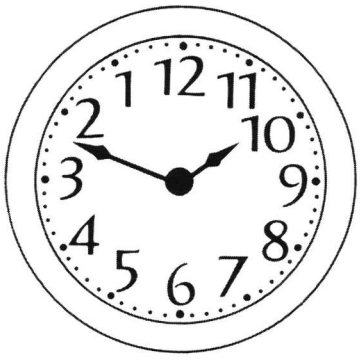
A statistical chart usually involves *metaphoric* correspondence.
Examples of statistical charts (figures 2-06 and 2-40):



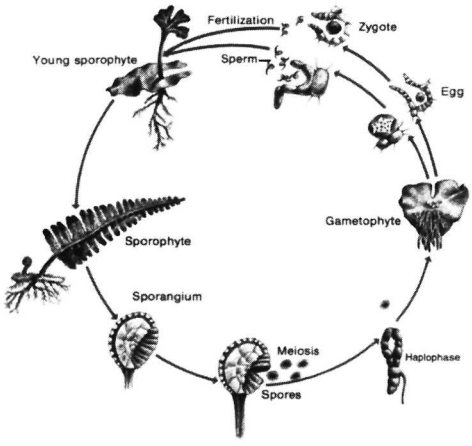


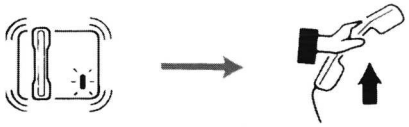
A **time chart** is a graphic representation in which the syntactic structure serves to show the passing of *time*. Such a syntactic structure may be an *ordered lineup* (subsection 2.5.1) or it may be based on a *metric axis* (subsection 2.5.2). A time chart involves *metaphoric* correspondence (order/length in graphic space stands metaphorically for order/length in time). According to Tufte, time charts are the most frequently used type of graphic representations (Tufte 1983, p. 28). Examples of time charts (figures 2-29 and 3-13):



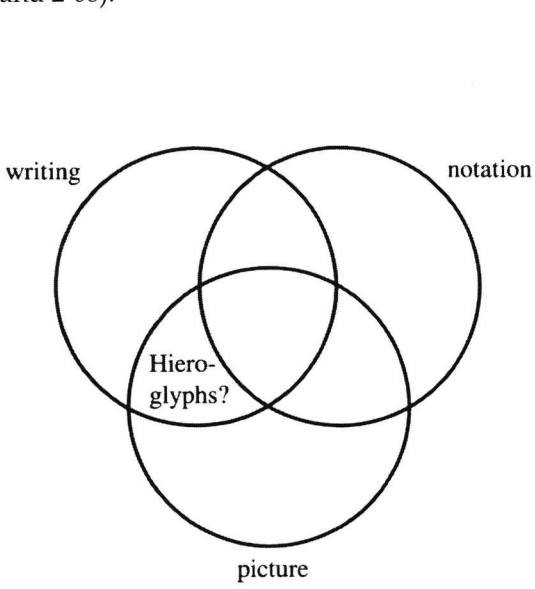


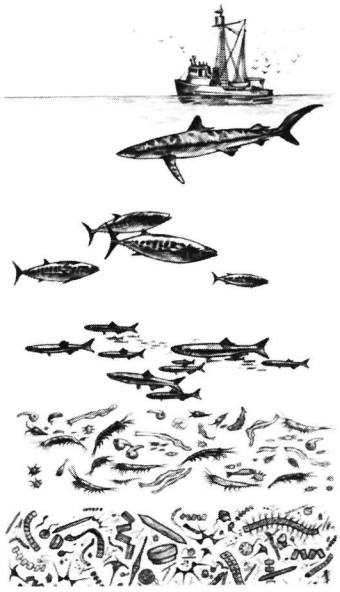
A **link diagram** is a graphic representation in which the syntactic structure consists of *linking*. Syntactic structures that consist of linking can be divided into *linear chains*, *circular chains*, *trees*, and *networks* (see subsection 2.5.1). Examples of link diagrams (figures 2-14 and 2-17):





