Observations Concerning Practical Visual Languages

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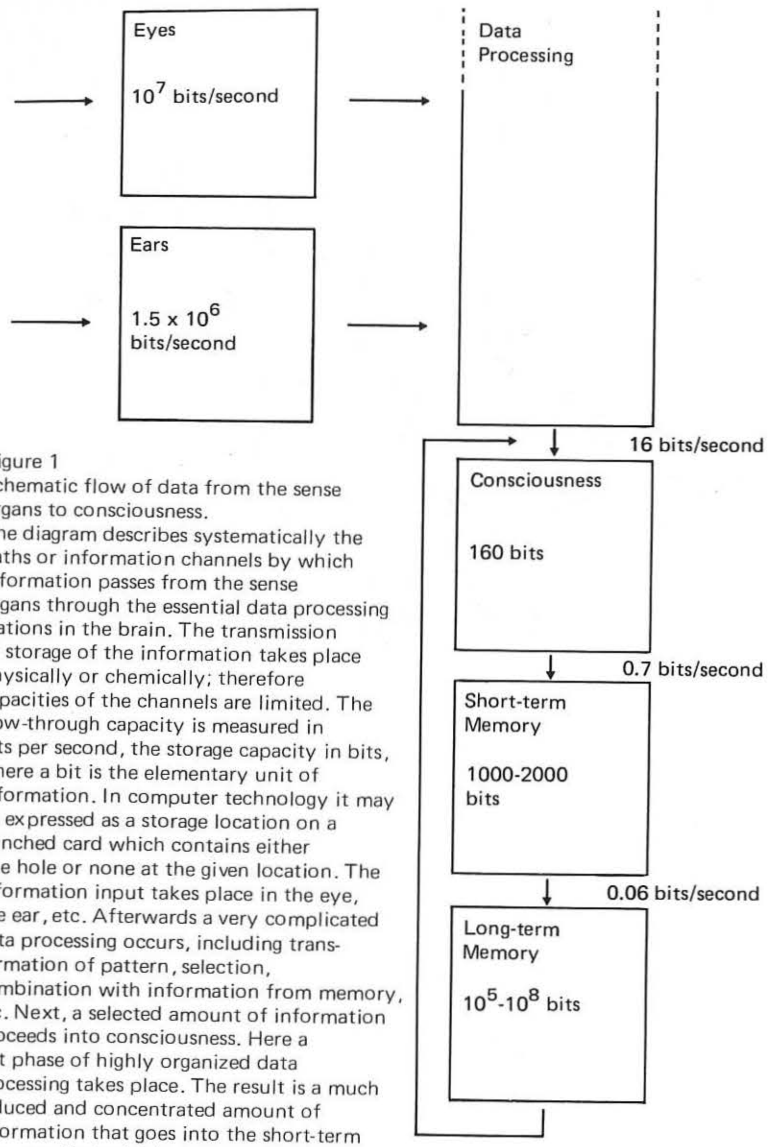


Figure 1
Schematic flow of data from the sense organs to consciousness.
The diagram describes systematically the paths or information channels by which information passes from the sense organs through the essential data processing stations in the brain. The transmission or storage of the information takes place physically or chemically; therefore capacities of the channels are limited. The flow-through capacity is measured in bits per second, the storage capacity in bits, where a bit is the elementary unit of information. In computer technology it may be expressed as a storage location on a punched card which contains either one hole or none at the given location. The information input takes place in the eye, the ear, etc. Afterwards a very complicated data processing occurs, including transformation of pattern, selection, combination with information from memory, etc. Next, a selected amount of information proceeds into consciousness. Here a last phase of highly organized data processing takes place. The result is a much reduced and concentrated amount of information that goes into the short-term memory. Part of this may eventually enter the long-term memory. (The figure is redrawn from the work of H. Frank, 1962).

