A Schema for the Study of Graphic Language (Tutorial Paper)

Michael Twyman

This paper presents a schema that attempts to embrace all graphic language. The essence of the schema is shown in a matrix which presents a number of theoretical possibilities in terms of approaches to graphic language. One axis of the matrix describes the methods of configuration of graphic language, using such terms as pure linear, linear interrupted, list, linear branching, matrix, non-linear directed, non-linear open. The other axis describes the modes of symbolization of graphic language, using four somewhat crude categories: verbal/numerical, pictorial and verbal/numerical, pictorial, schematic. Numerous examples are shown to clarify terms and the underlying concepts they describe. It is emphasized that the matrix is a device for directing thinking, rather than a means of defining graphic language.

The paper is written from the standpoint of a practising graphic designer. The matrix is used to illustrate the wide range of approaches open to us in graphic language and the effect this is assumed to have on reading/viewing strategies and cognitive processes. It is suggested that the matrix is useful in focusing attention on two fundamental questions that ought always to be asked when deciding how a graphic message should be communicated: What should be the mode of symbolization and what should be the method of configuration? Legibility and related research is briefly reviewed in order to establish what light it throws on these questions; with a few notable exceptions it is found wanting. It is suggested that there is a need for more research that crosses the boundaries of the cells of the matrix.

This paper is not the culmination of a sustained programme of research and brings no firm evidence to bear on any aspect of graphic language. It is the contribution of a graphic designer who has had the opportunity of associating with research workers concerned with the evaluation of graphic language, and is written as a tutorial paper to stimulate thought and discussion. It is an attempt to define the scope of graphic language and to show relationships between different approaches to it that have been, and can be, used. Throughout the paper, the totality of graphic language and its specifically graphic variables are emphasized. Though the approach may appear to be somewhat theoretical, it is intended that it should have practical implications.

For the purpose of this paper "graphic designer" means someone who plans graphic language; "graphic" means drawn or otherwise made visible in response to conscious decisions, and "language" means a vehicle of communication. The graphic designer is usually seen as someone who operates between those with messages to transmit and those to whom they have to be communicated; in this respect he is the graphic equivalent of the radio producer. The graphic designer may not always be a professional however and, whether lay or professional, he may on occasions be the originator of the message. It should be stressed therefore that the term graphic designer is used here to refer to anyone who plans graphic language.

While all of us use graphic language as originators and consumers, very few of us are aware of how it should be planned so that it can be most effective. In this respect, as in many others, graphic language differs from oral language, which is either not consciously planned at all - as in most conversational situations - or is planned by those who engage in public speaking with a reasonable understanding of what they are doing. Our experience of planning graphic language - unless we have special problems, such as those presented by the preparation of a table for a scientific paper or a hand-made notice for a jumble sale - probably ended at school when we learned how to organize a letter, address an envelope, or set out a sum in mathematics. Most of those who use graphic means of communication professionally in everyday situations involving continuous prose merely pass on their problems to their typist who does the planning for them. In more complex areas of graphic communication, particularly when the message is non-linear, the originator has less control over the graphic presentation of his message and frequently relies on a specialist draughtsman, cartographer, or typographer. This is a situation that has few parallels in oral language.

Outline of Objectives

The principal objective of this paper is to demonstrate by means of a schema the wide range of approaches open to us in graphic language. The proposed schema, which is presented in the form of a matrix, draws attention to the different modes and configurations of graphic language and is firmly rooted in practical applications. It is relevant to consider a schema of this kind - though not necessarily the one proposed - for both practical and theoretical reasons. In practical terms it is important because a schema which presents graphic language as a whole has the value of drawing attention to the variety of approaches available when using graphic language and defines those areas where decisions have to be made. All this is made necessary because our training and experience, whether primarily verbal, numerical, or visual, tends

to predispose us towards particular approaches to graphic communication. In more theoretical terms, the overall pattern presented by the schema enables us to see points of connection between different areas of graphic language that are normally seen as discrete and that our traditional attitudes and terminology encourage us to keep separate.

The secondary objectives of this paper stem directly from the first. The matrix will be used as a means of identifying, in a very general way, those approaches to graphic language that are most commonly adopted. It will also be used to consider the extent to which legibility and related research has responded to the real needs of those making decisions about graphic language.

The schema does not pretend to be watertight, and some of the boundaries between the cells of the matrix are drawn subjectively. The fact that some kinds of graphic language do not fit perfectly within the matrix serves only to highlight the subtlety and flexibility of graphic language. This should not invalidate the schema itself, which is intended as a device for directing our thinking and not as an end in itself.

Fragmentation of the Study of Graphic Language

Over the last few years I have attempted to develop approaches to the description of graphic language. In this respect I have taken a leaf out of the book of linguistic scientists, many of whom believe that description is a necessary prelude to understanding. Certain aspects of graphic language have, of course, been extremely well covered from a descriptive standpoint. The characters of the Latin alphabet, for instance, have been minutely studied: there are numerous classification systems designed to accommodate thousands of different styles of letter forms (most of which are not even noticed by the layman), and a precise language has been developed to describe the various parts of letters and their related characters. All this can perhaps be compared with phonetics as a branch of linguistics. There is also a vast literature which focuses on the iconography of that part of graphic language we call art, and traces subtle stylistic influences of one artist or school on another. This activity might be seen, at least in some respects, as akin to literary criticism.

These two aspects of graphic language have been chosen to highlight the diversity of the field and of the activities of those who work within it. Those who study letter forms in the manner described above are likely to be practising typographers or historians of printing; those who study the iconography of paintings are likely to be art historians. Though related to one another in that both are concerned with forms of graphic language, the two disciplines hardly interact. To a large degree the same must be said of other fields of scholarship concerned with graphic language within a theoretical framework, such as semiology, psychology, topology, anthropology, palaeography, linguistic science, and cartography.

The Matrix

The proposed schema is based on the matrix (Figure 1) which presents a number of theoretical possibilities in terms of approaches to graphic language. The column headings describe what have been called methods of configuration, by which is meant the graphic organization or structure of a message

Method of configuration

Mode of symbolization	Pure linear	Linear interrupted	List	Linear branching	Matrix	Non-linear directed viewing	Non-linear most options open
Verbal/ numerical	1	2	3	4	5	6	7
Pictorial & verbal/ numerical	8	9	10	11	12	13	14
Pictorial	15	16	17	18	19	20	21
Schematic	22	23	24	25	26	27	28

Figure 1. The matrix.

which influences and perhaps determines the "searching," "reading," and "looking" strategies adopted by the user. There is no accepted terminology in this field, apart from the headings "list," "linear branching," and "matrix," which will be readily understood. The division between the two headings to the extreme right of the matrix, "non-linear directed viewing" and "non-linear most options open" (shortened henceforth to "non-linear directed" and "non-linear open") is highly subjective and is therefore indicated by a dotted line. In reality the two categories, which are shown as discrete items in the matrix, form a continuum. There are elements of linear reading in some of the "nonlinear directed" categories, but the heading serves to emphasize that the principal searching strategy is non-linear. The most important general characteristic presented by the column headings is that they show a transition from pure linearity on the left to extreme non-linearity on the right.

Column headings have been limited to major categories since the main aim of this paper is to concentrate attention on a few central issues. It would not have been difficult to subdivide some of these major categories. For instance, the heading called "linear interrupted" could be further divided according to whether all reading was in the same direction (i.e., left to right, or right to left), or whether it was to be done boustrophedon (as the ox ploughs). Within each of these categories the interruption of the linear flow may be made on the following grounds:

1) semantically (with the lines broken only after linguistic units, the smallest such unit being the word)
2) quasi-semantically (with the lines broken only between words or within words according to etymology)
3) partially semantically (with the lines broken between words or within words either phonetically or arbitrarily)
4) mechanically (with words broken at the most convenient point, regardless of meaning).

Even within these four categories there are different ways in which these line endings may be achieved, and most of these can be found in everyday use. It is clear, however, that little is to be gained by producing a matrix of such complexity that it would be understood only by its originator or those prepared to spend an inordinate amount of time studying it.

The row headings describe the modes of symbolization. This is a fairly crude breakdown of modes, especially in relation to those sections that relate to pictorial language. The subject is one that has attracted considerable attention from semiologists over the last few decades, particularly in relation to iconic and symbolic images, but such issues are not central to the theme of this paper, which is more concerned with the relation between mode of symbolization and method of configuration. It should be said that it is more difficult to establish a distinction between pictorial and schematic modes than between the other categories on this axis; for this reason the division between them is indicated by a dotted line. A number of additional headings could also have been introduced on the axis of the matrix. A "numerical" mode might have been included as a separate category from "verbal/numerical"; in addition, it might have been valuable to introduce a combined "schematic and verbal/numerical" category and to distinguish between discrete pictorial symbols and unified synoptic pictures. However, it was felt that such additions

to the matrix would have blurred an important issue - the conflict in reading/-viewing strategies that arises from the linearity of the verbal mode and the non-linearity of both the pictorial and schematic modes.

