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# **Practice, principles, and theory in the design of instructional text**

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Submitted in part fulfilment  
for the degree of Doctor of Philosophy  
University of Glasgow  
Department of Education  
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# Abstract

This study is concerned with an analysis of the research arising from three quite different perspectives on instructional text — the ‘physical characteristics’ research (legibility, layout, and readability), the ‘improvement of text’ research (visual illustrations, adjunct aids, and typographical cueing), and the ‘learning theories’ research (representation of knowledge, human memory, and quality of learning). From this analysis there is synthesised principles for the design of instructional text against which heuristic practice in text design is evaluated and from which a nascent theory of instructional text design is evolved.

The principles derived from the various research perspectives provide a basis for the manipulation of text design elements in order to ensure that (a) existing knowledge in the reader can be activated, and (b) new knowledge can be assimilated in a manner facilitative of comprehension by (i) presentation in a structured and organised way, and (ii) appropriately highlighted through verbal and typographic cueing supported, as required, by verbal illustration and organisation.

The emerging theory of instructional text design suggests: a topic analysis to determine the hierarchic relationship of ideas within the topic and the desired learning outcomes or objectives; a consideration of the linguistic aspects of the text; a consideration of the role of visual illustrations; and a consideration of the physical parameters of the text. These activities are concerned, respectively, with the design areas of structure and organisation, readability, visual illustration, and legibility, and are summed up in the acronym SORVIL.



# Acknowledgements

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# Introduction

In a publication designed to provide guidelines for learning from the written word, Lunzer and Gardner (1984) make no reference to any research basis for their proposals. In a publication concerned with reading for learning in the sciences, Davies and Green (1984) avoid reference to research in the main text but have, as an appendix, an annotated bibliography entitled 'from practice to theory'. The theoretical foundation for text design practice is seldom made explicit. Perhaps those who have been concerned with text design have been concerned more with *what* works rather than *why* it works. It has to be acknowledged that 'good practice' certainly exists but what makes good practice 'good' is often both unexplored and unexplained.

This position is not confined to the design of text, but is to be found in the broader area of the design of instruction. Stewart (1985) has suggested that the practitioners of educational technology tend to rely upon established practices of educational technology rather than on the principles of educational technology and that, in relying on practices, the practitioner is not required to go through the deductive reasoning process involved in the application of principles to the solving of an identified problem — a distinguishing characteristic of scientific thinking (Gunn, 1983) — resulting in operation at a cognitive level substantially below that at which professionals in educational technology might be expected to operate.

Since guidelines to practice can too readily be regarded as a recipe that can be uncritically applied, this thesis is concerned with the identification of principles rather than with the prescription of practices. It is acknowledged, nevertheless, that many practices in text design seem, *prima facie*, to be reasonably valid although the theoretical foundation for their validity and, hence, the principles on which they are based, have not been made explicit. The relationship between theory, principle, and practice is therefore explored to determine the theoretical justification for current practice and to identify the principles against which practice can be validated.

By 'practice' is meant those procedures adopted, sometimes intuitively, sometimes on the basis of experience, which are either believed or known from previous use to be able to effect desirable or planned outcomes. Some



practices may, in fact, become elevated to the status of heuristics and be valuable 'rules of thumb'. A 'principle', however, indicates a formal relationship among phenomena enabling the prediction of consequences, the exploration of events, the inferring of causes, the controlling of situations, and the solving of problems. By adopting an 'if ... then' format for the statement of principles in this thesis emphasis is given to the prediction of consequences simply because the principles are to be invoked at the design stage of instructional text construction. A theory is considered as being a formal tentative statement of relationships among a class of phenomena, including the postulates and constructs that represent a conceptualisation of phenomena, the paradigm or model which represents the relation among constructs, and the hypotheses which are deduced from the theory and express expected relationships among observed phenomena. The purpose of theory construction is taken to be the generation and integration of tested or testable hypotheses which, taken together, constitute a general description or explanation of phenomena of interest.

Few principles have been explicitly stated in the literature relating to the design of text, partly because practice has assumed pre-eminence over principle and partly because adequate theories to explain practice or to influence practice have only recently been promulgated.

### **The nature of research relating to instructional text design**

Although research into printed instructional materials has not been conducted for as long as printed materials have been available, Britton and Black (1985) suggest that the study of discourse structure seems to have begun in the Western world before 600 BC, but within the past 50 years there have been notable changes in the nature of the research that has been conducted in the various strands of textual research. Basically, research relating to instructional text has been carried out from three different perspectives — that associated with the physical characteristics of text and typified by the research in legibility and readability; that associated with ways of improving instructional text and typified by the research on visual illustrations, adjunct aids, and typographical cueing; and that associated with the way people learn from text and typified by the research on the psychology of learning and memory.



Goetz (1984) asserts that psychological theory and research have failed to be successful in helping students to derive information from text, a failure which he attributes to the traditional sharp separation between basic research, applied research, and educational practice, and to the traditions within each strand. Entwistle (1984) has pointed out that teachers look to psychologists for explanations of fundamental principles of learning but that much of the early work in experimental psychology involved attempts to answer general principles of learning by following as closely as possible the well-tried research procedures in the physical sciences, an approach which he considers inappropriate to the task. Voss (1984) also recognises this problem, acknowledging that two or three decades ago the psychological study of human learning was dominated by associationism, but arguing that, with the emergence of cognitive psychology, the study of human learning has undergone a number of changes including a concern with *what* is assumed to be learned and *how* something is learned, together with a change in the experimental paradigms used to study the learning process.

The experimental paradigm of educational research was questioned by Parlett and Hamilton (1972) who described the classical approach as the “agricultural-botany” paradigm which used a hypothetico-deductive methodology derived from the experimental and mental-testing traditions in psychology, an approach which has also been questioned by Entwistle (1984) who argued that quantitative methods imply reductionism and the use of formal or mechanical models which embody assumptions about chains of causality. Entwistle (1984) proposes an alternative paradigm involving approaches to research rooted in phenomenology which derive from a direct explanation of students’ experiences of learning, an approach which involves a shift not just of methodology, but of perspective.

Voss (1984) has observed that there is not a well-developed theoretical framework that provides for the systematic study of the learning process, both in relation to theoretical mechanisms and experimental paradigms, the result of which is that the issue of how a person learns from text cannot be considered as a special case of a more general theory.

“The investigator interested in how people learn from text is thus confronted by a challenge and an opportunity. The challenge



is to develop a theory of learning from text; the opportunity is to contribute to the development of a more general theory of learning via establishing a theory of learning from text". (p 194)

This study does not purport to develop a definitive theory of learning from text: what it does is to work toward a theory of instructional text design through the derivation of principles for the design of instructional text based on an analysis and evaluation of the evidence which exists from the various perspectives on instructional text research, and the consideration of practices in instructional text design within the context of available theories of learning. The main purpose of the study must be the improving of the effectiveness of the teaching/learning process through the adoption of identified principles in the design of instructional text. The study is, in effect, an integrating of basic research, applied research, and educational research for the purpose of enhancing learning from text.