Increasing insights into scientific and technical processes oblige us to contemplate highly complex relationships and to respond to them logically. Such a registration does not merely restrict itself to a more or less complete description; essential for the use of scientific materials is also its verbal-visual codification, i.e., an adaption to the organization of the human processes of perception and thinking (Franke, 1970). The basic rules for a visual language which can mirror the realities of such knowledge are provided by the principles of psychology oriented toward information theory.

Fundamental Rules of Information-Oriented Psychology

In every linguistic utterance lie semantic contents in a codified form. The addressee—the receiver of the news—is given the task of accepting and of deciphering the code-presentation which is put before him. Every practical linguistic system must be adapted to the addressee in order that he can deal easily with the reception as well as with the decoding of the message. One must here distinguish between the physical and psychological conditions (Franke, 1962). The physical requirements must be fulfilled by choosing favorable reproduction conditions adapted to the eye and to the ear: sound and light intensities, as well as frequencies, fluctuation-variances, contrasts, etc. The psychological suppositions, which have been investigated only recently, concern the information channel, the storage, and the input capacities of the brain. In the following study, these aspects of communication are examined as they relate to consciousness and to short- and long-term memory (Franke, 1975) (Figure 1).

For the decoding of linguistic communication, the information path from ear or eye to consciousness is decisive. The striking difference between the information received by the sense organs and by consciousness reveals that perception is a special kind of data processing. In this process it is essential to organize, to select, and to transform an excess of detailed information so that into consciousness arrive only the essential contents in an optimally coded form. This (unconscious) data processing takes place according to previous knowledge, i.e., to known conceptions, connections, evaluations, associations, etc.

Essential differences exist in the sequence of data processing, depending upon whether there is required a decoding of (linearly-coded) verbal texts, or two-dimensional representations, or of three-dimensional images. In particular many difficulties in the interpretation arise if the data processing requires that one reconstructs correctly in the imagination multi-dimensional relationships (for example, spatial connections) that are presented only in a verbally coded form. In such cases the question of visual language becomes especially important. For the situations just mentioned the conditions of information-oriented psychology are also valid, although in a correspondingly changed format. Visual languages should be drawn up and used in such a manner that they may be easily taken in and that the positions codified by them are optimally to be recognized. Of

Figure 2
Elements of graph theory are illustrated. Connections between elements are marked by arrows. The drawing represents the most important possible qualities of graphs.

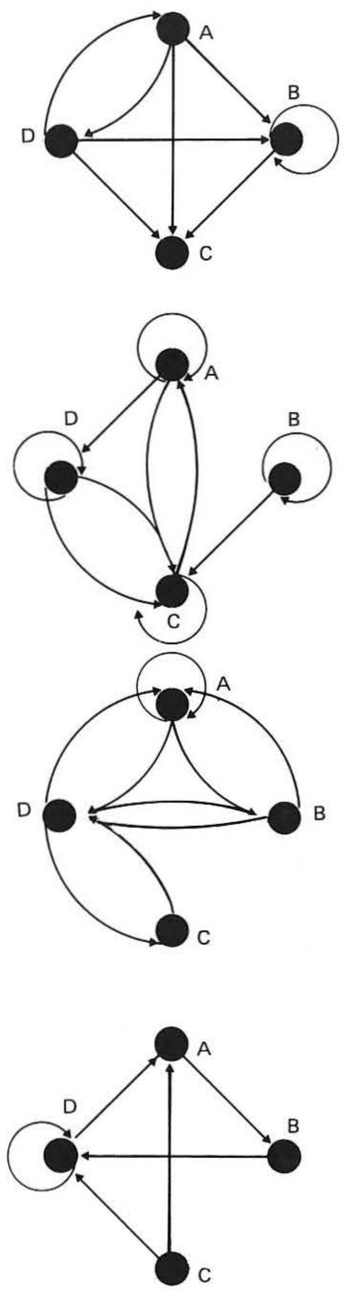
Transitivity (top): If (A,B) and (B,C) belong to the graph, then (A,C) belongs to the graph.

Reflexivity (top middle): The graph contains all pairs (A,A), (B,B), etc.

