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A Study on Graphic Languages

Eiichi IZUHARA

Osaka University of Arts, Kanan-cho, Minamikawachi-gun, Osaka 585, Japan

Abstract. There are special figures which may be said to constitute a "graphic language," for they have their own code-like grammar. They are classified by their code into four groups; tables (matrixes), maps (territorial systems), networks (linear graphs), and graphs (coordinate systems).

Because of their codes, these figures have qualities similar to sentences in natural languages and formulas in mathematics. Yet these figures are graphical, so fundamentally they are different from sentences and formulas.

Generally speaking, a sentence is understood sequentially from its parts to the whole. But figures in graphic languages are understood in the opposite order—the whole meaning is caught at a glance, with understandings of the details coming later.

This article discusses the reasons why graphic languages have this holism and examines the structure of meanings in graphic figures.

1. Preface

The forms in which information is visually expressed can be divided up into: 1) text (prose, poetry), 2) formulas (mathematical formulas, logical formulas), 3) graphs (graphs, musical notation) and 4) pictures (paintings, photographs). Graphs and pictures, however, are two-dimensional, so they are essentially different from one-dimensional arrays like text and formulas. But the word "graph." refers to a wide range of objects—maps, diagrams, plans, symbol marks—some of which meet the conditions for being considered a "language." They are therefore referred to as "graphic languages." Differences in the symbolic elements used and the rules for their arrangement allow graphical languages to be divided up into four categories: matrixes (tables), networks (linear graphs), territorial systems (maps) and coordinate systems (graphs).[1]

Because they have their own syntactic structures, graphic languages are quite similar both to sentences in natural languages (real languages), and the statements and formulas of man-made languages like mathematical formulas, logical formulas and computer languages. But still the individual figures in graphic languages are graphical, so they are fundamentally different from other statements and formulas—their entire meaning is understood at a glance.

Generally speaking, one first understands the parts of a sentence or formula and then its meaning as a whole. But the meaning of the figures in graphic languages is understood in the opposite order—the meaning of the whole is understood at a glance, and then later on one understands the meanings of the individual details.

In this paper we will be considering several questions: What causes this holistic quality peculiar to graphic languages? What kind of meanings can be understood at a glance from the overall form? And if one understands these meanings before one understands the meaning of the individual parts, what is it that enables this understanding?

2. Holism and General Meanings

The meanings that are understood at a glance from the overall form of the figure are arrived at before the forms and meanings of the individual parts of the figure are known. Since they are not dependent on the individual parts, they must be "*general meanings*" which are apparent from the form of the entire figure itself. When one moves farther away from a figure, it becomes harder and harder to distinguish between its component parts, but one is still able to grasp overall characteristics. If one moves even father away, at some point one will no longer be able to understand even the overall form, but there is a point before this—the point in which one can grasp the features of the whole by not of the parts—and the meaning which is understood at this point is what is referred to as the "general meaning."

A little experiment will point out the difference in this regard between graphic languages and descriptive languages like sentences and text. For example, if one moves one's eyes farther and farther away from a Japanese sentence, one will sooner or later arrive at a point where one is no longer able to make out the individual characters, and at this point one also loses the meaning of the sentence as a whole. Descriptive languages, therefore, do not have the same kinds of "general meanings" which graphic languages do. (This point, however, is modified in Section 3, "Graphical Elements in Descriptive Languages.")

It should be pointed out, however, that graphic languages also have certain rules which allow transformations to take place without changing meanings.[2] In a correct figure belonging to a graphic language, appropriate transformations allow some of its latent meanings to be highlighted. There is a strong relationship between these meanings and the general meanings discussed above.

Let us transform two or three figures according to the appropriate transformational rules. Take, for example, a correlation chart. By changing the way the horizontal lines and vertical columns are arranged, it becomes possible to understand the overall correlations at a glance. Another example is a diagram of group relationships. By drawing the right overlaps among the circles, one can give clear indication of territories common to different groups. (Figs. 1 and 2.)