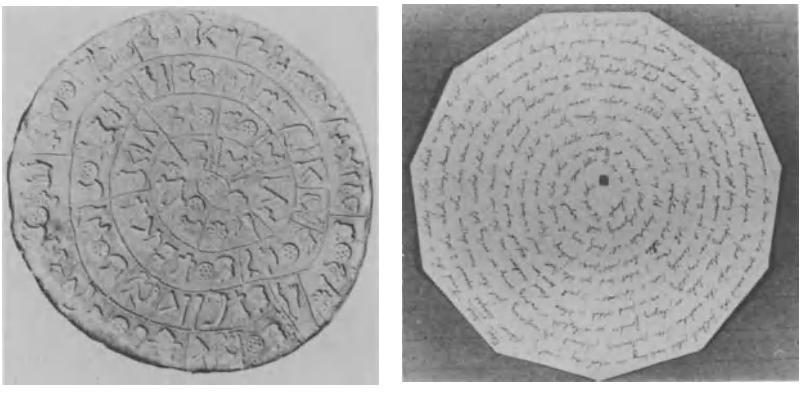
In other respects, too, emphasis has been placed on ease of understanding. Most obviously the matrix, as presented, takes no account of sequences in time as seen in film and television; nor even of the interrupted sequences in time presented by pages of a book or sets of slides. Such approaches could have been accommodated by adding a third dimension to the matrix, but at the expense of clarity. Similarly, a number of the graphic variables isolated by Bertin (1967) - such as size, tone, texture, colour, and shape are not specifically catered for. These can, and should, be considered in relation to all the combinations of modes of symbolization and methods of configuration presented in the matrix.

The Cells of the Matrix

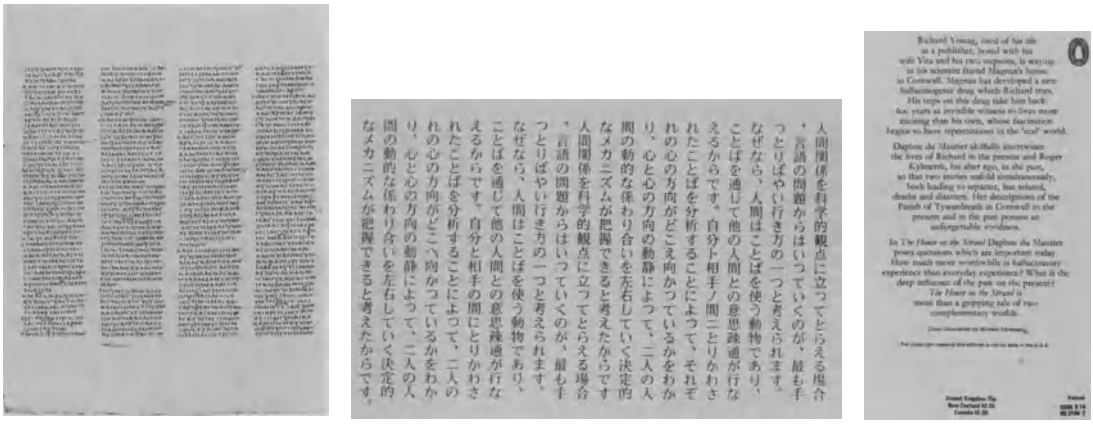
The cells of the matrix have been numbered for ease of reference, even though this approach reinforces one particular reading strategy at the expense of others. These numbers have been included in parentheses in the text of this paper where relevant.

The examples chosen to fill the cells of the matrix are mainly from this century and from those parts of the world using the roman alphabet. However, the matrix has validity in relation to other linguistic conventions and other periods of time, and culturally and historically based approaches to it would probably prove fruitful.

It is important to emphasize that each cell of the matrix offers a relatively wide range of graphic possibilities. The most effective way of presenting the essential characteristics of each cell would be to show numerous examples, but clearly a printed paper does not lend itself to this approach. There is the danger, in showing a single example, or even a limited number of examples, that this might lead to the formulation of a narrow set of definitions for the cells. It should be said therefore that the prime reason for presenting the matrix is neither to define nor confine graphic language. The examples shown here should be considered with these comments in mind; they are presented in list form in the numbered sequence of the cells of the matrix, together with a brief commentary.

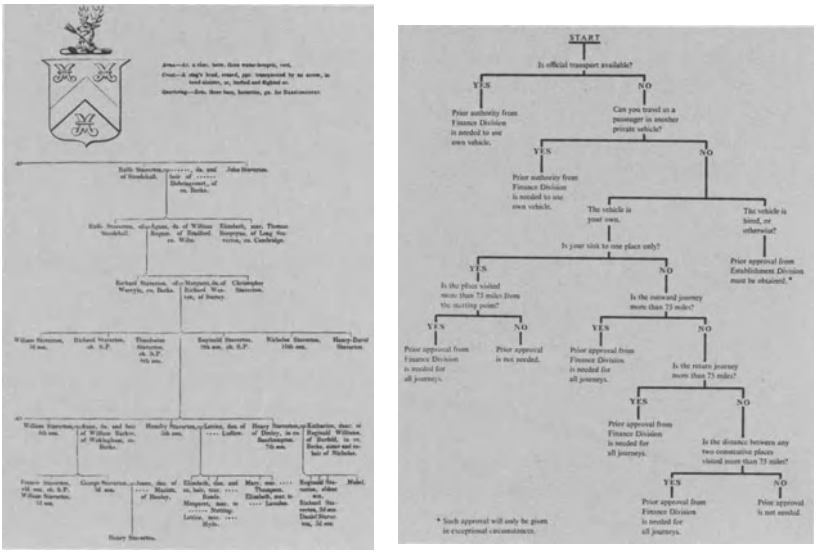


Cell 1. These examples come as close to pure linearity as a limited two-dimensional format will allow. On the left is the Phaistos disc (Minoan, c.1700BC) and on the right a recent handwritten letter. Both examples read from the outside to the centre.



Cell 2. In practice, linear flow of text is nearly always interrupted, as in the Codex Sinaiticus from the fourth century AD (left). The reasons for this practice are various (ergonomic, perceptual, practical) and apply throughout the world whether the direction of reading is left to right, right to left, or top to bottom (centre). Normally, line breaks do not relate to semantic units. Lines are usually more or less of the same length within a single passage of text, but linear interrupted text may take other forms (right). The methods used to make sequences of lines conform to predetermined arrays are too numerous to describe here.

Cell 3. Lists differ from 2 above in that the items presented on each line form discrete semantic units. On the left is the order of the coronation procession of George IV, 1821. On the right is a restaurant guide in which entries are distinguished from one another by occupying separate lines, though each entry consists of two parts which are distinguished from one another typographically.



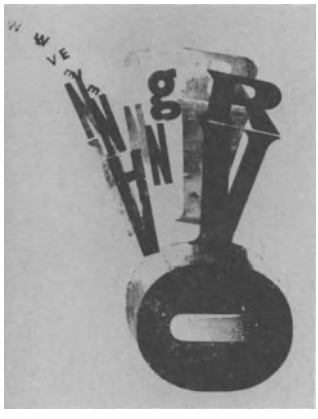
Cell 4. On the left is a traditional family tree of 1833, with many branches; on the right is an algorithm, which is binary.

FIRST DIVISION

	Home					Away					
	P	W	D	L	F	A	W	D	L	F	A	Pts
Leeds	13	5	1	0	12	4	3	3	1	8	5	20
Arsenal	13	6	1	0	21	2	1	3	2	6	11	18
Man. C	12	3	3	0	12	4	3	2	1	5	4	17
Spurs	13	4	1	1	9	4	2	4	1	10	6	17
Cryst P	13	5	0	2	10	5	2	3	1	5	4	17
Chelsea	13	3	3	0	11	8	2	3	2	5	5	16
Wolves	13	3	1	2	12	13	4	1	2	14	14	16
L'pool	12	4	2	0	12	2	1	3	2	3	4	15
Stoke	13	4	3	0	13	1	0	2	4	5	15	13
Cov C	13	3	1	2	6	3	2	2	3	6	8	13
Newc U	13	1	4	1	6	6	3	1	3	9	10	13
S'hmptn	13	2	2	1	8	3	1	2	4	7	10	12
Everton	13	2	3	1	9	6	2	1	4	9	15	12
Derby	12	3	1	3	11	9	1	2	3	7	11	11
WBA	13	2	3	1	13	9	0	2	4	9	21	11
Man. U	13	2	3	2	6	4	1	2	3	7	14	11
Notts F	13	3	2	1	12	6	0	3	4	1	12	11
H'field	13	3	3	1	9	5	0	2	4	3	12	11
Ipswich	13	3	2	2	13	7	0	1	5	1	8	9
W Ham	13	1	4	2	9	10	0	3	3	6	11	9
B'pool	13	1	3	2	6	9	1	1	5	4	14	8
Burnley	13	0	2	5	4	12	0	2	4	2	10	4

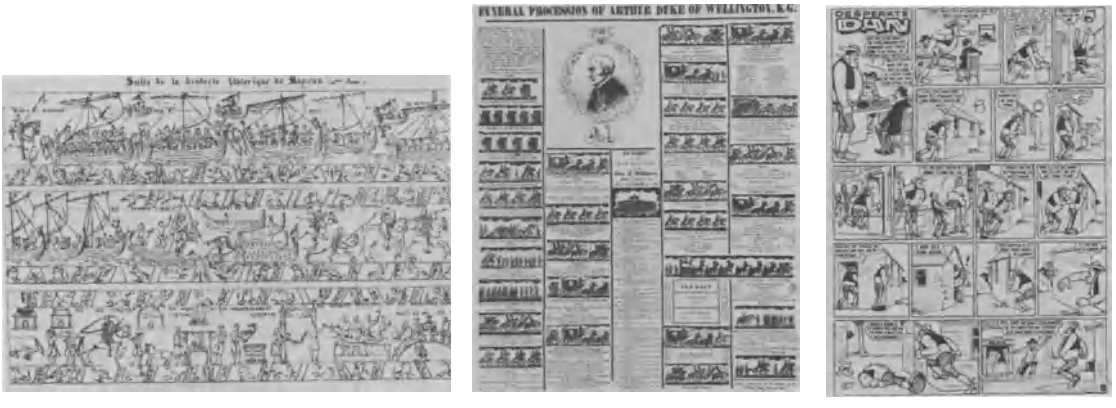
Cell 5. Both these matrices would be described as tables: the football league table (left) is primarily numerical, the page from a company report (right) is primarily verbal.