Symmetry (bottom middle): If (A,B) belongs to the graph, then (B,A) belongs to the graph.

Asymmetry (bottom): If (A,B) belongs to the graph, whereby A is different from B, then (B,A) does not belong to the graph. Symmetry and Asymmetry exclude one another.

(Redrawn from E.H. Graul and H.W. Franke. Die umbewaeltigte Zukunft. Munich: Kindler Verlag, 1970, p. 80.)



particular importance is the fundamental rule that all information must be structured into information parcels which do not exceed 160 bits of subjective information.[1]

The reason for that is simple: 160 bits is the maxim amount of information which can be simultaneously present in consciousness. If the complexity of a phenomenon or of a process demands a description of more than 160 bits, it is necessary to divide the description into several parts of smaller complexity. The complexity of certain statements is not the same for everyone. If one has a better information base or a better language, it is possible to describe the same facts with a smaller expenditure of symbols. Therefore the information content in this sense is not an absolute one, but a relative quantity proportional to qualities of the receiver. This quantity is measurable through testing methods, and one obtains the "subjective information" content which changes from person to person (Frank, 1962).

Consequences for Linguistic Expression

Many messages with which we must operate consciously greatly surpass the maximum information capacity of consciousness: 160 bits. However, man possesses routines for handling such overflows of complexity, and these are reflected in the structure of his language. In it the capability of abstraction, the concentration on certain classes of information, and the temporary neglect of others play a very important part. With the help of language it is possible to pick out partial aspects and to deal with them sequentially one after another.

The use of normal verbal language obliges one to perform another reorganization. Every information parcel must be transformed into a linear order conforming to the acoustic reproduction in chronological order or as printed in line-order. In principle, every order may be described with a sequence of linear signs, but some arrangements of such a description are more or less practical. Multi-dimensional concrete poetry is not considered here because it does not belong to the sphere of everyday communication. The predominance of linear verbal forms in everyday speech, in scientific descriptions, and in education introduces a natural preference for certain types of order, e.g., chronological, hierarchical, and causal rules. Because language is also biologically closely connected with our mode of thinking, our inclination for chronological and causal-oriented questions and descriptions is explicable as well as our propensity towards hierarchical organization structures.

Yet in our world there are also other basic relationships of importance, not the least of which are two- and three-dimensional topological relationships. It is well known that these are very difficult to grasp verbally. The most favorable manner of presenting such concepts is the picture. Therefore very different means of reproduction of information have developed, for example, the mapping of two-dimensional connections within a geographical area, the perspectival representation of spatial facts, and the sectional drawing of a coordinate space.

Reception with the eye has two considerable advantages. First, the eye is adapted to decode two- and three-dimensional environmental structures as no other sense organ. Secondly, this sense organ is capable of taking in larger quantities of information than all other sense channels combined. These capabilities are by no means exhausted in reading the written script of linearly arranged text symbols.

Description through more or less schematized picture is the kind of applied visual representation which is primarily used in special fields of inquiry. In topology, geometry, stereo-chemistry, biology, and other disciplines of modern science and mathematics, non-linear conceptual systems gain much importance.
To modern knowledge belong such imageable concepts as reciprocity effects, feedback, cyclical functions, and complicated network relationships. These are particularly fundamental to all activities of regulation and communication in the most general sense of the terms.

Our thinking, if limited to linear speech, tends to overlook or to neglect these relationships. Yet there is a need for new, more adequate means of expression to facilitate and strengthen our grasp of reality. One available means is the use of languages which are based on picture-symbols with which one may register two or more dimensional states. Contrary to descriptions of reality by photographs and other such pictures, one is not concerned in these cases with the problems of iconic signs. Much more abstract visual schemes are used which must be just as flexible in the description of network order as is speech in the description of linear order. An inventory in the realm of scientific symbolism shows that several visual description systems are already in use that offer possibilities for further application beyond their more narrow and special usages. Two systems are pre-eminent among these: graphs and Venn diagrams. By means of graph symbology, one describes one-directional or bi-directional connections between things, for example, the influence of A on B or of B on A (Figure 6). The Venn diagram is a symbol for a set; it describes the connections between sets, e.g., their unification or intersection (Figure 6). These symbol systems are often employed for the display of logical-mathematical system-oriented and practical-technical tasks.