### **The nature of the study**

In the belief that a theory of instruction can be developed more effectively when based on an adequate theory of learning, this study brings together essential elements from a range of disparate areas of research which, together, provide a substantial body of information concerning how people learn from text and, by implication, how text should be designed for instruction. The areas of research are, however, disparate, and do not, collectively, provide a theory for the design of instructional text, although relevant principles can be derived in relation to individual aspects of the design of text. It is an important goal of the study, therefore, to work toward a unifying theory of instructional text design by integrating the separately identified principles.

The study is concerned, therefore, with an analysis of the research arising from three quite different perspectives on instructional text — the 'physical characteristics' research (legibility and readability), the 'improvement of text' research (visual illustrations, adjunct aids, and typographical cueing), and the 'learning theories' research (representation of knowledge and human memory) —from which can be synthesised, in the context of current cog-



native psychology and 'quality of the learning outcome' research, principles for the design of instructional text which are readily applicable in practice, and from which a theory of instructional text design can begin to be constructed.

The study begins with an analysis of the research on *legibility* of type for two reasons. The first is that such research has been carried out for a very long time, although the major activity has been in the last sixty years, and has yielded fairly consistent information which is valid irrespective of any theoretical position concerning learning from instructional text. The second is that, again irrespective of any particular theoretical perspective, there is a fundamental premise that the first step in reading for understanding must rest on the legibility of the material concerned. Thus, the research evidence on legibility is analysed to derive principles relating to the physical parameters of type and text and to derive a general principle of legibility in relation to the reading of text for understanding.

The second stage of the study is concerned with an analysis of the research relating to *readability*, partly because, at one particular point in the history of research into text, the term 'readability' was synonymous with 'legibility' and is sometimes even so at present, but primarily because, in educational practice, the concept of readability is a major factor in the design of instructional text and many computer programs have been written to help assess a text's readability and, even, to help write text to a given level of readability. The analysis of research is undertaken to try to identify principles relating to particular aspects of readability and a general principle of readability consistent with the idea of reading for comprehension.

The search for a theory of 'comprehension' in relation to learning from text takes up much of the early part of the study, and is reflective of the historical development of text design studies, particularly with respect to 'legibility' and 'readability'. In order to uncover a theoretical foundation which will sustain the development of principles, many avenues are pursued, not all of which prove to be equally helpful but the pursuance of which is illustrative of what might be referred to as the 'practice paradigm' — an experiential approach which often lacks a theoretical construct but which may, fortuitously, be illuminative of covert principles. The theoretical

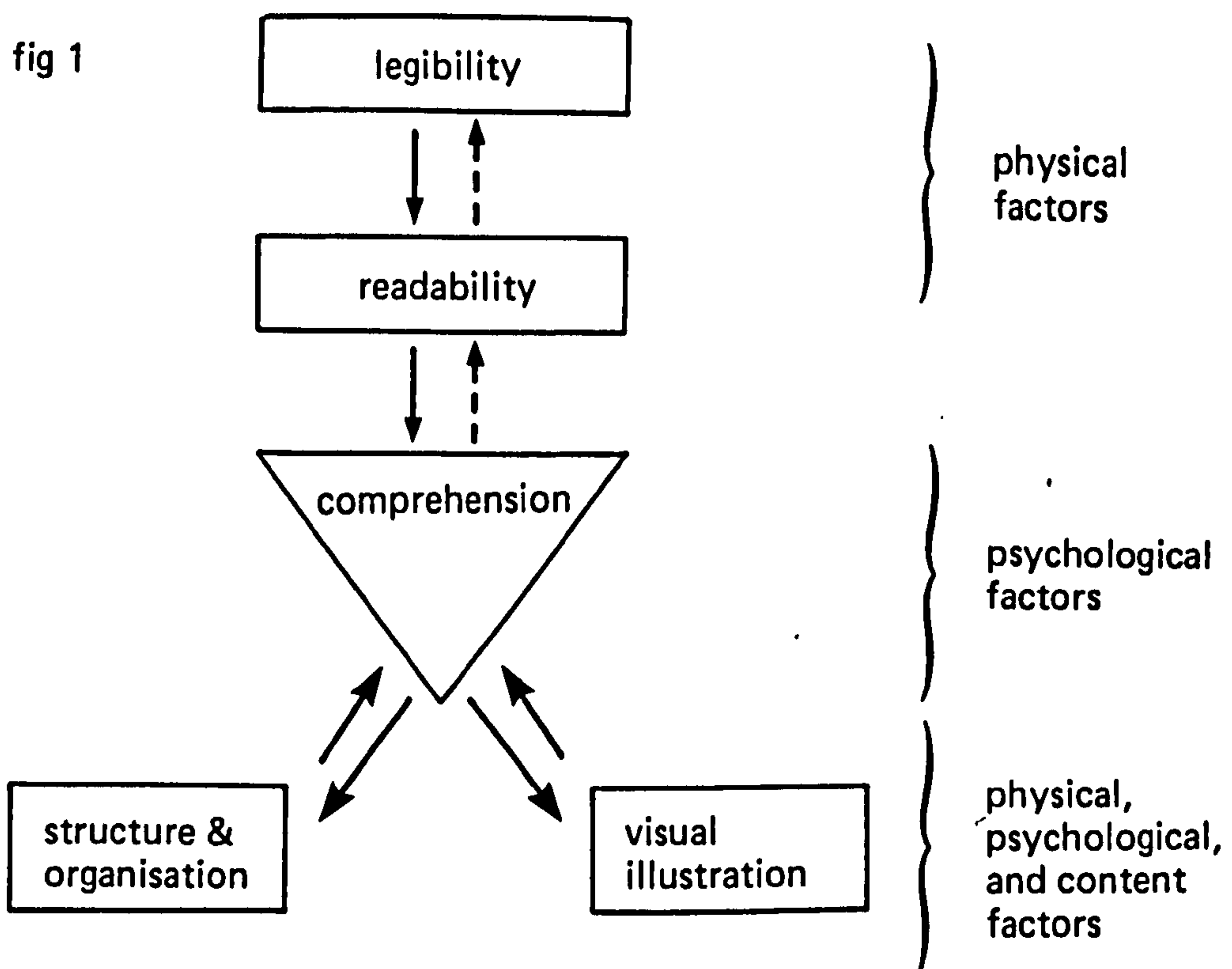


justification for practice tends to be 'through a glass darkly' until elucidation of the process of comprehension is carried out, from which point practice can be re-interpreted in the light of more sustainable theoretical justification. This stage of the study really becomes a watershed. The concept of 'understanding' associated with the research perspective on legibility and readability begins to look hopelessly inadequate for the purposes of the design of instructional text. To be able to derive principles related to *comprehension*, analysis is undertaken of research from other perspectives, including psycholinguistics, cognitive psychology, and imagery, and this is compared with research from yet another perspective in relation to the qualitative outcomes of learning. Principles are derived in relation to particular aspects of the reading comprehension process and also in a general sense to comprehension *per se*.