Neither of these transformations change the latent meaning of a figure, but there is a certain level of obvious meaning which can be understood at a glance from some figure but not from others. We can therefore say that the factors which highlight obvious meanings are not directly related to meaning of the elements

	a	b	c	d	e
a	1.0	.2	.0	.9	.5
b	.2	1.0	.9	.4	.9
c	.0	.9	1.0	.2	.6
d	.9	.4	.2	1.0	.8
e	.5	.9	.6	.8	1.0

(1)

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	a	d	e	b	c
a	1.0	.9	.5	.2	.0
d	.9	1.0	.8	.4	.2
e	.5	.8	1.0	.9	.6
b	.2	.4	.9	1.0	.9
c	.0	.2	.6	.9	1.0

(2)

Fig. 1. The latent meaning of this correlation table does not change by changing the order in which the horizontal and vertical lines are arranged. But it is easier to understand the correlations at a glance from No. 2 than it is from No. 1.

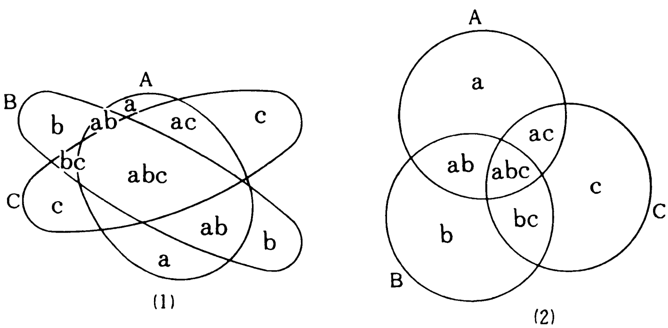

Fig. 2. These Venn diagrams show group interrelations. Both have the same latent meaning, but No. 1 is harder to understand, because groups of the same kind have been divided into two different locations.

which compose the figure, nor to the rules by which they are arranged.

While there are many kinds of forms and general meanings which are understood at a glance, most of them are not unique to a particular graphic language. Rather, they are common to all graphic languages. For example, the overall form and general meaning of hierarchic structures, tree branches, and circular perimeters are understood at a glance, but they are found in matrixes, networks, maps and sometimes even in coordinate systems. (Figs. 3 and 4.)

And if one looks closely, one can see the same kind of links between overall forms and general meanings even in the sentences and formulas of descriptive languages.

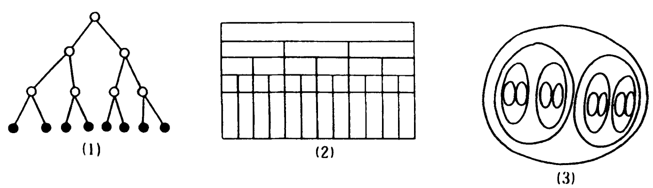

Fig. 3. Though No. 1 is a network, No. 2 a matrix and No. 3 a territorial diagram, all have the same branch-like structure.

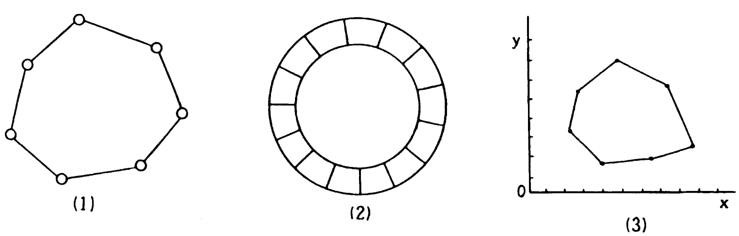

Fig. 4. Though No. 1 is a network, No. 2 a territorial diagram and No. 3 a coordinate diagram, they all have the same circular structure.

3. Graphical Elements in Descriptive Languages

Natural language when it is written down in a descriptive language (Japanese or English text, for example) is generally thought to be a mere record of vocal language or a script to be read aloud. But when sentences are laid out carefully on the two-dimensional surface of a sheet they take on more meaning than just that. Grammar normally covers only the rules for the spoken language and does not give any indication of the principles by which descriptive languages should be laid out.