There exist extensive examinations covering both symbol systems oriented toward their possibilities and limitations in the realm of complicated professional problems. However, there exist scarcely any works that are occupied with questions of the practical use of these symbol systems for purposes of general communication. The relationship described with their help may be so judicious and clear that they are likely to be as useful, if properly prepared as are the Cartesian coordinate charts and histograms that are already ubiquitous in daily life and in education. Initial signs of their increased use already exist.

Aspects of Use

The examples shown in this article indicate how natural, generally understandable picture-symbols that follow the visual logic of graphs and Venn diagrams may be created for use in descriptive diagrams (see Figures 2–9).

The usefulness of visual languages can be measured according to the principles of psychology related to sensory apparatus and consciousness which were mentioned above. The choice of the symbols is dependent upon whether they are easily recognizable,

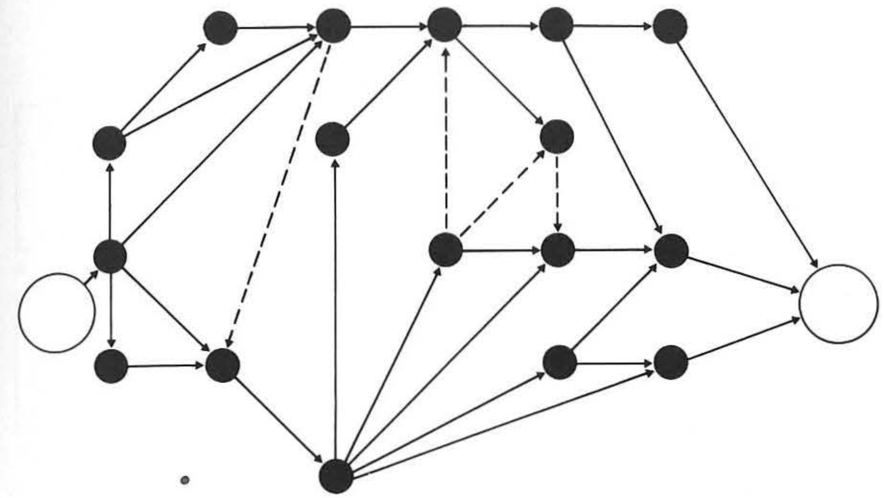


Figure 3
A sequence of discrete administrative steps leading to a merger according to principles of graphing. The operations are reproduced with arrows, interim aims by circles.