Reading comprehension thus becomes a pivotal focus in the study. Legibility and readability contribute to reading comprehension and the nature of their contribution has thus to be re-examined in the context of an understanding of the reading comprehension process. Other major areas of research endeavour, in particular the contribution of visual illustrations, adjunct aids, typographical cueing, and other structural and organisational devices to the reading comprehension process need to be considered not only in the historical theoretical context of their respective developments, but from a new perspective of a cognitive framework for reading comprehension. Not only can they be considered as ways of contributing to reading comprehension: the means of that contribution is determined by the nature of the reading comprehension process and there is, thus, a two-way interaction between the theoretical foundation for reading comprehension and these devices whose utilisation can contribute to its achievement.

The flow of the argument can be summarised diagrammatically as follows:





The areas of structure & organisation and visual illustration are each examined, initially within the historical research frameworks with which each is, respectively, associated, and then from the perspective which emerges from an understanding of the reading comprehension process. In this way, principles are developed with respect to the various aspects of each area and, overall, with respect to the broader areas of organisation and illustration.

In each chapter there is a review of the research from the perspective of that particular field of endeavour with comment as occasion requires. The research evidence is then discussed within the context of its theoretical framework and, where appropriate, assessed in the context of the reading comprehension process. From this analysis, principles are derived and implications for practice discussed.

In essence, each chapter is considering the relationship of the reader to the text, but considering the relationship from different perspectives.

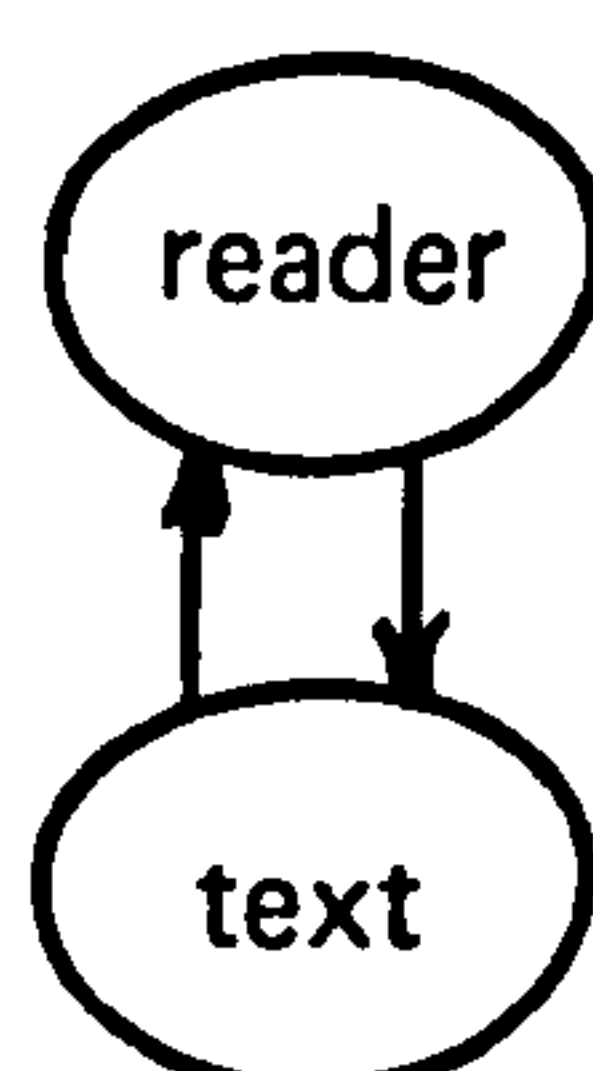


fig 2



Thus, depending upon the particular framework being discussed, additional aspects may need to be incorporated in the diagram, associated with either the text or the reader or as an intermediary between the text and the reader. The diagrams at the various stages of the study are not intended to be definitive. Rather, they indicate visually some of the characteristics and relationships involved and provide a framework for the discussion.

In the final chapter, the principles derived in the previous chapters, together with their implications for practice, are discussed, not only within the context of each chapter's concern, but within the broader, emerging, context of principles of instructional text design arising from integration of the various considerations and the evolving theory of instructional text design.

The argument of the thesis is that from the wide range of disciplines either closely or loosely associated with the design of text as a medium of instruction there can be derived both broad and specific principles and from which, in turn, there can be developed a unifying theoretical framework which can either explain commonly accepted practice or influence what should be appropriate practice. The instructional designer or instructional materials developer should, therefore, be able to utilise the derived principles in the design of instructional text, applying them within the context of a sustainable theoretical framework.

While many of the principles owe their origin to theories of learning, the emphasis in the study is on the application of principles in the *design* of text. Text is designed to facilitate learning, but the application of principles within a sustainable theoretical framework is the process of *instruction*, and it is for this reason that in the title of the thesis the phrase *design of instructional text* is adopted.

### Postscript

Each chapter is preceded by a visual organizer which, in conjunction with the advance organizer aspects of the chapter orientation and this introduction, should aid in the comprehension not only of the content but of the structure of the argument.



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# 1 Legibility of text

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## 1.1 Introduction

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## 1.2 Typographical factors affecting legibility

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### 1.2.1 Legibility of typefaces

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1.2.1.1 research relating to typeface

1.2.1.2 research relating to typestyle

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### 1.2.2 Size of type, length of line and interlinear spacing