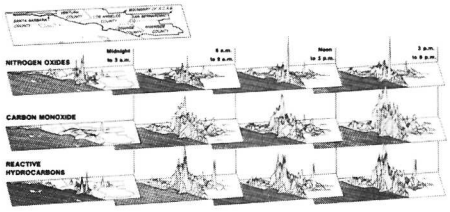
A **grouping diagram** is a graphic representation in which the syntactic structure serves to express the categorization of a set of elements. The syntactic structure of a grouping diagram may consist of a *spatial clustering*, of *separations by separators*, or of (overlapping) *containers* (all discussed in subsection 2.5.1). This type of representation involves 'grouping' in the sense proposed by Richards (1984). Examples of grouping diagrams (figures 2-18 and 2-08):



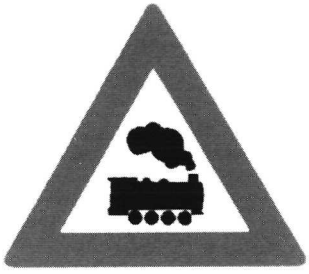


A **table** is a graphic representation in which the syntactic structure consists of a *simultaneous combination* of *horizontal separations* and *vertical separations* and/or of a *simultaneous combination* of *horizontal lineups* and *vertical lineups* (subsection 2.5.1). Examples of tables (figures 2-10 and 2-45):

Train No.	3701	XM 3301	3801	A 67	3 3803	3 3201	A3 51	3 3703	3 3807	3 3203	A3 61	3 3809	A3 47	3 3901
New York, N.Y.	A M 12 10	A M 12 40	A M 1 30	A M 3 52	A M 4 50	A M 6 10	A M 6 25	A M 6 35	A M 6 50	A M 7 10	A M 7 30	A M 7 33	A M 7 45	A M 7 50
Newark, N.J. P	12 24	12 55	1 44	4 07	5 04	6 24	6 38	6 49	7 04	7 24	7 45	7 47	7 59	8 04
North Elizabeth										7 30				8 10
Elizabeth	12 31	1 03	1 51		5 11	6 31		6 56	7 11	7 32		7 54		8 13
Linden	12 36		1 56		5 16	6 36		7 01	7 15	7 37		7 59		8 18
North Rahway								7 03		7 39				8 20
Rahway	12 40	1 11	2 00		5 20	6 40		7 06	7 20	7 42		8 03		8 24
Metro Park (Iselin)	12 44		2 04	4 26	5 24		6 56	7 10	7 25		8 04	8 07	8 15	
Metuchen	12 48		2 08		5 28			7 14	7 29			8 11		
Edison	12 51		2 11					7 17	7 32			8 14		
New Brunswick	12 55		2 15		5 35		7 05	7 21	7 35			8 18	8 25	
Jersey Avenue	1 02		2 18					7 28				8 21		
Princeton Jct S			2 31		5 50		7 19		7 50			8 34	8 41	
Trenton, N.J.			2 42	4 58	6 03		7 28		8 01		8 31	8 44	8 52	



A **symbol** is a graphic representation that is either an *elementary graphic object* (section 2.3) or a *composite symbol* (subsection 2.5.1). Examples of symbols (figure 3-04 and an outdated traffic sign):



A **written text** is a graphic representation in which:
- the *syntactic structure* of the representation is a *lineup*,
- the *graphic objects* represent expressions in an existing human language, and
- the *linear ordering* within the lineup is determined by the sentential grammar of that language.

See section 3.2 for a discussion of written text. An example of a written text is what you are reading right now.