There are unspoken understandings about this and they have up to this point been left ambiguous. Traditional semiotics has deemed this to be a matter of pragmatics or performance and has thus only dealt with it in the most general of ways, so no more detailed analysis has been forthcoming.

For example, one can say that it does not matter how many words one puts in a line of text, it changes neither the meaning of the vocabulary nor the meaning determined by the sentence pattern. But if one compares a sentence in which the words are arranged in one long line and a sentence in which they have been laid out with appropriate spacing, one can see quite readily that there are differences between them in the meanings one is able to immediately pic up. Text, when it has been given titles and subtitles and laid out with an eye to visual placement of the words, takes on other meanings not found in spoken language. The factors which carry these meanings, we shall call the "graphical factor in descriptive languages."

If, like a newspaper, text is provided with appropriate titles and subtitles, it is possible to understand its general meaning at a glance. This general meaning is not dependent on Japanese grammar, either. Rather, it seems to come from the graphical factor called "layout."

Actually, the division of a statements into sentences and clauses itself has nothing to do with the grammar of natural language. And just like a paragraph or a blank line, sentences and clauses are also graphical factor which help make the divisions and interrelations of the meaning easier to see. (However, special descriptive forms in descriptive languages—for example, the arrangement of the title and author's name on an article—follow special rules of arrangement which are not found in the grammar of spoken language. This could be deemed a form of [descriptive] grammar. Its relationship with the graphical factor described above is discussed in Section 5).

4. Overall Form and the Universality of its Meaning

We have already discussed the fact that the relationship between the overall form of the figures in a graphic language and their general meaning does not depend on the rules of a arrangement for any specific language. And this is not limited just to graphic languages. Descriptive languages also share certain graphical factors, which are considered to be the graphical characteristics which all graphic and descriptive languages have in common. But since they do not depend on the grammar or rules of arrangement of any language, they are not syntactic characteristics per se (of either descriptive or graphical languages). Rather, they are best thought of as graphic characteristics which are common to all signs.

Some of the relations between overall form and general meaning are listed below:

(Overall Form)—(General Meaning)
Linear—Order, Flow
Circular—Rotation

Symmetrical—Contrast
Tiered—Stratification
Branching—Division, Systems
Overlapping—Interrelations
Inclusive—Belonging,
(See Fig. 5.)

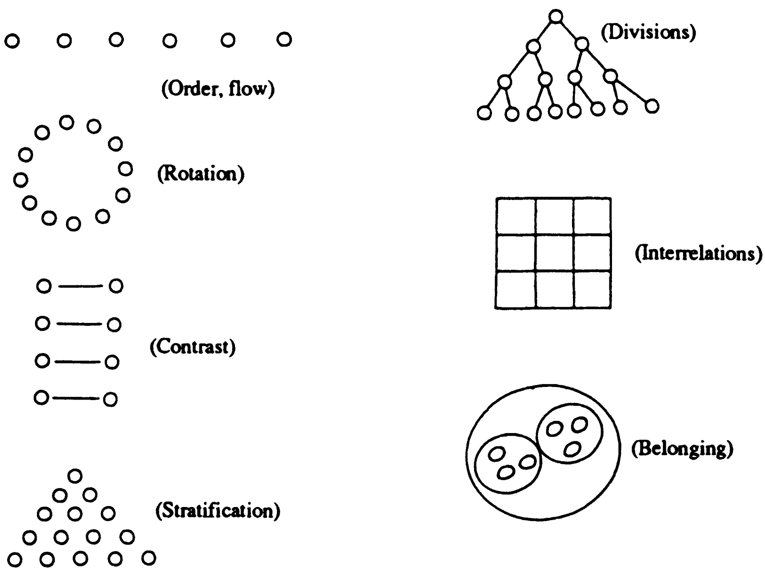

Fig. 5. Common patterns which express general meanings.