Cell 6. The boundary between Cells 6 and 7 is subjectively drawn. "Non-linear directed" has traditionally been the language of advertising. Examples shown range from a consistent method of directing the viewing (left), where it is assumed that the bold headings will be scanned vertically as a first operation, to others (centre and right) where it is most unlikely that reading strategies will bear much relation to those adopted in relation to "linear interrupted" language.

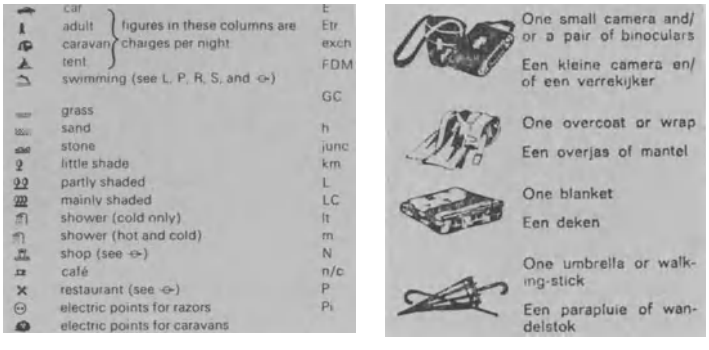


Cell 7. In the "non-linear open" configuration, verbal language usually breaks down in terms of precise communication. In concrete poetry however it may take on other dimensions of meaning.

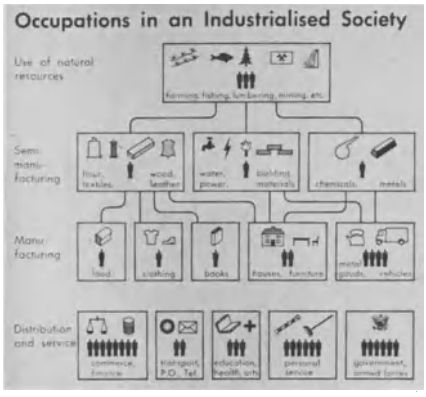
Cell 8. The Bayeux Tapestry is probably the nearest approach to a "pure linear" image in this mode that can be found. It is not purely linear, however, as the verbal image is divided into discrete units and the picture is not a continuous narrative.



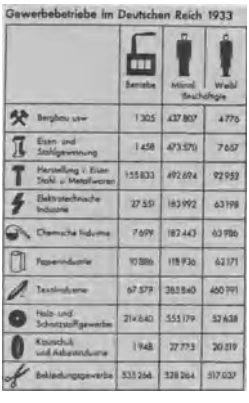
Cell 9. When presented in book form the Bayeux Tapestry (left) is usually divided into units of equal length as in traditional text setting. The broadsheet of the funeral procession of the Duke of Wellington in 1852 (centre) shows a division of pictorial and verbal information into hunks to form five columns. A well tried application of the linear interrupted configuration in this mode is the comic strip (right), where the interruptions to the story are usually made on the basis of what will fit into the line.

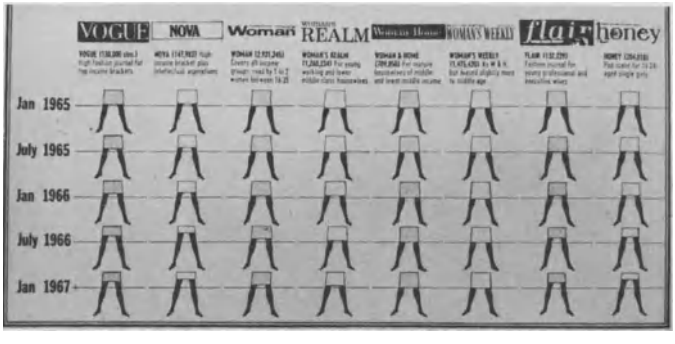


Cell 10. Combinations of pictures and words are found in list form in such things as keys to maps and guides (left) and travel regulations (right).



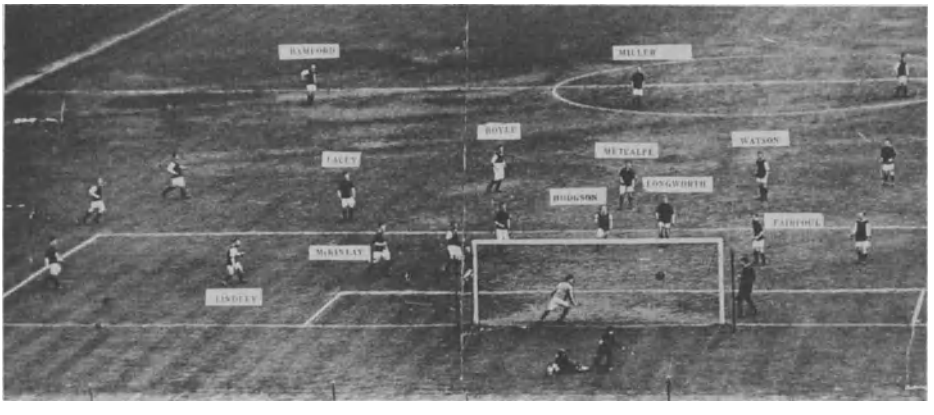
Cell 11. This is an unusual example of a multiple tree presented in the combined "pictorial & verbal/numerical" mode.



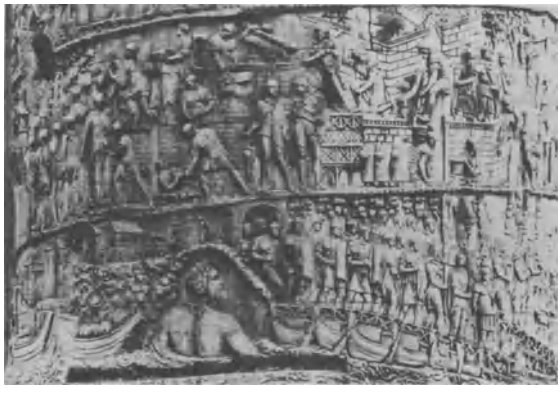


Cell 12. In the example on the left pictures are used as column and row headings to identify the numerical information in the cells of the matrix. In the example on the right, prepared for the Sunday Times, the actual content of the matrix is presented in pictorial terms and the user "reads off" the information by assessing the length of the miniskirts.

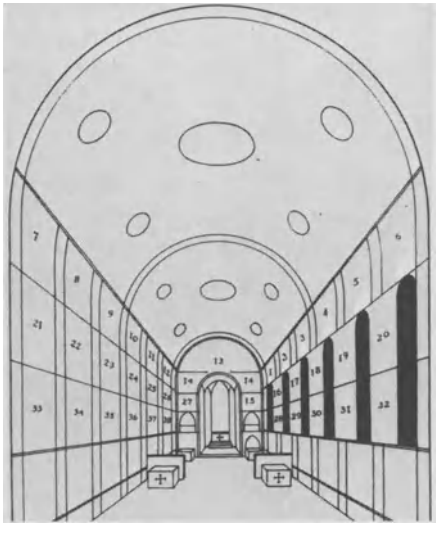
Cell 13. In the exhibition catalogue (left) the user's viewing is directed in a number of ways: horizontally along the row of pictures; horizontally from one column of text to another; and vertically so that each picture is read in conjunction with the passage of text beneath it. This scheme of organization is a rational one that has some of the characteristics of a matrix, whereas the directed viewing associated with advertising (centre) and popular journalism (right) is more intuitive and open to a wider range of reading/viewing strategies.



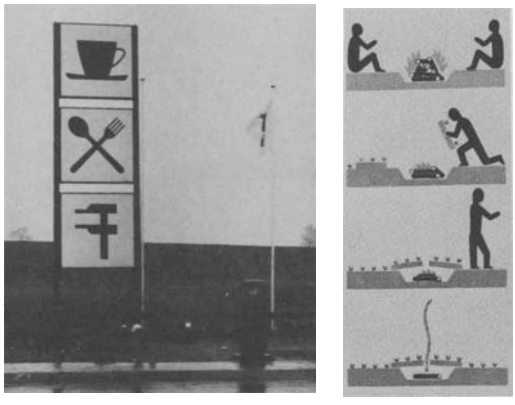
Cell 14. This early example of football reporting is probably as near as one can get to a graphic image in this mode, in which most options of viewing and reading are left open.



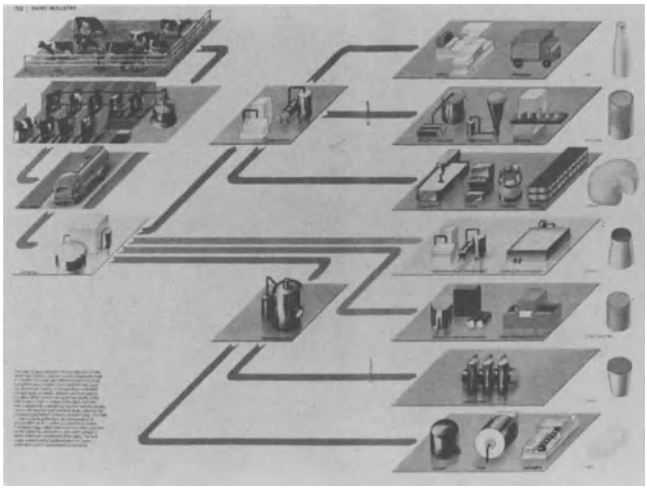
Cell 15. The story in relief sculpture spiralling up Trajan's Column of 112AD in Rome (left), and panoramic views of coastlines and rivers (right) are examples of the linear presentation of pictures.