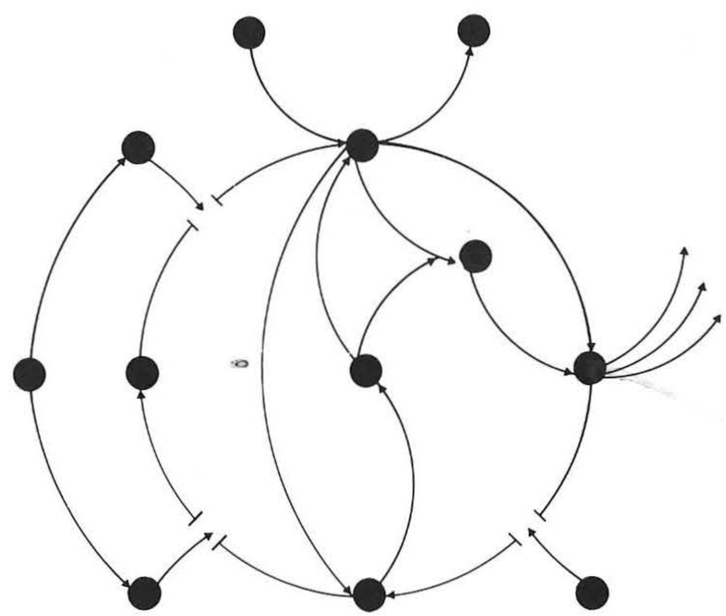
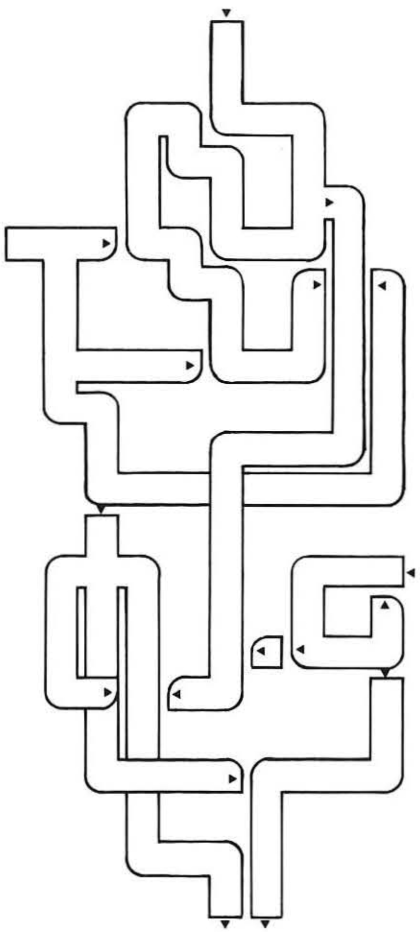


Figure 4
A cyclical process is presented in graph form.

Figure 5
A production flow chart shows the use of graph presentation.



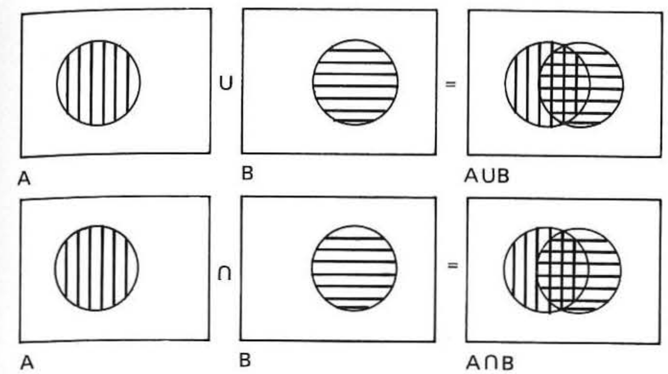
easily distinguished, sensible, and capable of taking on meaning. These are qualities that graphs and Venn diagrams readily exhibit. Graphs are based on the familiar arrow symbol, which is clear as a guiding element and as a means for suggesting attachment. In terms of Gestalt theory, Venn diagrams are excellently suited for presentation of boundary, inclusion, and content. As such they are fundamental for the logic of classes or set theory.

The visual means by which complex relationships are shown with the help of organized elements must be prepared according to the principles of maximum clarity. Among the requirements of the psychology of the senses one must above all respect those of information-oriented psychology: the subjective information and complexity of the individual symbol-configurations must not amount to more than 160 bits. As with verbal language exact measurements are scarcely necessary. An approximate examination of their apprehensibility is sufficient.

Considerations of the problem of visual languages have arisen recently as visually oriented communication media have gained importance. Only with these means are we able in practical terms to draw real consequences from insight to necessity. Film and television are not confined to reproduction of pictures; they may also be employed to convey content expressed with the help of visual languages. An essential element is the computer as a means of programmed assistance to the translation of ideas into graphic form via mechanical plotters and electronic displays. Just as the alphanumeric symbol can be combined into computer-controlled texts, so

Figure 6
The formation of combination and intersection is illustrated by Venn diagrams. (Redrawn from: Rolf Lohberger. Wir programmieren weiter LOGICUS - Zusatzset. Stuttgart: Franckh-Verlag, 1972, pp. 94-95)

Figure 7
The law of associativity for sets is presented by Venn diagrams. (Redrawn from Walter R. Fuchs. Eltern entdecken die neue Mathematik. Munich-Zuerich: Droemer Knaur Verlagsanstalt, 1970, p. 98.)