One of the reasons why these relationships between form and meaning are universal is because of structural similarities in the objects they indicate. Put a different way, these overall forms come from common patterns of human thought. Their meaning is universal because human recognition works by structuring objects along patterns. Perhaps this has something to do with why the rules of sentence composition and forms of logical induction—which in the broad sense belong to the study of rhetoric—are universal and transcend individual languages.

What is important is that the general meaning shown by these overall forms is first grasped at a single glance. That is why figures are understood first as a whole and then as individual parts. But as was discussed earlier, there is absolutely no cause and effect in the relationship between the elements (vocabulary) which compose of a figure and the syntactic structure determined by their arrangement (grammar). When a text is understood "from the parts to the whole" there is a certain continuity involved—one works from the meaning of individual words to that of the clause, and from there to the sentence, the section and the text as a whole. This, however, is not found between the syntactic meaning of a figure and its general meaning.

5. Types of Meaning

We have already discussed the fact that when figures, text and formulas have syntactic structure, the meanings they contain are dependent on both the meaning of the elements (words) unique to each linguistic system and the meanings determined by the order in which they are arranged. We then went on to state that there is also a *general meaning* which is dependent neither on the meaning of the elements nor the rules for their arrangement, but is found in figures, as well as in text and formulas when they are appropriately laid out. We now need to ask ourselves if there are any other kinds of meaning to be found besides these two. By looking at whether or not the meaning of a figure (or text or formula) is dependent on the meanings of its elements (words), and whether or not it is dependent on the meanings determined by its rules of arrangement (grammar), we can come up with four formal divisions.

		Grammatical Meaning	
		Dependent on	Not Dependent on
Elemental Meaning	Dependent on	(1) Syntactic Meaning	(2)
	Not Dependent on	(3)	(4) General Meaning

Number 1, of course, refers to the "syntactic meaning" that the language is expressing. By contrast, number 4 refers to the "general meaning understood at a glance" from figures, as well as from text and formulas which have been given a two-dimensional layout. Number 2 refers to cases in which some characteristics are added in order to emphasizing particular meanings—for example, when one part of a figure is enlarged, contracted, colored or caused to stand out in some other way. Further examples would be titles in newspapers (which we have already discussed) and the use of Gothic or italic typefaces to highlight meanings in text. Number 3 refers to something we have not yet discussed; the meanings expressed by conventionalized patterns which are recognizable at a glance. Examples include the patterns in diagrams of parallel or serial electrical circuits, the hexagons used to express molecular structure (say, the structure of a benzine molecule), parabolas in coordinate systems, and even sine-curves. The meanings expressed with the conventional sentence forms of natural language and general (alphanumeric) formulas of mathematics probably fall into this category as well. The rules for arranging a letter, or for laying out the title, subtitle and author's name on an article are all conventionalized patterns of arrangement that fall under this category.

But while the patterns in category 3 have developed into customary patterns and are understood at a glance, they depend on rules of arrangement (grammar) peculiar to each language. If one is to understand their meanings correctly, one must to a certain extent be able to observe them analytically. They should therefore be considered as having a different nature than "general meanings" which are understood at a glance from the overall form. In other words, the symbolic forms in category 4 are all general pattens not bound by any syntactic structures, whereas the members of category 3 are special patterns unique to each graphic language.

Figures and syntactic meanings (category 1) are understood through syntactic analysis. By contrast, general meanings (category 4) are universal patterns which are grasped directly from the overall form. This means that the layout of a figure or text may at times express a general meaning which is different from its syntactic meaning. These sort of design, obviously, is a layout which gives rise to misunderstandings.

6. Significance to Design

There is no need to belabor the importance of laying out figures, text and formulas well on a flat surface. We should point out, however, that layout takes on many different functions. Beautiful arrangements and beautiful colorings give it an artistic function which is the subject of aesthetics. Easy-to-understand arrangements and colorings give it a recognition function which is the subject of intellectual (sensory) psychology. And the use of general and specialized patterns to allow meanings to be understood at a glance, the addition of special characteristics to certain elements in order to emphasize particular meanings, and other similar techniques give layout a symbolic function which is the province of semiotics.