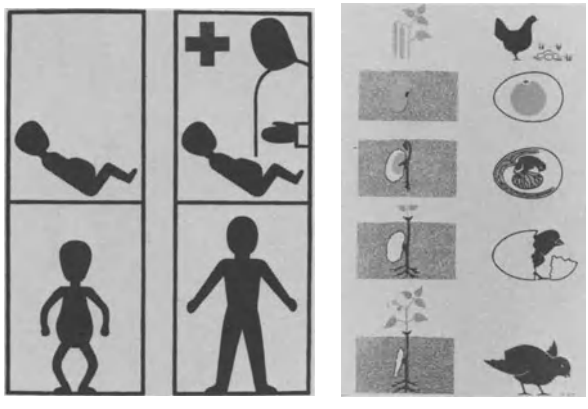
Cell 16. Wall paintings and mosaics have traditionally been presented in series of discrete scenes. The individual scenes of Giotto's fresco cycle in the Scrovegni Chapel, Padua (left and centre) of the early fourteenth century have been arranged, in so far as the structure of the building will allow, in much the same way as one reads text. A closer parallel with the "verbal/-numerical" mode is provided by the illustration of the funeral procession of Lord Nelson, 1806 (right) in which the rows of pictures have been "justified" by putting variable amounts of space between the pictorial units.



Cell 17. Amongst the simplest pictorial lists are arrays of symbols designed to facilitate international travel (left). A more complicated example is provided by the sequence of pictures (right), each of which represents a separate stage in the narrative.

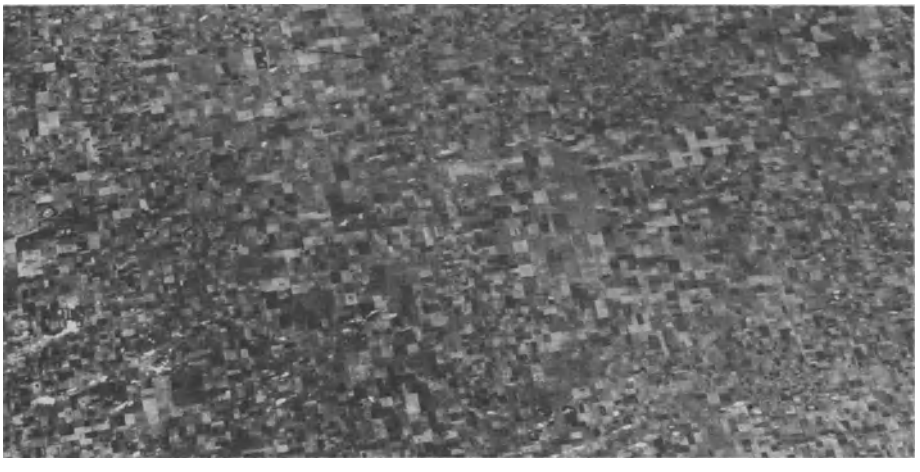


Cell 18. This pictorial tree from a recently published pictorial encyclopaedia illustrates the structure of the dairy industry. The original is colour coded.

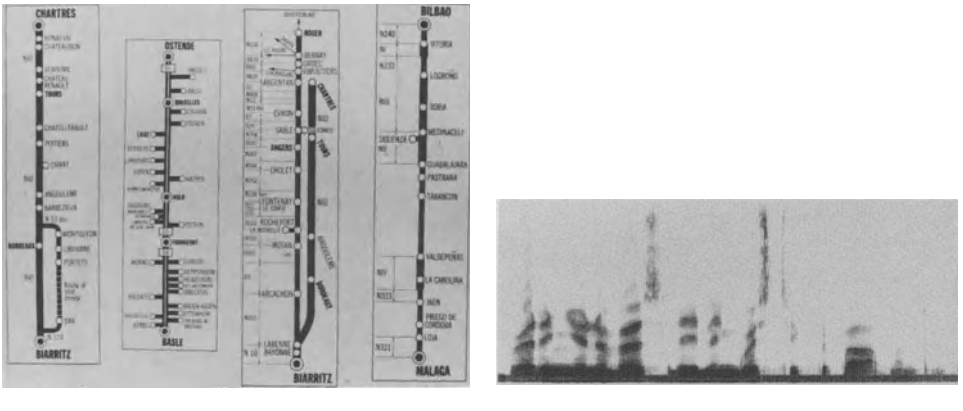


Cell 19. Matrices are rarely presented in the pictorial mode. In the example on the left the viewer has to deduce the headings from the content of the pictures (Column headings: no medical man / medical man. Row headings: swollen stomach / after swollen stomach). The example on the right shows the parallel life cycles of a bean and a chicken.

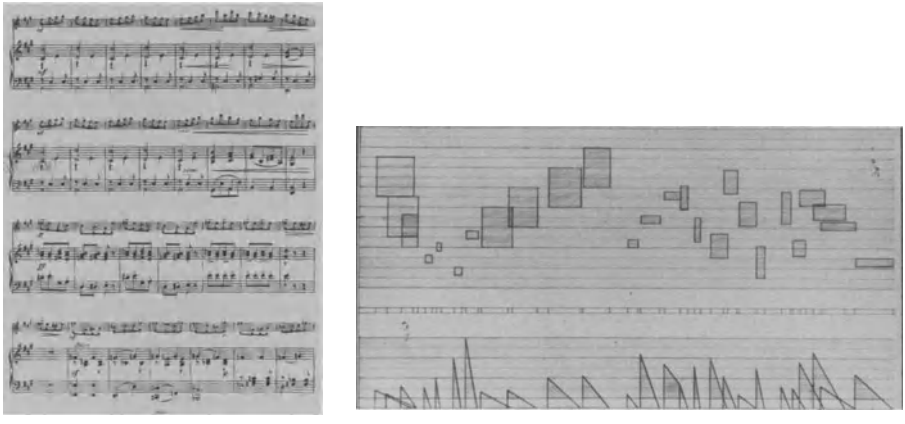
Cell 20. Most consciously-designed pictures fall into the category of "non-linear directed," since it is usually the intention of an artist or photographer to say something in visual terms. The difficulty lies in determining whether viewers do respond to images in the intended manner. It has been assumed that this perspective projection of the Great Exhibition building of 1851 provides a strong directive force in viewing.



Cell 21. For the reasons given in relation to cell 20, it is almost impossible to find an example of "non-linear open" in this mode. Even when a photograph is taken more or less at random there will be aspects in the organization of the image that influence our viewing. The example given is an aerial photograph.

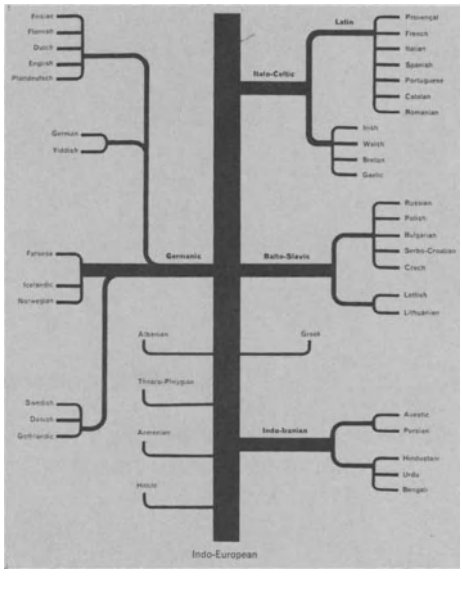


Cell 22. Route maps (left) and traces from graph plotters such as the spectrogram (right) provide well used examples of pure linear schematic language.

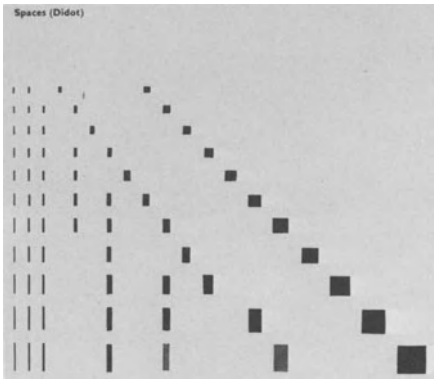


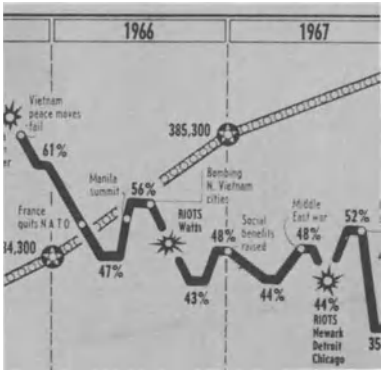
Cell 23. Traditional musical notation (left) and, more obviously, modern form of notation (right) follow the "linear interrupted" method of configuration.

Cell 24. No example has yet been found for this cell.