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1.2.2.1 size of type

1.2.2.2 length of line

1.2.2.3 interlinear spacing

1.2.2.4 interrelationships

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### 1.2.3 Justification

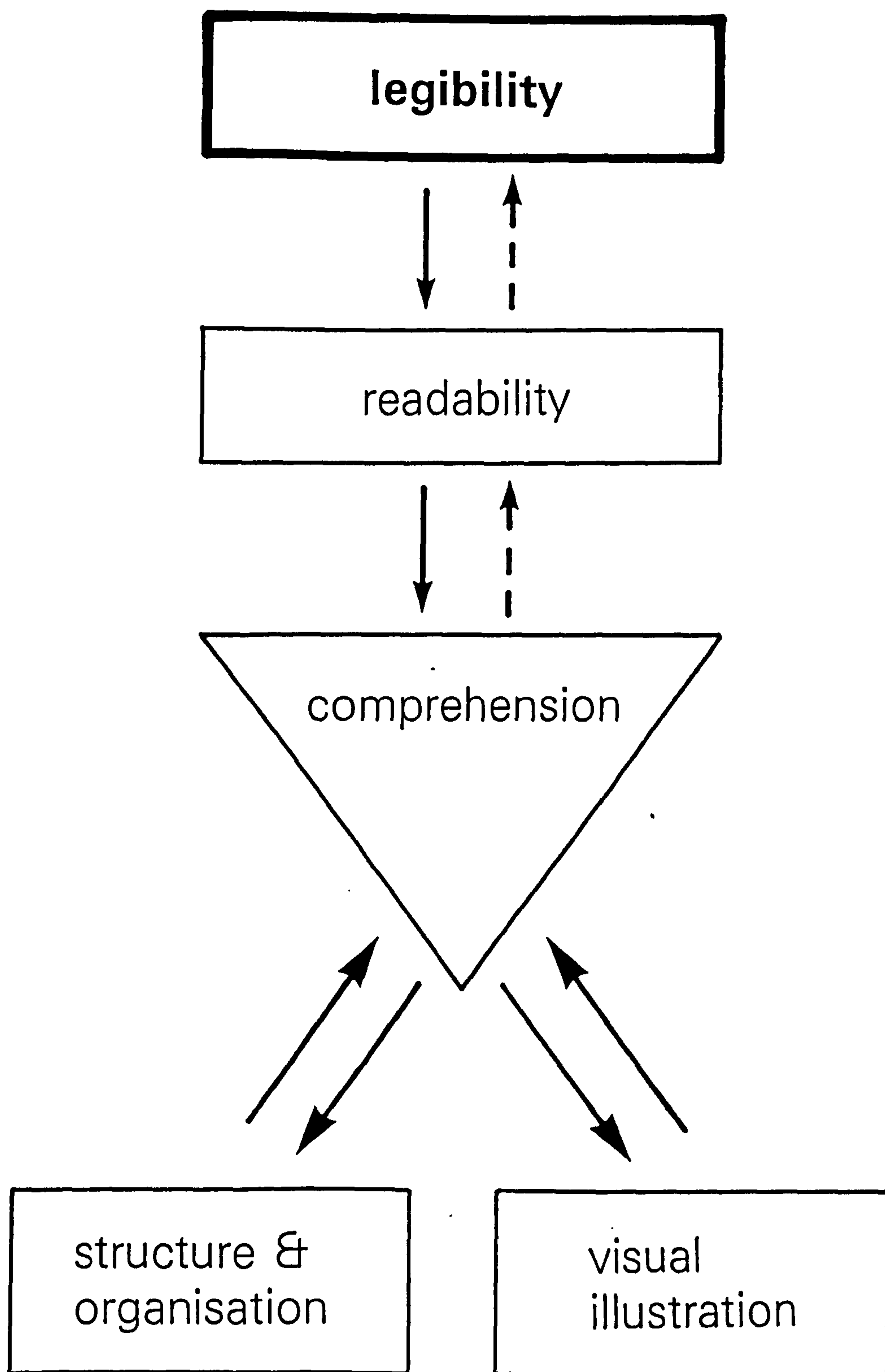
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## Discussion of issues in chapter 1

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## 1. Chapter orientation

The fundamental premise of this chapter is that the first step in reading for understanding must rest on the legibility of the material concerned. The principle,

“If it isn’t legible, it won’t be read”,

hardly needs to be derived from any research evidence since it is so self-evident yet, because legibility research, as Venezky (1984) claims, has been conducted in an a-theoretical way, its contribution to an interactive model of the reading process is largely ignored. The argument in this chapter is that the legibility of the text is an intermediary between the reader and the text and that the results of research in legibility, no matter the framework within which they were carried out, are relevant to the design of print for the purpose of instruction since the application of legibility principles is fundamental to the facilitation of reading comprehension.

The typographical factors affecting the legibility of text have been widely investigated, and four major issues are reviewed in this chapter, viz typeface; typestyle; size of type, length of line, and interlinear spacing; and justification. After a review of the research relating to the effect on legibility of these typographical factors, each of the issues is discussed and relevant principles are derived.



# **1 Legibility of text**

## **1.1 Introduction**

In his introduction to a paper entitled “The Potentials and Limitations of Print as a Medium of Instruction”, Carroll (1974) says

“Some would say that the premise of this paper — that it is important to talk about a particular medium (in this case print) — is erroneous. They will argue that since print is only a medium for conveying something . . . the medium is not as important as what is communciated in the medium . . . I believe that each medium has certain inherent characteristics that tend to determine what kind of messages are transmitted by that medium and how these messages are attended to, understood, and acted upon overtly or covertly”.

(p. 151-152)

R. Clark (1983), on the other hand argues that media are merely vehicles for instruction and do not directly influence learning. The problem is, essentially, one of the initiation of relevant cognitive processing by a particular arrangement of text. There is, therefore, justification for research which explores the nature of the messages that can be transmitted by print and, in particular, investigates the extent to which print can be used to facilitate the kind of deep processing identified by Saljo (1984).

McMurray and Cronbach (1955), in referring to the ‘Textbook in American Education’, a yearbook published in 1931, point out that of the eighteen chapters indicative of the problems which aroused interest at that time, there is only one on the textbook and the method of teaching. The main emphases were on typography, cost, and marketing methods.

Venezky (1984) identifies research on legibility as one of the many strands involved in reading research, but comments that legibility research has been conducted in an a-theoretical way since no conceptual framework has been invoked for guiding legibility research, no serious legibility models have been proposed, and consequently no theories of legibility exist. While there may



not be a theory of legibility, many useful studies have been carried out which can be considered within a theoretical framework of learning from print. In fact, it is not possible to consider the design and utilisation of text as a medium of instruction without, first, reviewing the research on legibility of text and identifying the implications for layout.

## **1.2    Typographical factors affecting legibility**

The first scientific investigation of legibility is thought to have begun in Paris in 1878 with Professor Emile Javal (Rehe, 1974), although Neman (1964) reports that the earliest legibility research may have been conducted by the Talmudists around 900AD.