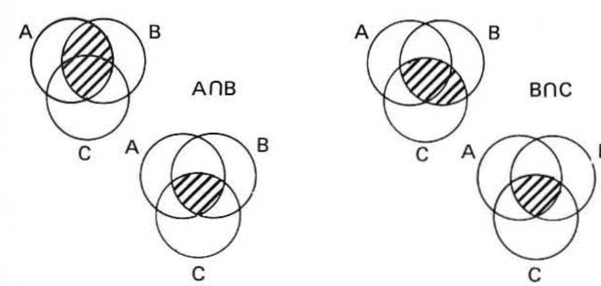


Figure 8
An attempt to illustrate a computer center uses a combination of graph and Venn diagram techniques. (Simplified and redrawn from Martin F. Wolters. Der Schluessel zum Computer. Duesseldorf und Wien: Econ-Verlag, 1969, p. 565.)

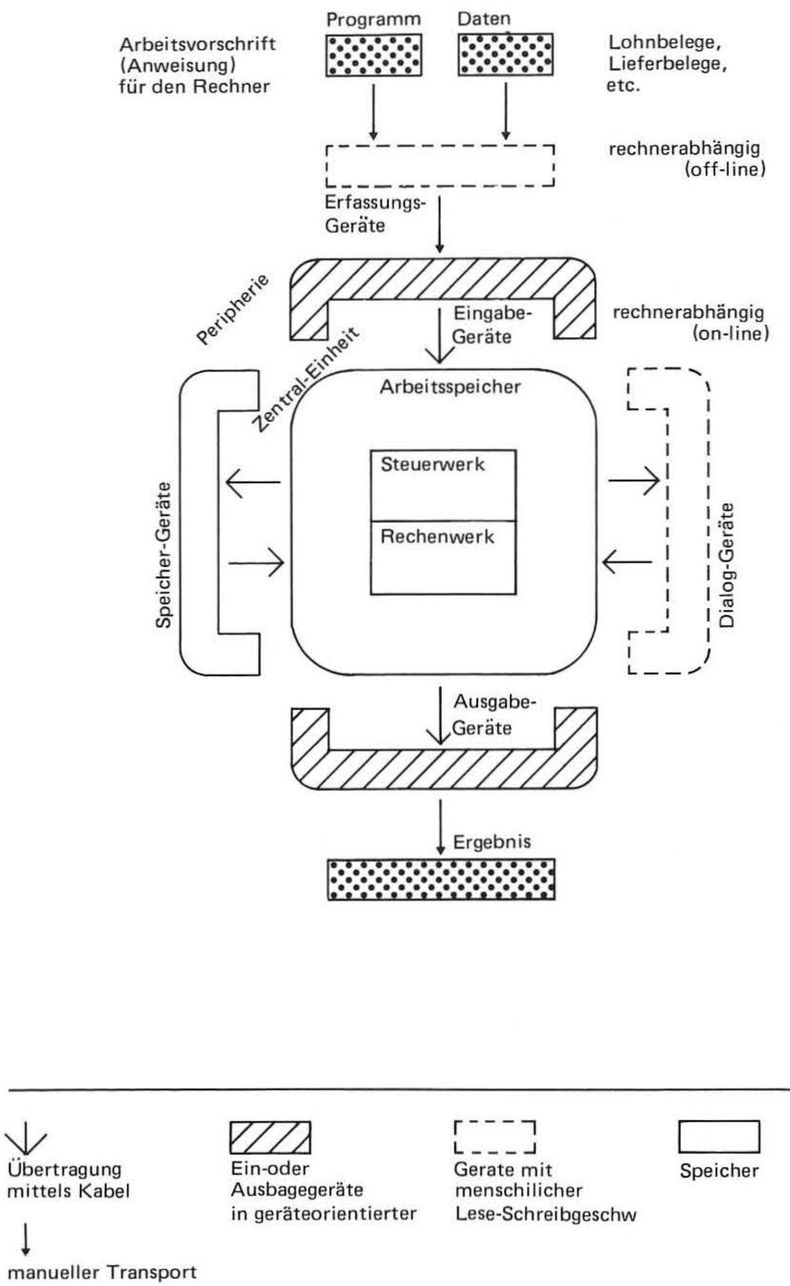
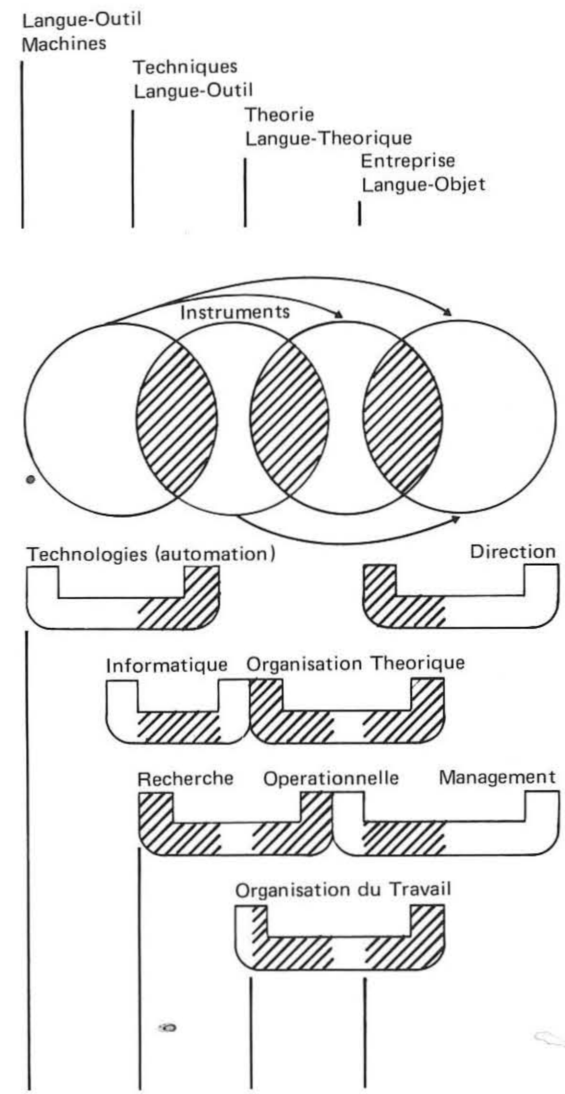