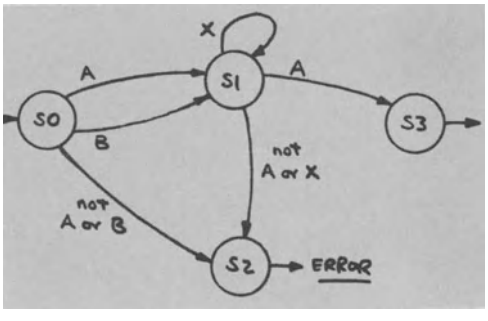


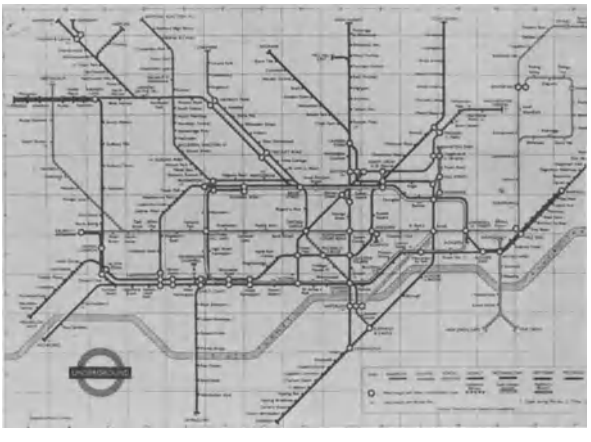
Cell 25. This schematic display of the relationship of the languages of the world follows a tree structure. The thickness of the lines relates to the evolutionary position of the languages shown.





Cell 26. The example on the left presents the range of spacing units available in letterpress printing using the Didot system. As with the set of bar charts (centre) it requires the user to make searches about two axes. Line graphs (right) fall into this cell because they represent schematically the plotting of points on a matrix.



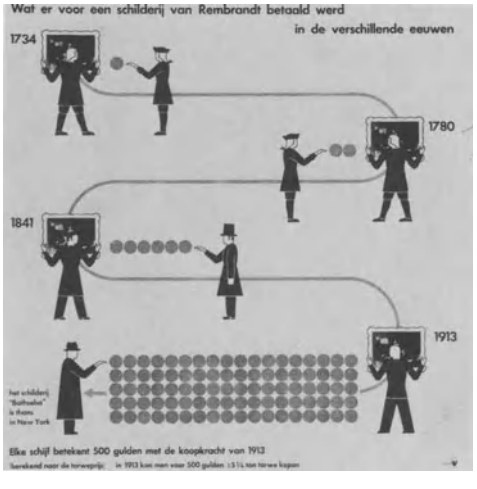


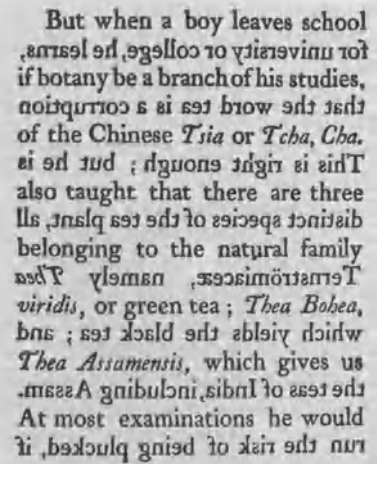
Cell 27. Most network diagrams fall into the "non-linear directed" category because only certain routes in them are regarded as legal. On the left is a network diagram by Wiseman and Linden (this volume). Some maps take the form of network diagrams: the London underground diagram, originally designed in 1933 (right), is perhaps the most influential network diagram ever produced.

Cell 28. Surface maps, such as this detail of a Canadian city, differ from network diagrams in that they leave most options open to the user. Some element of direction is provided for the user by such devices as colour coding and categories of labelling.

The following items have been provided as a visual footnote to the examples shown above in order to emphasize that the schema presented in this paper is a device for directing thinking about graphic language rather than a schema for the language itself. While there are many variants of graphic language that do not fit precisely within a single cell of the matrix, most such variants can be accommodated by it in that they combine the characteristics of a number of cells.

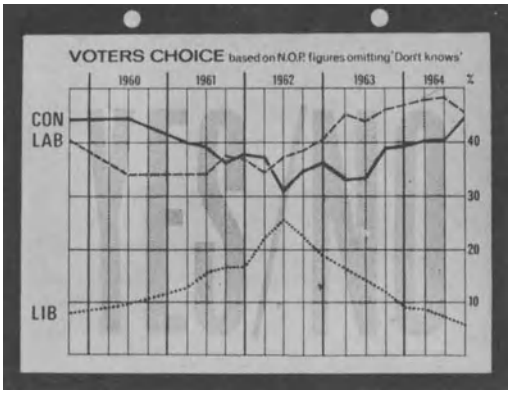
Display 29. This detail from a telephone directory shows a sequence of lines composed of three discrete items in terms of content (name, address, number). However, only two distinctions are made typographically (the number is distinguished from the other two items by space and by the fact that part of it appears in bold type). This is not a simple list, but further typographic distinctions would have to be made for it to be considered a matrix.

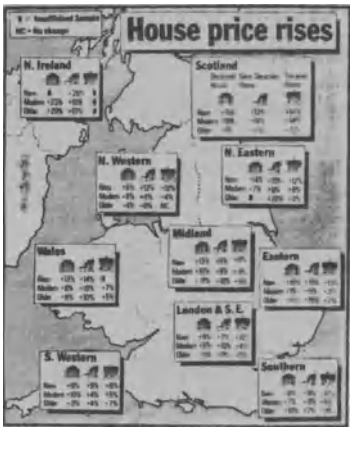




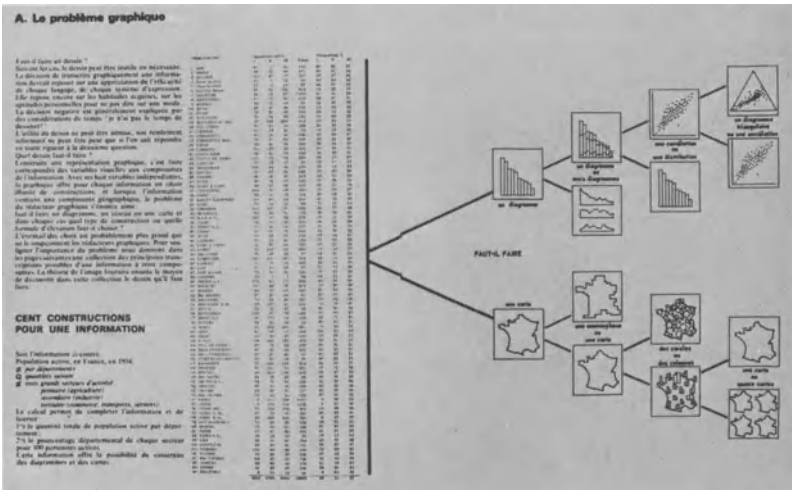
Displays 30 and 31. The pictorial chart (left) is particularly complex in its characteristics. It shows the growth in value of Rembrandt's paintings from top to bottom. In one sense it is purely linear in that viewing is directed in boustrophedon manner (as the ox ploughs) along a single drawn line; but there is a change in the orientation of the image on alternate rows as in some boustrophedon printing (right). Does this make it "purely linear" or "linear interrupted"? In any event, each row displays only one semantic unit, so that the chart has some of the characteristics of a list.

Display 32. This chart can be seen as a cross between a pictorial list and a binary branching tree. It is a very simple example of its kind, but the possibilities for the development of this approach are obvious.





Displays 33 and 34. Many examples of everyday language we are presented with combine different modes of symbolization and methods of configuration. The example on the left combines a simple statement in the verbal mode with a more complex message stated schematically. The example on the right is a map within which discrete units of information are presented in matrix configurations.



Displays 35 and 36. It is also common practice for a single sheet or other display of information to contain a variety of configurations such as tables with text (left), or text, tables, and trees (right). When other variables of graphic language are taken into account (such as size, tone, texture, colour, orientation, form, and projection) the range of graphic language becomes considerable.

What Does the Matrix Reveal?

A full discussion of the matrix and the way in which graphic language relates to it would clearly be a major undertaking, and beyond the scope of this paper. On a general level it seems valuable to approach each row, column, and cell of the matrix from the point of view of both the originator and consumer of graphic language. It scarcely needs stating that some of the cells of the matrix that are widely used by people when in the role of consumer are hardly used by them at all when in the role of originator. Few people produce pictures, though most make use of them. The matrix can also be approached from the standpoint of specialist and non-specialist users of graphic language (the term specialist here applies to anyone who in a particular situation adopts, or has to respond to, an approach to graphic language not held to be in general use). Clearly there are degrees of specialism and no clear line of demarcation exists between specialist and non-specialist users. Nevertheless, some cells of the matrix include approaches to graphic language that are frequently used by specialists, but hardly at all by non-specialists.

In a practical situation (that is, when a designer has to make decisions with regard to graphic language) it would be useful to consider the cells of

the matrix in relation to such factors as ease and cost of production, user capabilities, interests, and training, and the effectiveness of various approaches in connection with specific learning tasks. In order to make valid decisions without running special tests, a designer would need to know what empirical research reveals about the effectiveness of different approaches to graphic language in various circumstances. The matrix might therefore be considered as a useful aid for reviewing empirical research in the field of graphic language.

Some of the approaches to the matrix mentioned above need to be considered in relation to one another; a few of them have been isolated for convenience and will be touched on in the following sections of this paper.

Specialist and Non-Specialist

A discussion of this topic should be based on a carefully controlled investigation. No such investigation has been undertaken and the comments made in this section are therefore highly subjective. All the same, it can be said with some confidence that the approaches to graphic language that fall into the "verbal/numerical, linear interrupted" cell (2) are the norm for both specialist and non-specialist adults; and this applies to the origination of a message as well as to its consumption. Such approaches have obvious advantages over most others in terms of ease and speed of production. What is more, teaching of graphic language is concentrated almost universally in cell 2 of the matrix. Approaches to graphic language that fall into this cell are so bounded by conventions that they are perhaps the only ones most originators feel they have more or less under their control from conception through to production. There is little to be gained from dwelling on these approaches to graphic language, except in order to compare them with approaches falling within other cells of the matrix.

