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FOUR ASPECTS OF GRAPHIC COMMUNICATION
An Introduction to this Issue

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ABSTRACT

Information theory, while having a limited direct impact on the study of graphic communication, left a metaphor for communication that, reflecting the transient nature of electronic signals rather than the permanence of the printed media, is, it is argued, unhelpful and somewhat misleading. The metaphor is adapted to draw attention in particular to four aspects of the relationships of the originator and the user to the communication medium: the problem of encoding information in graphic form; diagrams as tools for enquiry and thought; illustrations as aids to learning; and illustrations as aids to problem-solving.

This issue of *Instructional Science* explores some of the problems of communicating educational and instructional materials by graphic means. The study of graphic communication has been approached in a variety of ways, by different disciplines and for different purposes; a rich but challenging literature confronts the newcomer. The problem of interpretation and integration is that each of these specialisms – they range from art history and the philosophy of science to psychology, sociology and ergonomics – tends to approach the issue from its own restricted perspective; it is rare to see the nature of graphic communication itself as the primary focus of investigation, rather than as an extension of a conceptual framework designed for some other purpose.

This apparent fragmentation is not entirely surprising, and nor is it unhealthy. It is the business of scholars to find order in an apparently chaotic world, and to do so they must clearly define their domain of investigation and find rules for the inclusion or exclusion of data. To think in terms of the "truth-value" of classifications or theoretical stances is thus not always appropriate; they are simply strategies for investigation, and so have a utility-value in relation to a particular task. It need not worry us, then, that many different approaches to graphic communication exist. It reflects the fact that each study is focussed on a different aspect of what is,

after all, an immensely complex field. A totally comprehensive view of the subject would have to cover all facets of the content of the communication, through the problems of encoding it in graphic form, to its interpretation and use by readers; we could well apply the slogan of a well-known British newspaper – "All human life is there".

There is a trade-off in investigations of this sort between breadth and depth of analysis. In this introduction a broad but not rigorous overview of graphic communication will be offered, linking themes that are explored in greater depth by the various contributors to this issue.

Information Theory: A Continuing Metaphor

The Shannon-Weaver model of communication (1949), although originally designed to describe the transmission of electronic information (signals) along wires, was subsequently adopted in many other fields of communication (see review by Johnson and Klare, 1961). As a general systems model of communication it was attractive because it suggested the application of precise mathematics to the theoretically rather intractable area of human communication. However, hindsight shows us that graphic communication proved rather more resistant to statistical research techniques than, for example, written language. Not being divided into regular identifiable units arranged according to a rule-bound system, graphic communication presents too great a challenge to statistical theories (Green and Courtis, 1966). Pictures are not easily reduced to individual components by analysis, and the range of marks and textures used by illustrators seems limited only by the human imagination; in addition, it is quite misleading to ignore the interpretative and inferential work done by the reader.

Even though the information theory model failed to suggest techniques for the detailed study of graphic communication, it did provide a metaphor for communication that has made a lasting impression on research and education. This metaphor, comparing human communication through printed images with the electronic transmission of signals, is in my view

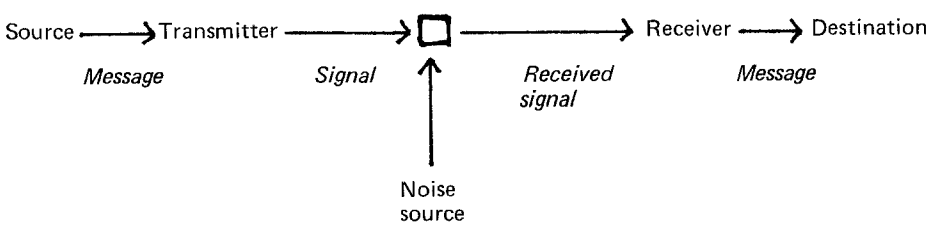

Fig. 1. Shannon's original model of communication systems.