Zachrisson (1965) offers the following relevant definitions:

“Typography is the art of selecting and using typefaces and typographic material with the aim of transmitting a message, ultimately by means of printing”. (p. 18)

“Legibility is the speed and accuracy of visually receiving and comprehending meaningful running text”. (p. 25)

Tinker (1963), after reviewing the nature of legibility and the methods used in its investigation, concludes that

“Optimal legibility of print is achieved by a typographical arrangement in which shape of letters and other symbols, characteristic word forms, and all other typographical factors such as type size, line width, leading etc., are co-ordinated to produce comfortable vision and easy and rapid reading with comprehension”. (p. 8)

Legibility deals, therefore, with the the co-ordination of those typographical factors inherent in letters and other symbols, words, and connected textual material which affect ease and speed of reading with understanding, although ‘understanding’ is not, at this stage, defined.



### **1.2.1 Legibility of typefaces**

One of the early investigations was carried out by Roethlein (1912) who described the aim of her investigation to be

“to determine the relative ease or difficulty with which various ‘faces’ or forms of printed letters can be read; and to discover what relationship obtains between legibility and certain definite modifications of ‘face’”.

(p. 1)

The conclusions of this early study are worth reproducing in full so that subsequent investigations can be considered within the framework thus established.

“1. Certain faces of type are much more legible than other faces; and certain letters of every face are much more legible than other letters of the same face.

2. These differences in legibility prove to be greater when letters are presented in isolation from one another than when they are presented in groups.

3. Legibility is a product of six factors

(i) the form of the letter;

(ii) the size of the letter;

(iii) the heaviness of the face of the letter (the thickness of the lines which constitute the letter);

(iv) the width of the white margin which surrounds the letter;

(v) the position of the letter in the letter group; and

(vi) the shape and size of the adjacent letters.

The first factor seemed to be less significant than any of the other five, i.e., in the typefaces which were employed in the present investigation, the form of any given letter of the alphabet usually varied between such narrow limits as to constitute a relatively insignificant factor in the determination of its legibility.

4. The relatively heavy-faced types prove to be more legible than the light-faced types. The optimal heaviness of face seems to be in a mean



between the bold faces and such light faces as Scotch Roman and Cushing Monotone.

5. The initial position in a group of letters is the most advantageous position for legibility; the final position comes next in order of advantage, and the intermediate or internal positions are least favorable for legibility.

6. The size and the form of the letters which stand adjacent to any given letter play an important role in determining its legibility; and the misreadings which occur in the case of grouped letters are of a wholly different sort from those which occur in the case of isolated letters. When letters of the same height or of similar form appear side by side, they become relatively illegible. But the juxtaposition of an ascender, a descender and a short letter tends to improve the legibility of each, as also does the juxtaposition of letters which are made up wholly or chiefly of straight lines and letters which are made up wholly or chiefly of curved lines.

7. The quality and the texture of the paper is a much less significant factor than has been supposed — provided, of course, that the illumination and the inclination of the paper are such as to secure an optimal condition of light reflection from its surface.

8. There is an urgent need for modification of certain letters of the alphabet. " (p. 33-34)

While some of the findings may be relevant to the designers of type, they can be of little interest to the designers of print because for the latter, the typesstyles already exist and cannot be altered: only a judicious choice of typestyle can be made.

The obsession of psychologists to investigate letter shape outwith the context of word shape and purposive reading continued for some time.

Tinker (1963) analysed the reports of Roethlein (1912), Ovink (1938), Sanford (1888), and Tinker (1928), revealing a marked tendency for the letters of poor relative legibility, c, e, i, n, l, to be confused with other letters. The analysis also provided information relevant to factors which can improve



and which can lessen legibility of single letters and that, of all the factors concerned, the emphasis upon 'differentiating parts' such as ascenders and descenders is the most important in determining relative legibility of lower-case letters, with 'white area' within a letter, then 'size' being the next most important.

It was Vernon (1929) who identified that confusion of similar appearing letters occurred mainly in material with little contextual meaning and that in the reading of meaningful materials the confusion of individual letters was a very minor factor.

It is therefore important, when considering research relating to legibility, to consider not only the findings in relation to individual letter-forms but also those relating to the cumulative effect when letters are combined into words, words into sentences, sentences into paragraphs, and paragraphs into pages of instructional materials.

As types were originally copied from manuscript letters written with broad-nibbed pens, they inevitably emulate the strokes which were possible with such pens. Thus, in an "O" there would be two thick parts and two thin parts, with the thick parts opposite each other on the relatively vertical parts of the letter. However, as Jaspert, Berry, and Johnson (1970) point out, to achieve such effect meant holding the pen at right angles to the paper, which was a strain, and the angle of 45° was more usually adopted giving a "diagonal" shading, a style which is common to the early print faces and is still used today (usually referred to as 'old' style).