Many approaches to graphic language appear to have been developed for special situations. Outside the "verbal/numerical, linear interrupted" cell (2) there is a much weaker relationship between the language of the specialist and the non-specialist on the one hand, and the originator and the consumer on the other. Thus algorithms (4) appear to be nearly always specialist in origination and mainly specialist in terms of consumption, but are used only rarely by non-specialists either as originators or consumers (even though research has shown that they can be highly effective under certain circumstances). Tables (5) and maps (27, 28) tend to be specialist in origination, though they are often intended for non-specialist consumption and in some cases, such as football league tables (where the nature of the information is usually understood), they appear to present few problems to the user. Even a casual survey of papers in particular branches of science and technology makes it clear that specialists in these fields frequently abandon both the "verbal/numerical" mode of symbolization and the "linear interrupted" method of configuration. At the other end of the complexity scale, stories for the entertainment of young children and poor readers frequently take the form of comic strips (9) which make use of the combined "pictorial and verbal/-numerical" mode of symbolization along with the "linear interrupted" method of configuration. The fact that there are common words in English for a approaches to graphic language which fall into some cells of the matrix, such

as family tree (4), table (5), strip cartoon (9), and map (27, 28) is in itself testimony to the accepted use of such approaches in non-specialist situations.

It would also be of interest to consider the distribution within the matrix of those cells of graphic language that are most commonly used. But how does one determine common use? As a rough and ready way of doing so, it is proposed that a further matrix might be considered within each cell of the master matrix to record a positive or negative response according to originator/consumer and specialist/non-specialist use (Figure 2). The dotted line indicates that no clear line of demarcation exists between specialist and non-specialist and, following the definition of specialist given previously, it is possible to record the same response in both specialist and non-specialist cells on the same axis.

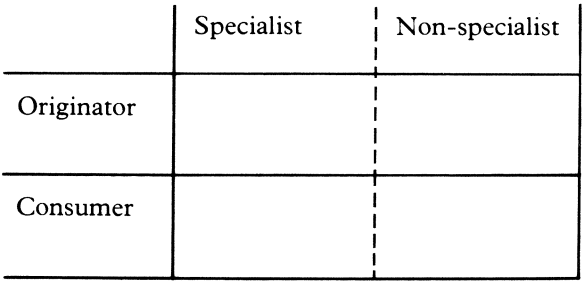


Figure 2. Matrix according to use.

The writer's own subjective analysis of common use on this basis is included in Figure 3 simply as a discussion point. Those cells marked ■ received three or more positive responses; those marked □ received one or two. Such an analysis reveals a clear clustering of commonly used cells at the top left and bottom right of the matrix, and this reflects the association of the verbal mode with linearity and the pictorial and schematic modes with non-linearity.

It is perhaps surprising that the cells of the matrix that accommodate those approaches to graphic language that can be described by common words (family tree, table, strip cartoon, and map) are widely scattered in relation to both axes of the matrix. One is forced to consider why this should be so and, in particular, why some cells of the matrix appear to be used so much less than others. Has there been a process of design gestation that has led to the promotion and survival of appropriate combinations of mode of symbolization and method of configuration at the expense of others, or have certain combinations never been seriously considered?

The Evolution of Graphic Language

This is not the place to consider the historical evolution of graphic language in any serious way, but the matrix makes clear what many would claim is self-evident: that language in the pictorial and schematic modes has tended

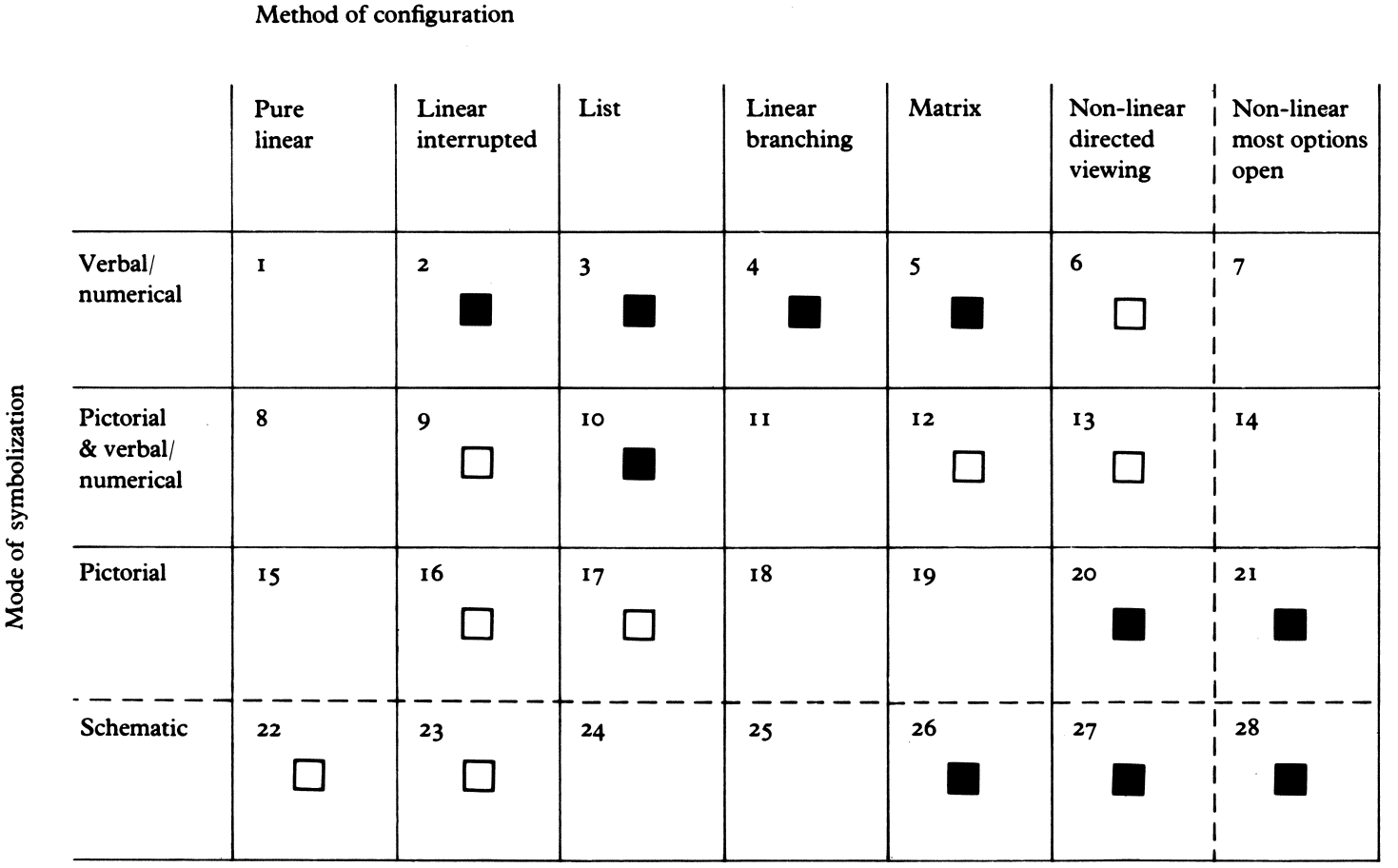


Figure 3. Presumed common use of kinds of graphics.

to develop in non-linear ways, while language in the "verbal/numerical" mode has developed in linear ways. The relationship between oral and graphic verbal language accounts to a large degree for the linearity of the latter, but the technology of printing has undoubtedly helped to reinforce it. The ease of production of graphic language using the prefabricated and modular characters of printing type has been a powerful force in maintaining the dominance of the verbal mode and, consequently, graphic linearity. The constraints of ergonomics (book size), perception (line length), and the method of production have led to the linearity of graphic language being interrupted at regular, and usually non-semantically determined, points.

Nowadays it is largely the typewriter that determines the initial configuration of graphic language. One very reputable book published recently on the subject of typing for print (Westwood, 1976) even advises the originators of graphic language against the use of tables for simple information on the grounds that they are expensive to set. If production difficulties are to be a deterrent in such cases, when the organization of the language can be done on a machine using repeatable units, how much greater the production difficulties are going to be when the originator wishes to use modes of symbolization that involve purpose-made marks in addition to individual planning. It is hardly surprising that the approaches to graphic language most widely used are those involving the verbal mode of symbolization and linear methods of configuration.

Pictures almost certainly pre-date graphic verbal language as vehicles for graphic communication of ideas and information and, along with geometry and cartography, are major exceptions to the dominance of linearity in the early days of graphic communication. Tables too were in use before printing was invented, and so were scientific and concept diagrams. All the same, it was not until the work of Priestley and Playfair in the late eighteenth century that non-linear methods began to be widely used in relation to problems of communication in fields such as history and economics, which had hitherto been treated in predominantly linear ways. The movement towards non-linear pictorial or schematic modes of presenting information gained momentum in the nineteenth century, in the inter-war years of this century, and again in the 1960s. The general trend, taking a long-term view from the Renaissance, has been a shift from linear to non-linear methods of configuration.

The Teaching of Graphic Language

It makes little sense to consider the general issue of graphic design options and the evaluation of graphic language without some consideration of the teaching of graphic language, for the simple reason that nearly all language relies on the learning of conventions. Yet formal teaching of graphic language appears to be limited, at least in so far as general needs are concerned, to the "verbal/numerical" mode of symbolization and the "linear interrupted" method of configuration. In practice, literacy means the ability to write (originate) and read (consume) linear verbal language.