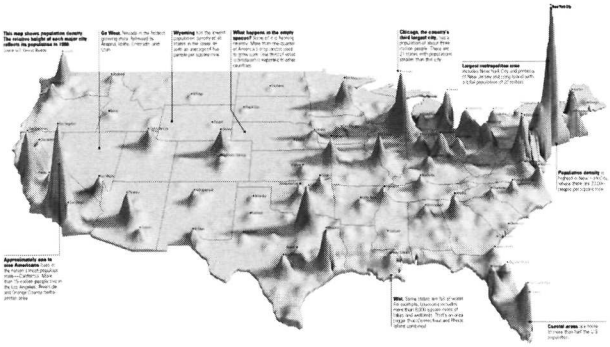
HYBRID TYPES OF GRAPHIC REPRESENTATION

Some types of graphic representation are *simultaneous combinations* of the primary types described above. See the table in figure 4-01.

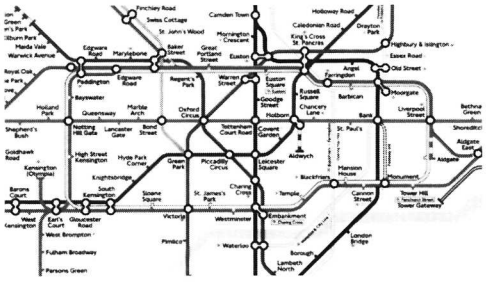
	statistical chart	link diagram
map	statistical map	path map
time chart	statistical time chart	chronological link diagram

FIGURE **4-01**: Some combinations of primary types of graphic representation, resulting in hybrid types.

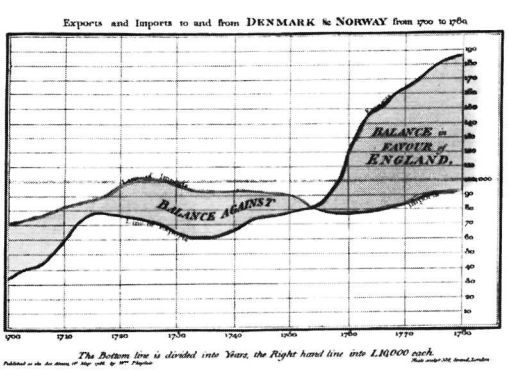
A **statistical map** is a representation that qualifies both as a *statistical chart* and as a *map* (a *map* that displays *quantities*). Example of a statistical map (figure 2-30):

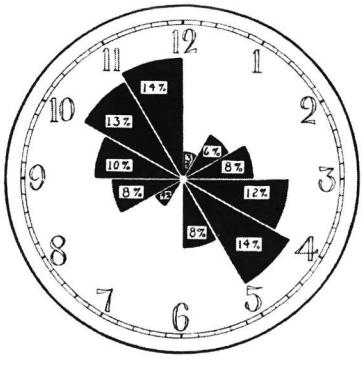


A **path map** is a representation that qualifies both as a *link diagram* and as a *map*. Example of a path map (figure 2-15):

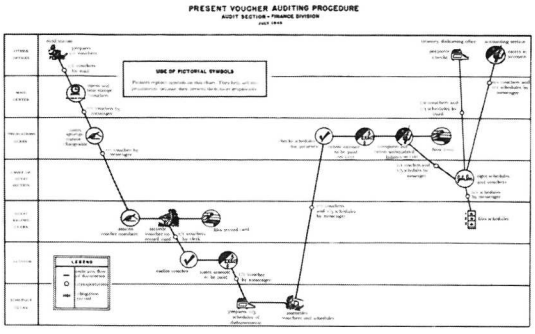


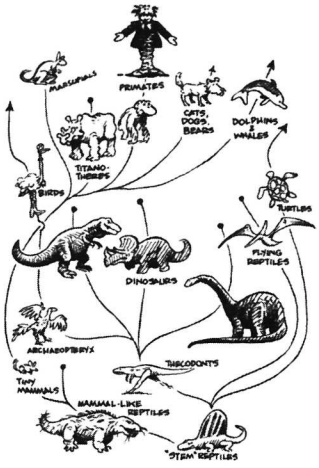
A **statistical time chart** is a representation that qualifies both as a *statistical chart* and as a *time chart*. Examples of statistical time charts (figures 2-25 and 2- 27):