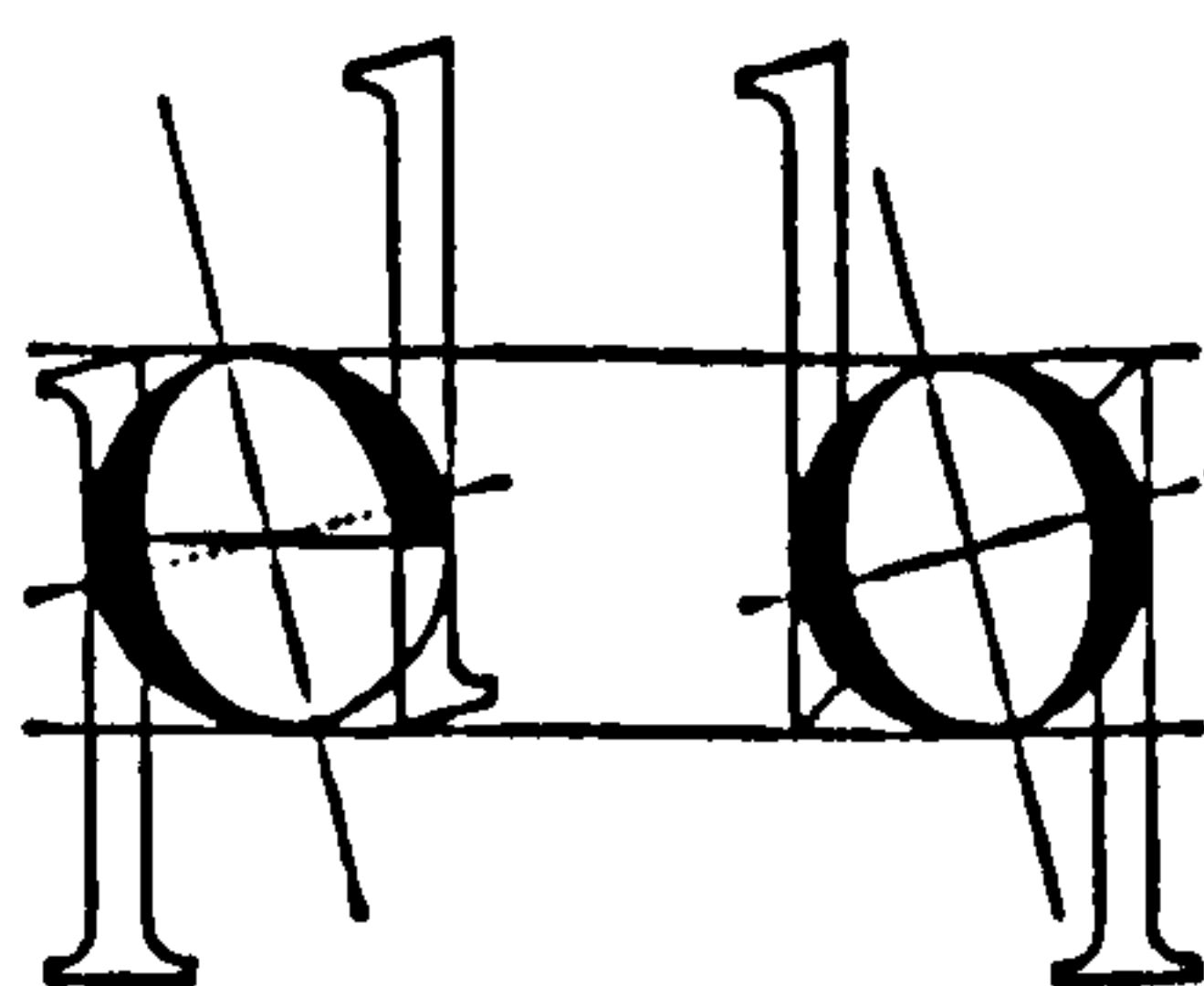


fig 1.1 Diagonal shading of Old type face.

In 'modern' type faces, the influence of the pen-made stress has disappeared, and the shading becomes vertical with, usually, an increase in the contrast between thick and thin strokes.



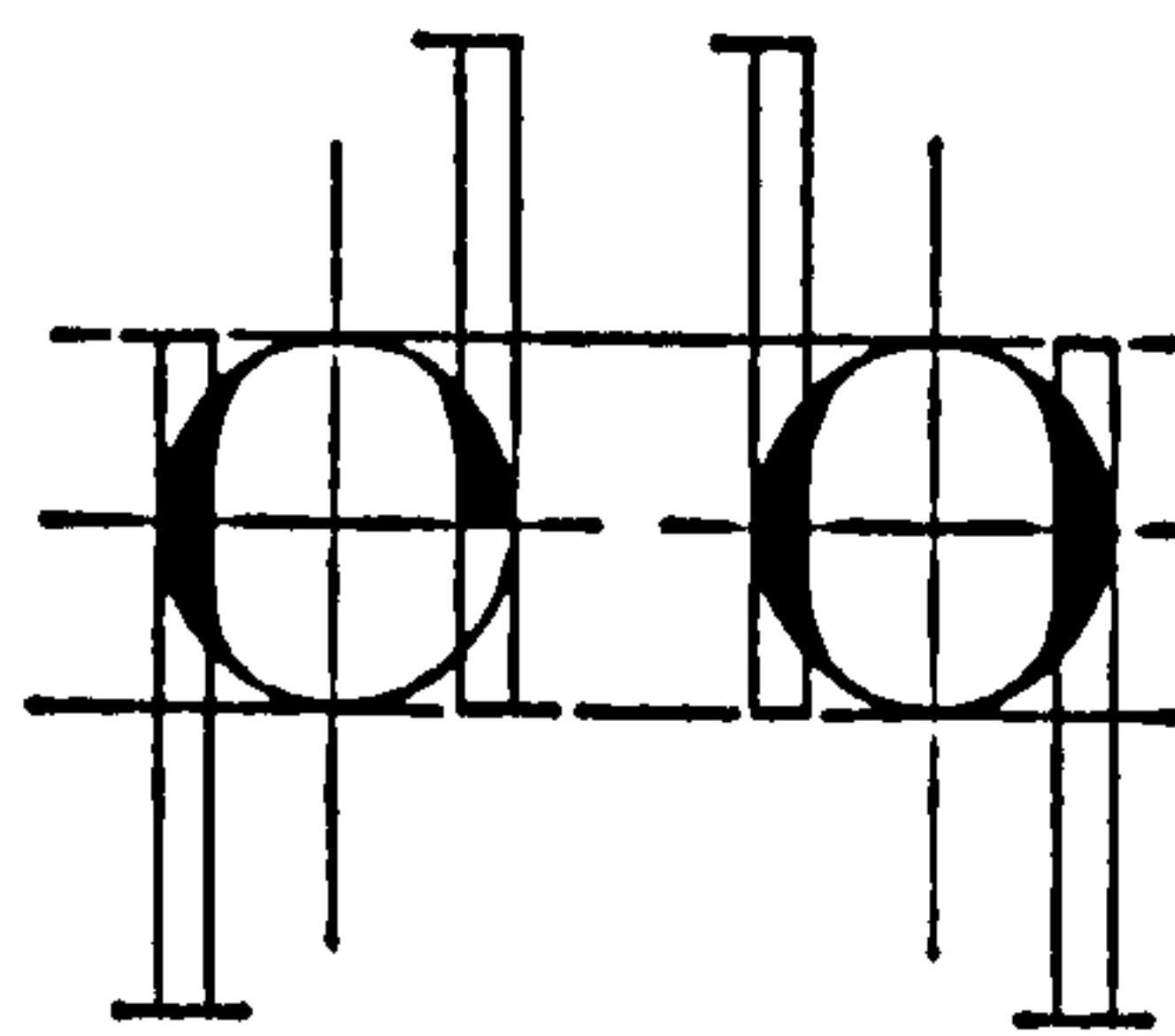


fig 1.2 Vertical shading of Modern type face.

There was, however, an intermediate stage in the evolution of type faces with the emergence of 'transitional' faces in which the angle of stress was reduced.