fundamentally inappropriate; but although it is ignored or rejected by many researchers, it nevertheless continues to survive, often tacitly or expressed only vaguely, evidenced by research strategies, educational materials and so on. It suggests that a communication process consists of a *transmitter* of information, a *signal* or message and a *receiver*; they are connected, as in Fig. 1, by arrows running from the transmitter to the receiver. Each end of the diagram is embellished by different theorists with concepts such as *encoder, decoder, selector* and so on. The transmission of the signal is said to suffer interference or *noise*, which is overcome by providing *redundant* information; these, originally probabilistic and statistical concepts, survive in the metaphor. Other embellishments include feedback loops, alternative channels, and so on; a full exposition is not the purpose of this paper. The intention here is not so much to analyse the basic metaphor and its variants in detail, but to question its fundamental appropriateness to graphic communication. In doing so we are in a sense extending Cherry's comment, on the application of the concept of "entropy" (from thermodynamics) to information theory, to the application of "signals-down-wires" concepts to graphic communication:

> Now, when such an important relationship between two branches of science has been exhibited, there are two ways in which it may become exploited; precisely and mathematically, taking due care about the validity of applying the methods; or vaguely and descriptively. Since this relationship [between entropy and information] has been pointed out, we have heard of "entropies" of languages, social systems, and economic systems and of its use in various method-starved studies. It is the kind of sweeping statement which people will clutch like a straw (Cherry, 1966, p. 215).

The information theory metaphor undeniably contains the basic ingredients of a communications system (the source of a communication, its vehicle, and its user), but our main quarrel is with the way in which they are connected. It appears to assume that communication is a basically unidirectional process, and that the outcome of an idealised communication act is the comprehension by a receiver of a message identical to that transmitted. Communication effectiveness so defined (whether explicitly or not) is relatively easy to measure, and the model has consequently become an implicit assumption of many experiments in instructional psychology. Recall and comprehension measures are convenient and justified, because according to the model there is a notional standard (the reproduction of the original message) against which subjects' performance may be assessed. This may in some sense be valid for the type of materials used for many of these studies (e.g. military or industrial training materials), but the paucity of any claims for such a model as a *general* model of communication is not

hard to demonstrate. For example, it is only by stretching the model uncomfortably far from its original base that we can apply it to the users of maps. Each (self-motivated) map-user receives a different message from a map, according to where he is and where he wants to go. There is only a transmitter of that particular message in a very remote sense. The cartographer displays data according to a set of rules; his display is not so much directed at a particular audience as made available for a wide variety of purposes to be determined by the users. Whereas the terms *transmitter* and *receiver* imply activity and passivity respectively, in this situation the roles are reversed. The user, not the originator of the communication, is supplying the structural and logical framework for the particular message he receives – in other words, the argument. He is using the map as a problem-solving device; the same could be said of many other graphically structured devices – tables, assembly diagrams, book indexes etc. (Waller, 1979).

There is perhaps no need to overstress this point, as the notion of reading as an active process (at the micro-level) is widespread, and the view of reading as a selective process (at the macro or text-wide level) is also quite well documented (Pugh, 1975). To some degree, then, my criticism of the information theory model is a "straw-man", with which to contrast an alternative. But because it is convenient for experimentation and because the understanding of human learning is a central goal of psychology (quite apart from the solving of practical communication problems), there does appear to be a continuing bias in the literature towards this implied model of communication that, while not always using the same terminology as information theory, nevertheless retains the notion that communication consists largely of the one-way transmission of an institutionally-determined message from teacher to student. A review by Hatt (1976) has so far made little impact; he proposes a taxonomy of communication outcomes in which the rejection or partial use of a message is seen as quite valid and not necessarily inconsistent with adequate comprehension

Figure 2 incorporates roughly the same ingredients as Fig. 1, but the terminology is changed to reflect the active roles of both participants in the

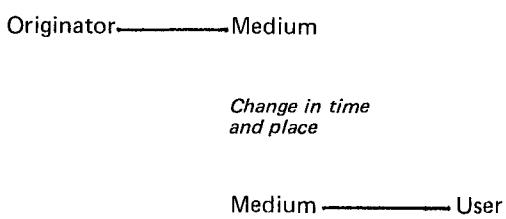

Fig. 2. The indirect nature of printed communication.

communication process. It is designed to serve not so much as a source of theory as a convenient story-line with which to explain the rationale behind this issue.