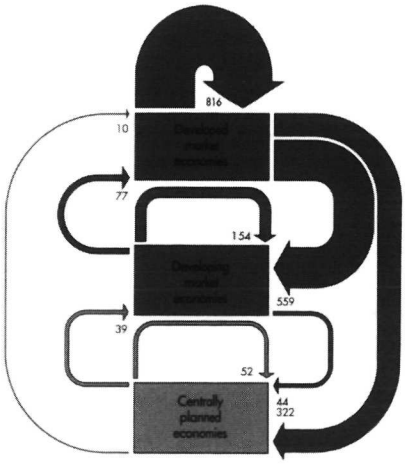


A **chronological link diagram** is a representation that qualifies both as a *link diagram* and as a *time chart* (e.g. family tree). Examples of chronological link diagrams (figures 2-38 and 2-31):

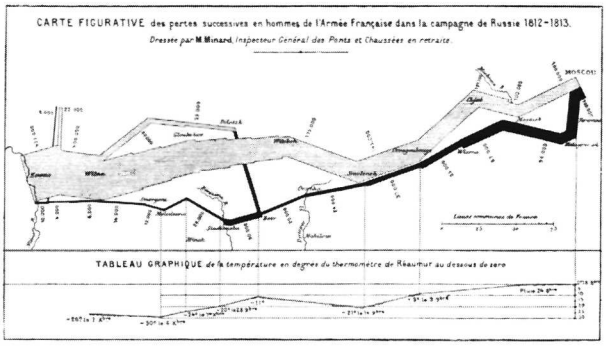




A **statistical link diagram** is a representation that qualifies both as a *statistical chart* and a *link diagram* (e.g. quantitative flows are represented by the thickness of lines). Example of a statistical link diagram (source: Bounford 2000, p.111):



A **statistical path map** finally is a representation that qualifies both as a *path map* and as a *statistical link diagram*. Example of a statistical path map (figure 2-47):



A complex graphic representation may involve a *nesting* of one or more of the above listed types of graphic representation into each other. The nesting of graphic representations into a *multipanel display* - usually arranged as a *lineup* or a *table* - is quite common. Two special cases of such a nesting are the *shared-axis lineup* and the *graphic multiple* (see subsection 2.5.4).

A LOOK AT THE LITERATURE CONCERNING CLASSIFICATIONS OF GRAPHIC REPRESENTATIONS

<table>
<tr><th>Categories proposed here:</th><th>Richards 1984 (3 categories)</th><th>Holmes 1993 (3 categories)</th><th>Kosslyn 1994 (4 categories)</th><th>Bertin 1967 (4 categories)</th></tr>
<tr><td>symbol</td><td>symbol</td><td>-</td><td>-</td><td>symbol</td></tr>
<tr><td>picture</td><td>pictorial illustration</td><td>diagram</td><td>diagram</td><td>-</td></tr>
<tr><td>map</td><td rowspan="8">diagram</td><td rowspan="2">map</td><td rowspan="2">map</td><td rowspan="2">map</td></tr>
<tr><td>statistical map</td></tr>
<tr><td>link diagram</td><td rowspan="3">chart</td><td>chart</td><td>network</td></tr>
<tr><td>statistical chart</td><td>graph</td><td rowspan="3">diagram</td></tr>
<tr><td>time chart</td><td rowspan="2">-</td></tr>
<tr><td>table</td><td>-</td></tr>
</table>

FIGURE 4-02-A: Some existing classifications of graphic representations. Continued on next page.