Figure 9
The process of science, technology, and application is shown by a combination of graph and Venn diagrams. (Redrawn from B. Lussato. Introduction critique aux theories d'organisation. Paris: Verlag Dunod, 1972.)



graph and Venn diagram symbols might easily be combined by programs to create totally new graphic texts.

Only a few years ago the author of a book on chemistry could still boast of having succeeded in writing his text without illustrations. Today the creation, through neglect, of such barriers to understanding and imagination would be no cause for pride. In the future audio-visual world an equality between text and image in information transmission will be a matter of course not only out of economic compulsion, but also in response to the current realms of thought and problem solving.

People are prepared for a new dimension of visible language by illustrated magazines, film, and television. Even in comic books one can find complex activities of visual communication which are by no means as simple as some theorists maintain. In a dozen grames of a cartoon series, occurrences are expressed whose narrative description might require a whole chapter of a novel. Even youngsters have little difficulty in understanding this form of information which often contains relatively complex action patterns, conflict situations, social interdependencies, etc. The use of quite general, easily understandable visual symbol languages should not be confined to comics.

Language, thought, and action are connected in a complex feedback system. Therefore, the step toward a more visual visible language will have an influence on thinking and acting. One may hope that this development in the direction of visual thinking will lead to a more beneficial, augmented clarity of thought and to a better understanding of the abstract connections of the modern, technical world.