The main distinction is in the way the elements are connected. Firstly, the direct nature of relationship between originator and user is emphasised. In the acts of writing and reading, the originator and user relate directly to the medium, but only indirectly to each other – sometimes not at all. It is common to write with little sense of audience, and to read without deducing much about the source of the communication. An appropriate analogy might be found in the difference between an army stores and a supermarket. In the former, a predetermined set of goods is handed to the receiver over a counter; in the latter they are placed on shelves to be selected by customers according to their relevance and attractiveness. The manager and the customers need never meet – they are both primarily occupied with the display of goods on the shelves (the medium).

Secondly, the lines used to connect the elements do not at present have directionality. By adding arrows in different places we can use the diagram to direct our thinking and broaden our perception – to suggest relationships between the three elements that might usefully be explored. The four connections thus derived are shown in Fig. 3.

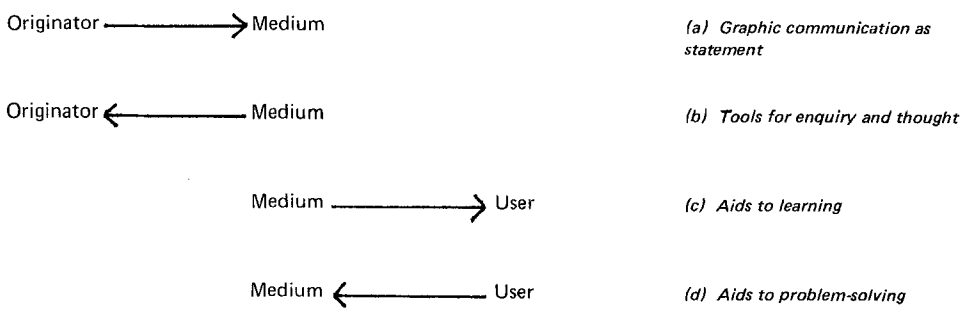

Fig. 3. Adding directionality to the connections suggests four areas for attention.

Graphic Communication as Statement – Fig. (3a)

The first connection represents the problem of encoding information in graphic form. To consider the role of graphic communication as *statement*, quite apart from its behavioural effects on users, requires us to concentrate on problems that are complex and interesting, but easy to overlook. Although most people find it hard to draw pictures and diagrams with any confidence, their perception and interpretation is often seen as unproblematic. A naive view of pictures is that they are unmediated

representations of reality which, although their content is capable of intellectual processing, are themselves received on a purely perceptual level.

Although they are often imagined to be more direct and reliable than words, even to have historically predated written language, it seems that many pictorial systems of the past have disappeared and most current diagrammatic conventions have been introduced comparatively recently, many within our own lifetime. The transitory nature of graphic language can be explained partly through changes in the visual world owing to historical and cultural differences (Mangan, 1978). But it also reflects the fact that pictorial and, in particular, diagrammatic conventions do to some extent constitute a formal language system, which like spoken language may change over time, and which has to be acquired either naturally or by instruction.

Barnard and Marcel (1978) directly compare verbal and graphic languages; they point out that whereas alphabetic communication works within a widely shared framework of syntax, semantics and pragmatics, graphic communication can only draw on a strictly limited repertoire of isolated rules.The integration of information supplied by the pictorial medium is left largely to the reader, who must make inferences from his knowledge of the visual world and from his deduction of the internal logic of the image (which may not correspond with graphic systems used in other images). For example, the action in a comic strip often has to be inferred by the reader from differences between two frames (the aircraft is bigger, so has probably got nearer), rather than by specific graphic indications (such as "speed-lines").