Categories proposed here:	Tufte 1983 (5 categories)	Bounford 2000 (8 categories)	Lohse et al 1994 (11 categories)
symbol		symbol	icon
picture	-	pictorial diagram	picture, structure diagram, process diagr.
map		relational diagram	map
statistical map	data map		cartogram
link diagram	-	organizational diagram	network chart
statistical chart	relational graphic	graph, chart	graph
time chart	time series, narrative of space and time	time diagram	time chart
table	table	table	table, graphic table

FIGURE **4-02-B**: Some existing classifications of graphic representations. Continued from previous page.

The table in figure 4-02 (split in figure 4-02-A and 4-02-B) shows that eight of the sixteen types of graphic representations that are proposed here can serve as a common denominator for existing classification systems. In addition, the classification proposed here offers discrete categories of very common representations for which most existing classifications have overlapping categories. *Statistical time charts* for example - the most common type of quantitative graphics - have to be classified *either* as 'statistical charts' *or* as 'time charts' in most existing classification systems, probably depending on whether their quantitative aspect or their chronological aspect appears more dominant. Likewise, *chronological link diagrams* - such as family trees and work flow diagrams - have to be classified *either* as 'networks' (*link diagrams*) *or* as 'time charts' in most existing classification systems, ignoring their dual nature.

We will conclude this section by taking a brief look at the classifications proposed by Bertin, by Tufte, and by Richards.

Bertin's classification of graphic representations is shown in figure 2-36 of this thesis. First of all, Bertin makes a distinction between *graphics* and *pictography* (Bertin 1981, p.176). Pictography is concerned with the design of *symbols*. The aim of a symbol is to "*define a set* or a concept". The aim of *graphics* on the other hand is to make "*relationships* among previously defined sets appear".

Concerning *graphics*, Bertin distinguishes between *diagrams*, *networks*, and *maps*. This classification depends on the nature of the correspondences that are expressed on the plane. When the correspondences on the plane can be established:

- between all the elements of one information component and all the elements of *another* information component, the construction is a *diagram*. In other words, a diagram transcribes the relationships between two sets of elements. (Bertin 1981, pp. 192, 230; Bertin 1983, pp. 8, 50, 193.)
- among all the elements of the same information component, the construction is a *network*. In other words, a network transcribes the relationships within a single set of elements. (Bertin 1981, pp. 192, 232; Bertin 1983, pp. 8, 50, 269.)
- among all the elements of the same information component, arranged according to the actual arrangement of elements in physical space, the construction is a *map* (sometimes referred to by Bertin as a *topography*). (Bertin 1981, pp.192, 232; Bertin 1983, pp. 8, 51, 285.)

In summary, Bertin divides graphic representations into four groups: diagrams, networks, maps, and symbols. See figure 4-02-A.

Tufte distinguishes four 'fundamental graphical designs': *data maps*, *time series*, *narratives of space and time*, and *relational graphics* (Tufte 1983, pp. 15-50). Tufte does not mention this explicitly, but this classification seems to be based on whether or not graphic space is used to represent *physical space* and

whether or not graphic space is used to represent *time*. If this is true, then the four possible combinations would be: space, time, both space and time, and neither space nor time (see table in figure 4-03). These four possibilities match with Tufte's classification. In addition to these four fundamental graphic designs, Tufte discusses tables, which he does not regard as graphics (1983, pp. 178-181 and 1990, pp. 104-105).

		graphic space represents **physical space**	
		yes	no
graphic space represents **time**	yes	narrative of space and time	time series
	no	data map	relational graphic

FIGURE 4-03: Our arrangement of Tufte's four 'fundamental graphical designs' into a table.

Richards makes a distinction between *pictorial illustrations*, *symbols* and *diagrams* (Richards 1984, pp. 1/1, 10/1, and 2002, pp. 85-86). *Pictorial illustrations* "show physical appearances". *Symbols* "indicate a presence or act as pointers". *Diagrams* "exhibit relationships". See figure 4-02-A.

This rounds up our discussion of the classification of graphic representations. The next chapter will provide a brief overview of the various concepts from existing graphic theories, and describe how these concepts fit into the framework that is proposed in this thesis.