Children may be taught to draw simple maps (though rarely to originate them) and to read more complex ones; they may also be taught to organize such things as equations and calculations in non-linear ways. In recent years young children have been taught how to produce simple line graphs, bar charts, and pie charts from data they have acquired themselves. At a later

stage in their education, those specialising in certain fields may well learn the particular approaches to graphic language that are held to be appropriate to their speciality. On the whole, however, it is true to say that children are not taught to read the wide range of graphic language they will be confronted with in later life. Still less of course are children taught to originate information in anything like the range of approaches to graphic language presented in the matrix. The issue of when to use one approach rather than another hardly arises as far as the lay designer is concerned. What is more, when it comes to a comparison of the effectiveness of different approaches to the presentation of information, the long-term consequences of the dominance of one approach to graphic language cannot be calculated.

The Evaluation of Graphic Language

The graphic designer (both lay and professional) concerned with deciding how to communicate a message effectively ought to ask himself two fundamental questions at the outset: What should be the mode of symbolization? What should be the method of configuration? The answers to these questions will not be arrived at easily and will be influenced by a number of factors: the nature of the message to be communicated, the people to whom it is directed, the effect it is intended to have, and practical considerations of cost, time, and means of production. Though such matters are often crucial in real situations, they are of interest in the context of this paper only in so far that it has to be accepted that they have a bearing on the two fundamental questions concerning graphic language mentioned above. The wider issue as to whether a communication problem should be solved by graphic or non-graphic means, or by a combination of both, though important, falls entirely outside the scope of this paper. The two axes of our matrix provide the graphic designer with a synopsis of possible answers to the questions concerning mode of symbolization and method of configuration. But where does he turn for help when making his decisions? It seems reasonable to look to the findings of empirical research for guidance.

A review of research literature with our matrix in mind reveals two interesting things. First, a large proportion of empirical research undertaken in the field of graphic communication falls within two cells of the matrix (2 and 20); second, other approaches to graphic language that have attracted attention have, in the main, been confined to isolated cells of the matrix. In other words, there has been little work that crosses cell boundaries either horizontally or vertically in order to compare the effectiveness of different modes of symbolization and different methods of configuration.

It was originally intended that this paper should include a survey of the literature of graphic communication as it relates to some of the central issues raised by the matrix. Since this paper was first planned, however, two publications have appeared that make a survey somewhat superfluous. An extensive bibliography of the subject has been compiled by Macdonald-Ross and Smith (1977), which includes general observations on the field it covers and perceptive comments on particular areas of research. The structure of the classification system adopted in the Macdonald-Ross and Smith bibliography has points in common with the matrix presented in this paper and the publication as a whole serves to underline the lack of research work that crosses the boundaries of the cells of the matrix. Wright (1977) has

reviewed part of the field recently in a wide-ranging paper on the presentation of technical information which offers some guidelines based on research findings. Another useful contribution that relates to various cells of the matrix is a collection of some 600 abstracts of papers relating to social graphics prepared by Feinberg and Franklin (1975).

The match between the matrix and empirical research in the field of graphic language is a tidy one in the sense that the bulk of research seems to fall within two areas of the matrix - those already identified as areas of greatest use. The largest single body of research relates to the "verbal/-numerical" mode and the "liner interrupted" configuration (cell 2). Work in this field has been reviewed in general terms by Tinker (1965), Spencer (1968), and Foster (1971, 1972), by Watts and Nisbet (1974) as it relates to children, and by Plata (1974) as it relates to newspapers. The findings of research workers in this field are readily accessible and there is little point in stating more here than that empirical research over the last century relating to this cell of the matrix has, by and large, confirmed the "horse sense" of many practising typographic designers and printers. Considerable work has also been undertaken in relation to the pictorial mode, specifically in relation to cell 20 of the matrix. The general field has been reviewed by Kennedy (1974). Much of the most interesting applied work has been concerned with two specific target areas - children and the developing countries. Watts and Nisbet (1974) and Smith, Watkins, and MacManaway (1970) reviewed the field in relation to children, and Hudson (1967) in relation to the developing countries.

Some other cells of the matrix that have attracted empirical research should be mentioned in passing. A few papers relating to cell 3 appeared early in this century, but of particular relevance to designers are two recent papers relating to bibliographical lists by Spencer, Reynolds, and Coe (1973, 1974). In recent years important and influential work has been done in relation to cell 4 on algorithms by Wason (1968), Jones (1968), Wright (1971), and Wright and Reid (1973). Cell 5 includes tables which have attracted a fair amount of attention over the last fifty years from, amongst others, Washburne (1927), Carter (1947, 1948a, 1948b), Tinker (1954, 1960), Feliciano, Powers, and Kearl (1963), and Hartley, Young, and Burnhill (1975). The programme of work in this field undertaken over the last ten years by Wright (1968, 1971, 1977), Wright and Fox (1969, 1970, 1972), Wright and Barnard (1975) makes a particularly important contribution to the evaluation of such approaches to graphic language. Cell 6 raises the issue of typographic cuing (a term used for particular ways of directing viewing), and the literature on this subject is reviewed by Foster elsewhere in this volume. Cell 9 includes what are commonly known as comic strips. Though they have considerable literature of their own (see Macdonald-Ross & Smith, 1977), they do not appear to have attracted empirical research workers. However, Holmes (1963) found a series of pictures presented in a linear configuration more effective than only two pictures, in experiments run with Kenyans. Cell 13 would include the work done by Spencer (1973) on labelling, which points to the value of keeping labels separate from technical drawings when the material is complex. Cell 26 has probably attracted more empirical research than any other cell of the matrix, apart from cells 2 and 20. Charts, graphs, and diagrams, many of which fall into this cell, have been evaluated from various standpoints

over the last fifty years, mainly in the USA. Research in this field has been reviewed by Feinberg and Franklin (1975) and Macdonald-Ross (1977). The findings of research workers in this area are somewhat conflicting, but work on one particular issue, a comparison of different kinds of charts and graphs, seems to be pointing to the superiority of bar charts, at least in certain circumstances. Cells 27 and 28 include network diagrams, maps, and plans. Research in the broad field of map design is not extensive and is reviewed by Phillips elsewhere in this volume.

Some, though very little, of the research referred to above crosses the boundaries of the cells of the matrix and thus helps to provide answers to our two fundamental questions: What should be the mode of symbolization and what should be the method of configuration? Research that specifically addresses itself to issues that cross the boundaries of the matrix is discussed in the following paragraphs.

As far as mode of symbolization is concerned, Dwyer (1972), Fuglesang (1973), and others have compared the effectiveness of different kinds of pictorial representations, such as photographs, masked out photographs, line drawings, shaded drawings, pictographs, and stick figures. But studies based on the rather crude differences between modes of symbolization as presented in our matrix have attracted little attention. Washburne (1972), in an experiment involving a comparison of fifteen approaches to the presentation of information which included different versions of text, tables, graphs, and charts, and Vernon (1946, 1950, 1952), in experiments involving a comparison of tables, graphs, and charts, studied, among other things, different modes of symbolization. Carter (1947, 1948a, 1948b) who compared the presentation of numerical data in tables and graphs, and Feliciano et al. (1962, 1963), who compared the effectiveness of text, tables, and graphs for statistical information, also crossed the boundaries of the cells of the matrix. The work of Walker, Nicolay, and Stearns (1965) on the responses of subjects to the largely verbal American road signs and symbolic signs similar to the international road signs, of Zeff (1965) and van Nes (1972) on digital and analogue time displays, and of Phillips, De Lucia, and Skelton (1975) in relation to digital and analogue presentation of relief on maps, are other examples of cross-modal research. More fundamental in this respect is the study by Magne and Parknäs (1963) in which the learning effect of pictorially and verbally presented information was assessed by running tests in different modes. Vernon (1951, 1952, 1953) and Smith and Watkins (1972) were concerned with establishing the part played by various kinds of illustrative matter (including pictures, graphs, and charts) when used with text; these experiments all included a comparison of illustrated and unillustrated material and in this respect can be regarded as cross-modal.

The question of method of configuration appears to have attracted even less attention from research workers than mode of symbolization, though it is a central one for typographic designers. The issue crops up incidentally in the work mentioned above on the comparative effectiveness of text and tables, both of which fall into the "verbal/numerical" mode but differ in their method of configuration. Papers by Coleman and Hahn (1966) and Carver (1970) on typographic "chunking" are also relevant to the issue of method of configuration.

The most interesting research in relation to method of configuration stems from work done in the 1960s more or less independently by P.C. Wason and B.N. Lewis, along with their colleagues, in developing ordinary language algorithms. Wason (1968) and Jones (1968) both provided evidence for the superiority of algorithms over certain kinds of prose. This line was followed up by Wright (1971) and Wright and Reid (1973), who compared the effectiveness of four different methods of presenting the same basic information. These methods are given below with the terminology of the matrix and the relevant cell number in parentheses:

Prose (linear interrupted, 2),
Short sentences (linear interrupted, 2),
Logical tree (linear branching, 4),
Table (matrix, 5).

It was found that prose was the least effective of the four in terms of both speed and accuracy, that the logical tree was the best when some uncertainty existed about the information presented, and that the table was the best when the user understood the problem beforehand. The conclusion was that the optimal configuration for verbal graphic language depends on the conditions of use. Such research, which was concerned with the effectiveness of different methods of configuration within the same mode of symbolization, closely matches the needs of graphic designers; yet it remains an isolated, or at least almost isolated, contribution of this kind.

It has to be said that the match between empirical research and those areas of graphic language that have been identified on a subjective basis as widely used, though described above as tidy, is not particularly helpful to the graphic designer. In practice there is a good chance that commonly used areas of graphic language work well, largely because they are commonly used (because of the craft design law - analogous to Darwinian theory - of the survival of the fittest). It is some of the less used areas of the matrix that call for the attention of research workers as far as the designer is concerned; and in particular there is a need for research that crosses the bundaries of the cells of the matrix.
boundaries of the cells of the matrix.