Cartoon conventions are part of a shared system that has been developed over a period of time by a well-organised publishing industry, and which can to a large extent be subjected to analysis. But a great many graphic communication tasks pose "one-off" syntactic problems. There appears to be competition, in a sense, for a limited vocabulary of graphic conventions from illustrations with quite distinct and sometimes conflicting requirements. In particular we may compare pictures with diagrams. Dictionaries typically talk about pictures as "descriptions," "representations" and "images"; definitions of diagrams, on the other hand, include terms such as "explain," "function" and "construction". It appears that we use pictures to tackle *who, what* and *where* questions that call for a descriptive answer, but *why, when, how* and *what if* questions demand an analytic diagram. Diagrams, then, are trying to achieve through visual means the sort of explanations for which, in terms of available syntactic rules but not economy of expression, we would normally use verbal language. When we write or speak we only need adjectives and nouns for simple static descriptions, but for analysis and explanation we need a separate vocabulary of verbs and connectives, and rules for their ordering. Graphic language does not

offer this organised grammar; instead, the same repertoire of available marks and surface qualities is used for quite different purposes. Compare, for instance, a conventional still-life painting, as an example of a descriptive picture, and a systems chart as an example of an analytic diagram:

Descriptive	Analytic
Dimensions are to scale.	Relative dimensions are symbolic or constrained by diagram shape.
Realistic colour and shading.	Colour and shading used to link items or assign qualities.
Drawn from one viewpoint (shadows, vanishing point etc.).	Plan-view.
Depicted objects describe real objects.	Depicted objects denote abstract concepts, or classes of objects.

Practical examples of this kind of ambiguity are common. For instance, the British Rail national route map is partly cartographic and partly a systems chart; it consequently equates the distance between Glasgow and Inverness (a five-hour journey) and that between London and Watford (twenty minutes). Recent proposals for a pictorial drug-labelling system (Anon, 1975) showed a graphic alternative to the instruction "take one teaspoonful by mouth" which juxtaposed a symbol for a teaspoon and a symbol for "take by mouth" (a head with an open mouth). The symbols were the same dimensions, and not drawn to the same scale, so that the resulting amalgam, interpreted purely pictorially, suggested "take a massive overdose".

Ambiguous "grammar" is the central problem of the graphic encoding of information, and it is hard to anticipate a solution to it that would not at the same time obscure the essential advantage of graphic communication – its realism and its flexibility. It may be that the answer lies in training; illustrators and designers should put functional communication objectives before stylistic or aesthetic ones, and should be prepared to test their solutions to new problems. At the same time the production and interpretation of graphic communication is an aspect of literacy that is generally neglected in education. Both producers and users of graphics can contribute to the evolution of a set of graphic communication strategies that, even if they are not universal or systematically designed, are shared within a given population on a reasonably reliable basis.

Tools for Enquiry and Thought – Fig. (3b)

It is only half true to say that the purpose of texts is for authors to communicate the structure and content of their knowledge systems to readers. Unless it is a repetition of a previous piece of writing, the construction of a text (or diagram) is itself part of the process of organising and structuring ideas. That is, it generates a particular kind of critical self-analysis that is impossible for most people to carry out in their heads. When we write or draw, our ideas are thereby depersonalised; they are arrayed for our inspection and criticism. It is a common perception that our style appears quite different when it emerges from the typesetter; the more formal appearance enables us to examine our work from an even more detached stance. Perhaps this may account for the publisher's eternal nightmare – author's corrections at final proof stage. MacLeod (1975) calls this the *incubation* stage of writing and comments that "an essential part of the writing process is explaining the matter to oneself" (p. 28). By seeing our ideas juxtaposed in space we can manipulate the argument and compare alternatives in a way that is impossible when we are constrained by the linearity of speech.