Up to now, most of the interest in design has been concentrated on its artistic and recognition functions. Research on its artistic functions has emphasized color harmonies and beautiful proportions, while research on recognition functions has looked at optical illusions and the ability to attract attention.

But parallel to these, emphasis should also be placed on the symbolic functions which serve to transmit meaning. The semiotics of figures discussed in this paper should point out directions to be taken in further studies.

Notes:

1. Konpuuta Gurafikku Ron ("Theory of Computer Graphics"), 1977, Nikkagiren Shuppansha

There is a wide range of meaning contained in the forms of the figures which we use for mundane or even academic purposes. But there are not so all as many forms themselves, and they can basically be divided up into:

1) matrixes (tables),
2) networks (linear graphs),
3) territ)rial systems,
4) coordinate systems,
5) symbolic systems, and
6) picture systems.

Symbolic systems include things like insignia and traffic signs, Picture systems include paintings, cartoons and sketches. But neither of these has any syntactic structure, so they may be excluded from our consideration. Graphic languages, therefore, can be narrowed down to the first four categories.

1) *Matrixes*

Matrixes make use of the ability of lines to divide up flat surfaces. Their main units of meaning are horizontal lines and vertical lines. The rules of arrangement give special meaning to the points where horizontal and vertical lines cross, which expresses the relationship between the overlapping horizontal and vertical items.

2) *Networks*

Networks make use of the ability of lines to link objects. Their main units of meaning are lines (called "bars") and points (called "nodes"). They may also use figures and letters. The rules of arrangement give meaning to the existence or absence of a bar connecting two nodes, which indicates their relationship.

3) *Territorial Systems*

Territorial systems make use of the ability of closed curves to divide up flat surfaces. Their main unit of meaning is a randomly-shaped closed curve. The rules of arrangement give meaning to relationships like inclusion, overlap, separation and proximity between different closed curves.

4) *Coordinate systems*

Coordinate systems make use of the ability of points to determine positions, and the ability of lines to indicate amounts, directions and line of movement. Their main units of meaning are axis lines (which indicate the coordinate axes), points (which indicate position), and lines (which indicate amounts, directions and movement). The rules of arrangement give meaning to quantitative positional arrangements of points and lines within fields defined by coordinate axes.

2. *Konpuuta Gurafikku Ron* ("Theory of Computer Graphics), 1977, Nikkagiren Shuppansha

Each graphic language has its own "transformational rules" which do not change the meanings induced by particular units of meaning and the rules for their arrangement.

These rules are similar to the rules of transposition and factorization used in mathematical equations, or to the ability of some natural languages like Latin or

Japanese , able to specify which words are subjects, possessives, objects, etc. The value of these transformational rules is most apparent in mathematics where a quadratic equation can be transposed into a form which allows the form and position of the parabola to be understood at a glance. An example is found in Fig. 6.

$$y = x^2 - 2x - 1$$
$$\Downarrow$$
$$y = (x-1)^2 - 2$$

Fig. 6. A transformation which makes the characteristics of the parabola easier to understand.

In graphic languages, as well, the meanings of correct figures do not change as long as they are transformed using the proper transformational rules. But each time they are transformed, the meaning which is understood from their form at a glance becomes a bit different. This may seem like a contradiction, but the meaning which is not changed during transformation is considered the "latent meaning" that the figure really has. When a transformation takes place, a part of this latent meaning is made more prominent, which changes the meaning perceived at a glance. (See Fig. 7.)

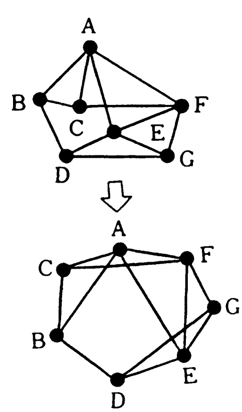

Fig. 7. A transformation which makes a Hamilton line easier to understand.