Conclusion

The matrix presented as the focal point of this paper reveals something of the scope and flexibility of graphic language. But how flexible is the human response to graphic language? The matrix invites us to ask how the reader/-viewer is expected to respond to the variety of graphic language he is bombarded with in everyday situations. Does he face up to images on a page or CRT in the same way that he responds to real-world situations with their multiplicity of visual stimuli? It is reasonable to assume that there is usually no great problem in identifying the mode of symbolization being used in graphic language; but how is the reader/viewer to determine the method of configuration of a graphic display of information? Various contributors to this volume have emphasized the importance of prediction in the reading process; but how does prediction apply when the rules of the game keep changing, or when there appear to be no rules? In any event, how does the reader/viewer develop an appropriate strategy for extracting information once he has identified the method of configuration? What problems are

presented by the apparent conflict between the linearity of the verbal mode and the non-linearity of the pictorial mode? This is a particularly important question since the two modes are being combined more regularly now, and at all levels of language, than at any time since the Middle Ages. What are the consequences of switching from one mode to another and one configuration to another on both eye movements and cognitive processes? Are there essential differences between absorbing information and ideas through discrete verbal statements (words, clauses, sentences), discrete pictorial symbols (pictographs, arrays of pictographs), and unified, synoptic pictures? How do all these questions relate to training in basic skills and working methods? Questions of this kind appear to be fundamental in relation to the processing of visible language. They can be formulated relatively easily; but how are they to be answered?

I should like to acknowledge the help and encouragement I have received while preparing this paper from my colleague Ernest Hoch: a number of specific problems have been discussed with him and his suggestions have been most valuable.

Many of the illustrations used in this paper are, strictly speaking, protected by copyright. It would have been virtually impossible to trace the sources for some of the illustrations used and if, through oversight or other circumstances, material has been reproduced without appropriate acknowledgments apologies are presented here. Those to whom acknowledgments should be made include the Automobile Association, The British Steel Corporation, the Daily Mirror, Mouton Publishers, Her Majesty's Stationery Office, Isotype Institute Ltd, Kimberly-Clark Limited, KLM Royal Dutch Airlines, the Kynoch Press, London Transport Executive, Macdonald & Co (Publishers) Ltd, Marlborough Fine Art (London) Ltd, Marshall Cavendish Ltd, G.J. Matthews, Penguin Books Ltd, Phaidon Press Ltd, and The Sunday Times.

REFERENCES

Bertin, J. Sémiologie graphique: les diagrammes, les réseaux, les cartes (2nd ed.). Paris The Hague: Mouton and Gauthier-Villars, 1967.

Carter, L.F. An experiment on design of tables and graphs used for presenting numerical data. Journal of Applied Psychology, 1947, 31, 640-650.

Carter, L.F. Relative effectiveness of presenting numerical data by the use of tables and graphs. Washington, DC: U.S. Department of Commerce, 1948. (a)

Carter, L.F. Study of the best design of tables and graphs used for presenting numerical data. Washington, DC: U.S. Department of Commerce, 1948. (b)

Carver, R.P. Effect of a "chunked" typography on reading rate and comprehension. Journal of Applied Psychology, 1970, 54, 288-296.

Coleman, E.B., & Hahn, S.C. Failure to improve readability with a vertical typography. Journal of Applied Psychology, 1966, 50, 434-436.

Dwyer, F.M. A guide for improving visualized instruction. State College: Pennsylvania State University Learning Services Division, 1972.

Feinberg, B.M., & Franklin, C.A. Social graphics bibliography. Washington, D.C.: Bureau of Social Science Research, 1975.
Feliciano, G.D., Powers, R.D., & Kearl, B.E. Text, table or graphs for communicating statistical information. University of Wisconsin Agricultural Journalism Department, Bulletin 32, 1962.
Feliciano, G.F., Powers, R.D., & Kearl, B.E. The presentation of statistical information. AV Communication Review, 1963, 11, 32-39.
Foster, J.J. Legibility research abstracts 1970. London: Lund Humphries, 1971.
Foster, J.J. Legibility research abstracts 1971. London: Lund Humphries, 1972.
Foster, J.J. The use of visual cues in text. (This volume.)
Fuglesang, A. Applied communication in developing countries. Uppsala: The Dag Hammarskjöld Foundation, 1973.
Hartley, J., Young, M., & Burnhill, P. On the typing of tables. Applied Ergonomics, 1975, 6, 39-42.
Holmes, A.C. A study of understanding of visual symbols in Kenya. London: Overseas Visual Aids Centre, 1963.
Hudson, W. The study of the problem of pictorial perception among unacculturated groups. International Journal of Psychology, 1967, 2, 89-107.
Jones, S. Design of instruction. London: Her Majesty's Stationery Office, 1968.
Kennedy, J.M. A psychology of picture perception. San Francisco: Jossey-Bass, 1974.
Macdonald-Ross, M. How numbers are shown: A review of research on the presentation of quantitative data in text. AV Communication Review, 1977, 25, 359-409.
Macdonald-Ross, M., & Smith, E. Graphics in text: A bibliography. Milton Keynes: The Open University, Institute of Educational Technology, Monograph No. 6, 1977.
Magne, O. & Parknäs, L. The learning effects of pictures. British Journal of Educational Psychology, 1963, 33, 265-275.
van Nes, F.L. Determining temporal differences with analogue and digital time displays. Ergonomics, 1972, 15, 73-79.
Phillips, R.J. Making maps easy to read: A summary of research. (This volume).
Phillips, R.J., De Lucia, A., & Skelton, N. Some objective tests of the legibility of relief maps. Cartographic Journal, 1975, 12, 39-46.
Plata, W. A study of newspaper design: Analysis and synthesis of legibility research and its applications. Nairobi: Walter Plata, 1974.
Smith, J., & Watkins, H. An investigation into some aspects of the illustration of primary school books. University of Reading, Typography Unit, 1972.
Smith, J., Watkins, H., & MacManaway, R. A survey of research in connection with an investigation into some aspects of the illustration of primary school books. Unpublished report, University of Reading, Typography Unit, 1970.
Spencer, H. The visible word. London: Royal College of Art, 1968.
Spencer, H., Reynolds, L., & Coe, B. The relative effectiveness of ten alternative systems of typographic coding in bibliographical material. London: Royal College of Art, Readability of Print Research Unit, 1973.
Spencer, H., Reynolds, L., & Coe, B. The relative effectiveness of spatial and typographic coding systems within bibliographical entries. London: Royal College of Art, Readability of Print Research Unit, 1974.

Spencer, J. Presentation of information on engineering drawings. The visual presentation of technical data. University of Reading, Typography Unit, 1973, 24-27.
Tinker, M.A. Readability of mathematical tables. Journal of Applied Psychology, 1954, 38, 436-442.
Tinker, M.A. Legibility of mathematical tables. Journal of Applied Psychology, 1960, 44, 83-87.
Tinker, M.A. Bases for effective reading. Minneapolis: University of Minnesota Press, 1965.
Vernon, M.D. Learning from graphical material. British Journal of Psychology, 1946, 36, 145-158.
Vernon, M.D. The visual presentation of factual data. British Journal of Educational Psychology, 1950, 20, 174-185.
Vernon, M.D. Learning and understanding. Quarterly Journal of Experimental Psychology, 1951, 3, 19-23.
Vernon, M.D. The use and value of graphical methods of presenting quantitative data. Occupational Psychology, 1952, 26, 22-34.
Vernon, M.D. The use and value of graphical material with a written text. Occupational Psychology, 1952, 26, 96-100.
Vernon, M.D. Presenting information in diagrams. AV Communication Review, 1953, 1, 147-158.
Walker, R.E., Nicolay, R.C., & Stearns, C.R. Comparative accuracy of recognizin American and international road signs. Journal of Applied Psychology, 1965, 49, 322-325.
Washburne, J.N. An experimental study of various graphic, tabular and textual methods of presenting quantitative material. Journal of Educational Psychology, 1927, 18, 361-376 & 465-476.
Wason, P.C. The drafting of rules. New Law Journal, 1968, 118, 548-549.
Watts, L., & Nisbet, J. Legibility in children's books: A review of research. London: National Foundation for Educational Research, 1974.
Westwood, J. Typing for print: A manual for typists and authors. London: Pitman, 1976.
Wiseman, N.E., & Linden, C.A. Non-serial language. (This volume)
Wright, P. Using tabulated information. Ergonomics, 1968, 11, 331-343.
Wright, P. Writing to be understood: Why use sentences? Applied Ergonomics, 1971, 2, 207-209.
Wright, P. Presenting technical information: A survey of research findings. Instructional Science, 1977, 6, 93-134.
Wright, P., Behavioural research and the technical communicator. The Communicator of Scientific and Technical Information, 1977, 32, 3-13.
Wright, P., & Barnard, P.J. Effects of "more than" and "less than" decisions on the use of numerical tables. Journal of Applied Psychology, 1975, 60, 606-611.
Wright, P. & Fox, K. Some studies of conversion tables. Report submitted to the Decimal Currency Board, 1969.
Wright, P., & Fox, K. Presenting information in tables. Applied Erogonomics, 1970, 1, 234-242.
Wright, P., & Fox, K. Explicit and implicit tabulation formats. Ergonomics, 1972, 15, 175-187.
Wright, P., & Reid, F. Written information: Some alternatives to prose for expressing the outcomes of complex contingencies. Journal of Applied Psychology, 1973, 57, 160-166.
Zeff, C. Comparison of conventional and digital time displays. Ergonomics, 1965, 8, 339-345.