Notes

1
The most important element shown in Figure 1, a diagram of information channels from the sense organs through data processing stations in the brain, is that of the input capacity of consciousness. As determined by different measurements, its value lies approximately between 8 and 25 bits per second. A probable value adopted by H. Frank is 16 bits per second. Note that this input capacity accounts for the sum of the information flowing through all sensory channels as well as the information being brought from memory. Usually if one concentrates on an auditory process, the information flowing through the eye is restricted, or if one tries to quote material from memory less information is at one's disposal from the external world.

It is very difficult to state how much information consciousness is able to accept; there exist only estimates. For instance, one may rely on the so-called duration of present time, about 10 seconds (H. Frank, 1959). It is possible, for example, to remember the text of linguistic expressions or of a musical phrase if it does not date back more than 10 seconds. Also extremely instructive is the fact that one is able to count unobserved strokes of a clock after it has been removed, but only for approximately 10 seconds. Taking into account these and similar considerations, one may estimate the following value for the storage capacity of consciousness: if within 10 seconds 16 bits enters, then 160 bits are accepted. If more information enters, part of the storage capacity must be given up or extinguished. The sum of 160 bits is not precise but is sufficiently accurate to allow one to draw qualitative conclusions having importance for investigations of cognitive processes as well as the structure of human language.

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To the Sincere Reader

Nelson Howe

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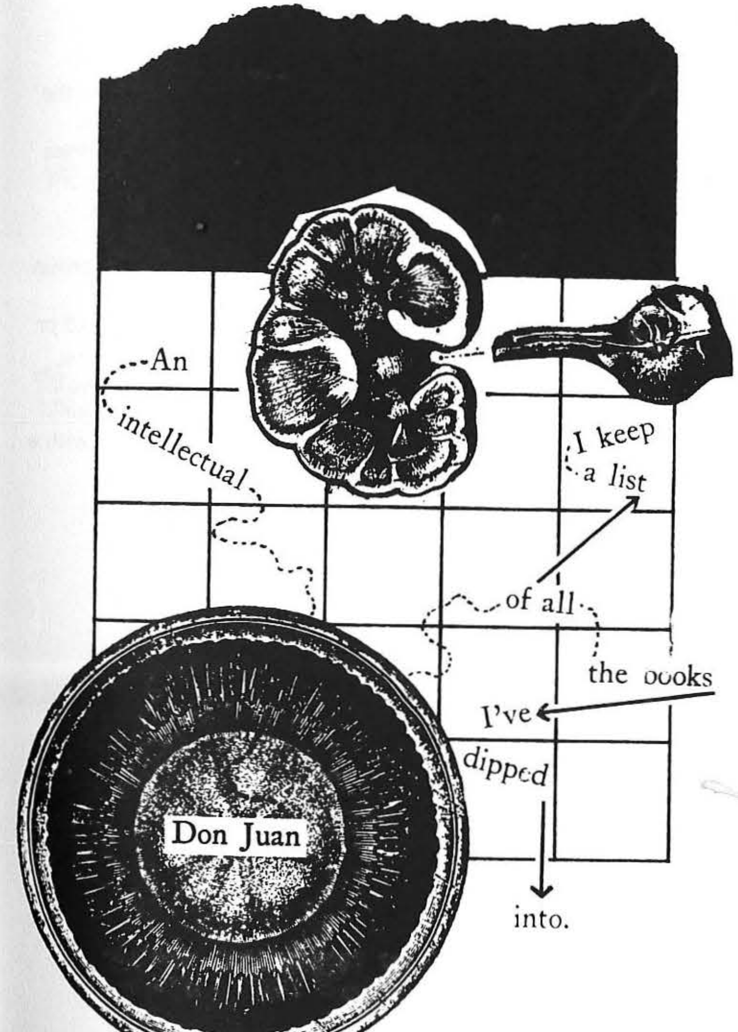

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