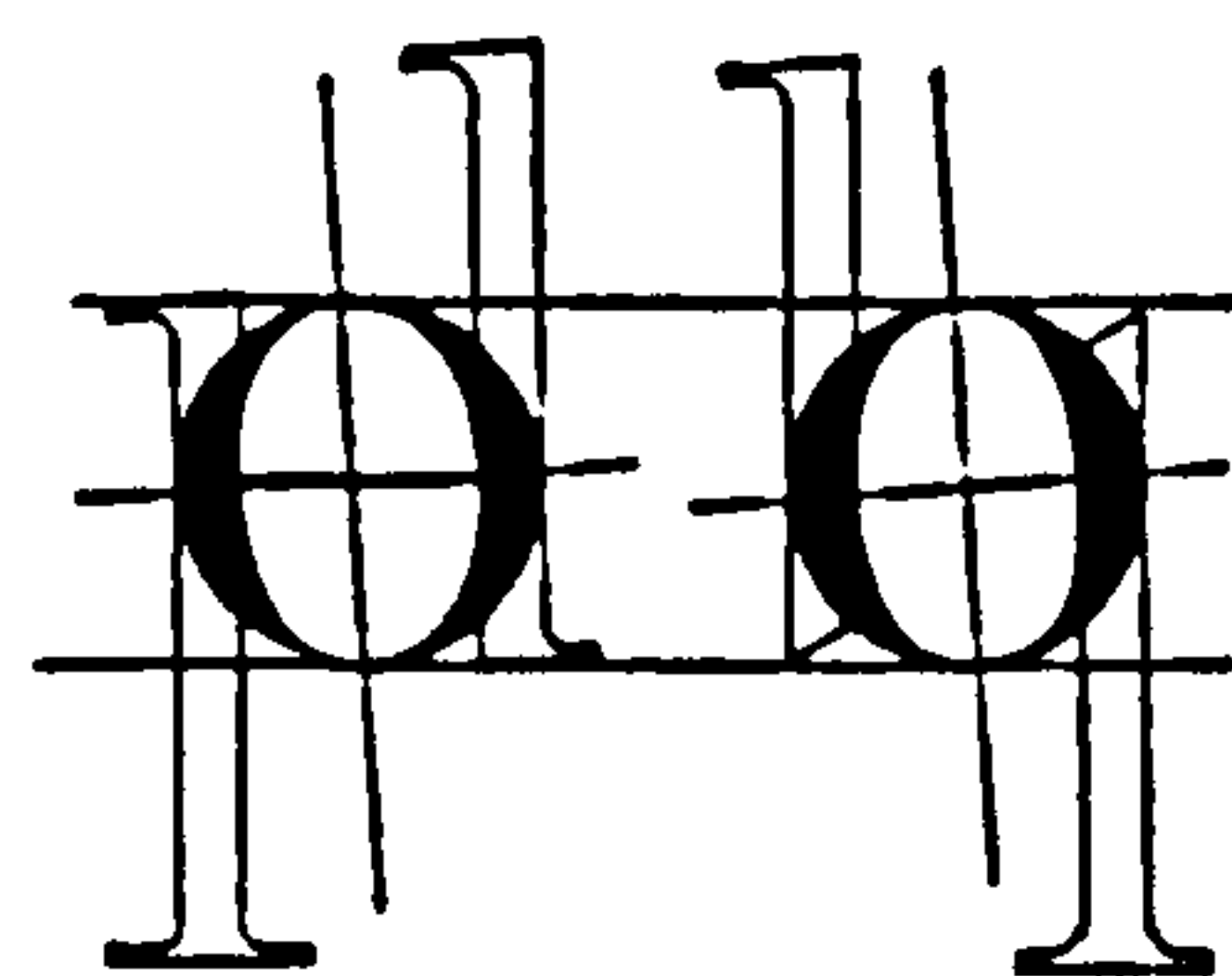


fig 1.3 Transitional type face

Craig (1978) has very usefully summarised the terminology associated with typography and given very helpful illustrations. Understanding of this terminology is important for evaluation of the research associated with typography.

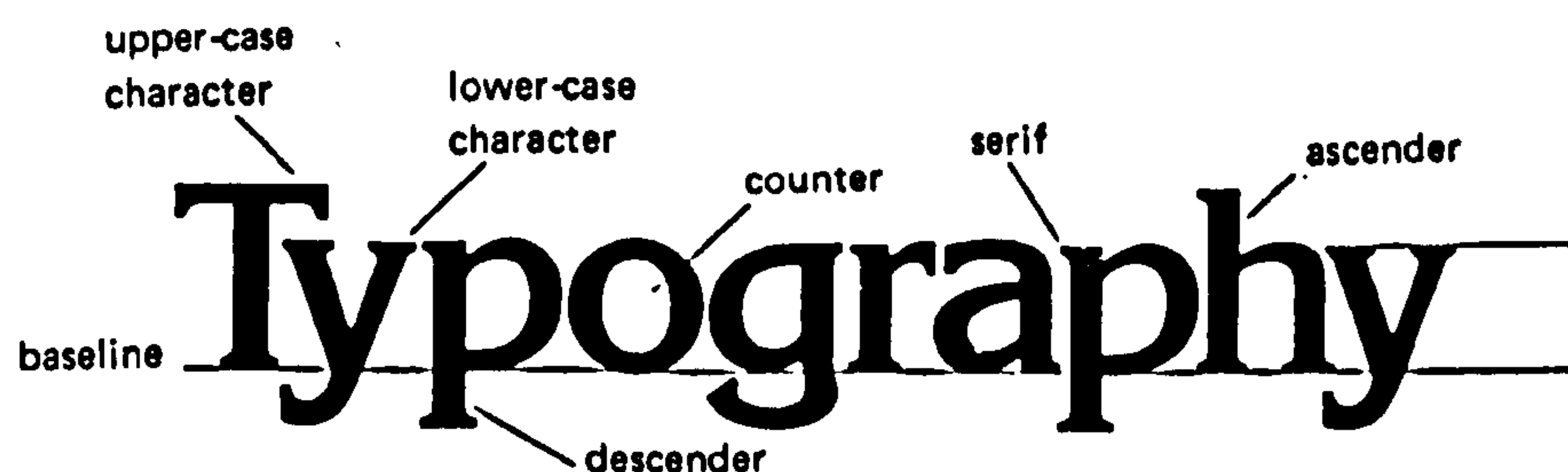


fig 1.4 Terminology associated with type

Individual letters and figures are called *characters*. Capital letters are called *upper-case* characters and small letters are called *lower-case* characters. The line on which all the capitals (and most of the lower-case) characters appear to stand is called the *baseline* and the height from there to the top of the main part of the letter is called the *x-height* (literally, the height of the lower-case x).



The *ascender* is that part of the lower-case letter that rises above the x-height, and the *descender* is that part of the lower-case letter which falls below the baseline. In an enclosed letter, the hollow part is known as the *counter*. In some type faces, there is a short stroke projecting from the ends of the main strokes, known as a *serif*. Such a type face would be known as a serifed type face whereas, in the absence of such strokes, the type face would be 'non-serifed' or 'sans-serif'.

# Typography

fig 1.5 Sans-serif characters

Although Davis (1980) states that there are now something like 7000 typefaces to choose from, he is probably including all the typestyles associated with each face. There are at least hundreds of typefaces available, some with serifs, some without, and some with modified serifs. Sometimes the difference between typefaces is subtle, sometimes very dramatic. Nevertheless, even slight changes in the x-height or the length of the ascenders or descenders can affect the appearance of a page of type.