This is even more true of diagrams. As we have seen, a diagram is a tool for analysis, not just an aid to description. The construction of a visual argument, no less than a verbal one, itself poses questions of logic and validity. Designers who have worked closely with authors frequently remark how often discussions over the design of diagrams lead to the substantial revision of the structure of the text it supports. The logical status of diagrammatic conventions appears not to have been widely investigated. That is, does the possibility of a particular visual connection or symmetry in a diagram necessarily indicate the presence of a logical connection? Classification is central to science and is essentially a graphically organised task – the perception of pattern and structure among apparently chaotic data. An example of this question of logic is whether or not an empty cell in an otherwise complete matrix necessarily indicates the existence of some hitherto undetected data. The answer would seem to depend on the nature of the axes of the matrix, but either way the diagram has suggested new connections and so directed the progress of our enquiry. The challenge to the nervous theorist, though, is that diagrams present ideas in their most stark and basic form, unclouded by apology or obfuscation – exposed to the critical eye of others as well as himself. In this issue, Michael Macdonald-Ross analyses the place of diagrams in science and argues for their role not just in the explanation of ideas but also in the generation of hypotheses.

Aids to Learning – Fig. (3c)

Turning now to the relationship between the user and the medium, the right-pointing arrow of Fig. 3c indicates a role for graphic communication in the learning and comprehension of information. As a major focus of educational psychology, this is an area where we would expect to find a reasonably large research literature; this is indeed the case, although it varies widely in quality and theoretical orientation. A major reviewer of the field is Malcolm Fleming (1967, 1977) and in this issue he analyses recent developments. In the past illustrations were very often viewed simply as aids to the learning of prose, rather than as significant in their own right, and picture research was conducted within theoretical frameworks focussed primarily on verbal learning. Fleming points out though that recent interest in the role of mental imagery in learning has led to a sounder base and a higher status and priority for picture research.

Aids to Problem-Solving – Fig. (3d)

Our earlier example of the map-user introduced the concept of graphic devices as aids to problem-solving. "Problem-solving" in this sense refers to cases where the sequence and strategy for obtaining information is determined largely by the reader, and is conditional on, firstly, his goal and, secondly, on the outcome of various steps in the problem-solving process. Tables of data, building plans, wiring diagrams, assembly charts, diagnostic aids and operating instructions are all examples of graphic communication used in this way. Diagrams and illustrations for problem-solving are subject to the same sort of encoding problems discussed earlier. Indeed, in his review in this issue, Karl Szlichcinski points out that the interpretation of graphic aids is in itself a complex problem-solving task.

The drawing of explanatory illustrations often involves a trade-off between realism and clarity of argument; in order to make relationships and functions clear, draughtsmen and illustrators use highly stylised representations of components. For problems like assembly tasks, though, both the relationships (the sequence and nature of various operations) and the realistic representation of parts (for recognition) are important. In addition, there are problems of denoting causality, and a wide range of conditional action possibilities, with a scarcely existent formal syntax. Szlichcinski points to evidence that the syntactic structure in pictorial instructions is largely supplied by the reader from his general knowledge and his familiarity with the problem or equipment concerned; illustrators thus have the task of providing this background information in addition to specific instructions.

Conclusion

The study of graphic communication has proved to be hard to handle, but we should neither be overawed by the creativity of artists who can make it work, nor ignore its complexities. It is an essential ingredient of many subjects, but neglected in education; it is thought to be easy to read, but it is notoriously difficult to construct; it is often assumed to be universal, but cross-cultural misunderstandings so often take place; it takes second place to prose in textbooks, but is central to the learning process. A number of different specialisms are involved in its investigation, but it seems that graphic communication is richer than any one area of scholarship suggests. It is certainly a clear case for interdisciplinary investigation.

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