Baskerville	Helvetica
Bodoni	Futura
Caslon	News Gothic
Caledonia	Times Roman

fig 1.6 The names of some popular typefaces each set in its own typeface.

Most typefaces are designed in a variety of different typestyles with the most common form, the upright form, being called *roman*. If the letter form slants to the right it is known as *italic*. The weight of the letter is variable (i.e. the thickness of the stroke) giving *light*, *medium*, or *bold*, but there is little agreement on terminology and medium in one typestyle may be the same as bold in another.



Roman	Light
<i>Italic</i>	Medium
	<b>Bold</b>

fig 1.7 Varieties of typestyle

A family of type is created by combining all the styles and sizes of a given typeface.

The height of type is measured in *points*, but because the measurement relates to the block of metal on which the type is formed (even although modern typesetting systems do not, necessarily, use such blocks) the height of the letter may vary between different families of type.

The spacing between lines, or *leading*, is also measured in points. If type is *set solid*, there is no additional interlinear spacing, but it is quite common to add one or two points of leading.

Although type can be set solid it is more usual to increase the space by the addition of leading.	Although type can be set solid it is more usual to increase the space by the addition of leading.	Although type can be set solid it is more usual to increase the space by the addition of leading.
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fig 1.8 10 pt type set solid, and with 1 and 2 points of leading

The length of a printed line is measured in *picas* and 24 picas is roughly equal to 10 cms.

Individual character widths and the spaces between characters are measured in *units* which are related to the point size of the character. Thus, one unit of additional space in, say, 10 pt type will have the same visual effect as one unit of space in a line of 36 pt type. The number of units involved in character widths depends upon the typeface being used. In some typesetting systems a capital 'M' may be 18 units wide, a lower-case 'a' might be 10 units, and a lower-case 't' can be only 6 units. In the IBM composer system, a capital 'M' is 9 units, a lower-case 'a' is 6 units, and a lower-case 't' is 4 units.

In standard typewriting systems, each letter has exactly the same width, i.e. unit spacing, but more complex typewriters have *proportional* spacing



which, although not as sophisticated as typesetters, does permit characters like 'M' to occupy more space than characters like 't'

### 1.2.1.1 Research relating to typeface

Tinker (1963) has commented upon the fact that books on typography devote far more space to descriptions of type faces and their uses than to all other typographical factors combined, pointing out that the emphasis is largely upon appropriateness of particular type faces for conveying specific kinds of message.

Paterson and Tinker (1932) selected ten type faces for study, and used a speed-of-reading technique to compare the faces against Scotch Roman as the standard. The reading material was printed in 10 point, set solid, in a 19 pica line width. Nine hundred college students were the subjects.

Scotch Roman	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as
Garamond	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as I
Antique	3. This morning my mother asked me to find out what time it was. I therefore ran just as
Bodoni	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as
Old Style	3. This morning my mother asked me to find out what time it was. I therefore ran just as
Caslon	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as
Kabel Light	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as I could to
Cheltenham	3. This morning my mother asked me to find out what time it was. I therefore ran just as rap-
American Typewriter	3. This morning my mother asked me to find out what time it was. I therefore
Cloister Black	3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as

fig 1.9 The typefaces tested by Paterson & Tinker

(Tinker, 1963, p 47)



Only the American Typewriter and Cloister Black were read significantly more slowly than Scotch Roman. It is hardly surprising that Cloister Black was read more slowly, but it is perhaps disturbing that American Typewriter, which is similar to that used in very many typewriters today, should be read more slowly. The explanation may lie in the non-proportional nature of type script and this will be explored later.

Burt (1959), using 10 - 11 year old children for his investigations, compared ten typefaces, using speed of reading and number of items comprehended

SPECIMENS OF TYPE FACES	
OLD STYLE	W M J Q R G C A H e w g s v w y z k p m g J Q W C Y
IMPRINT	W M J Q R G C A H e w g s v w y z k p m g J Q W C Y
TIMES NEW ROMAN	W M J Q R G C e w g s c b p q v w y z i j k p m h J Q W
PLANTIN	W M J Q R G C A P e b j g v w y z k p m g h J Q W
BODONI	W M J Q R G C K e w j b t u n v w y i j k p m t x g J Q W R
CASLON	W M J Q R G C A H U j e w g s v w y z k p m g J Q W C T A P H
BASKERVILLE	W M J Q R G C A H U j e w g s v w y z k p m g J Q W C T K N T
BEMBO	W M J Q R G e j g h y Th v w y z k p m g h J Q W
SCOTCH ROMAN	W M J Q R K u e w j b t k v w y i j k p m t x g J Q W R
MODERN 7	W M J Q R K U o w j b t h k v w y i j k p m t x g J Q W R

fig 1.10 The faces tested by Burt

as the measures. The investigation found statistically significant differences between the typefaces with Old Style and Imprint very much better than Bodoni. However, a similar investigation with university students and educated adult readers showed no significant difference between the typefaces tested.



Burt was very much against the sans-serif typefaces and did not even include any of them in his tests.

Poulton (1965) investigated the comprehension of 375 adults after reading about 450 words printed in one of seven typefaces by asking them to read in 90 seconds then answer 10 open-ended questions on the content. He found no reliable differences between the serified and sans-serified typefaces nor between the serified typefaces of Bembo (an old style), Baskerville (a transitional) and Modern Extended No. 1 (a modern). However, he did find significant differences within the group of sans-serif typefaces.

Robinson, Abbamonte, and Evans (1971) used a computer model of human visual processing as a test of a line detector explanation of the importance of serifs, viz. that "serifs" are important in the perception of small letters by humans. They react with the line detectors of the visual system within the component lines of letters. The component lines of letters are made easier to see when the letters are of serif form" (p 356). The investigation tested single letters 'E', 'T', 'f' and 'h' based on two IBM Selectric typewriter faces -- Courier (serif) and Artisan (sans-serif).

E T f h E T f h

fig 1.11 IBM type faces tested by Robinson et al (1971)

They concluded that

"If the computer model has any validity as an imitation of the human visual system, then one may conclude that serifs are important in preserving the image of small letters when they are represented in the neurological structure of the visual system". (p. 359)

As Watts and Nisbet (1974) point out, Burt's claim that the use of serifs increases legibility by "distinguishing between similar letters, correcting for effects of irradiation, and aiding the horizontal movement of the eye by combining separate letters into distinctive word wholes" is not substantiated by empirical evidence.



Poulton (1972) has suggested that the advantages of one typeface over another may be due to familiarity, citing the case where groups of scientists read most easily a particular typeface with which they were very familiar in scientific journals. Pyke (1926) had reached a similar conclusion nearly half a century beforehand.

The matter of preference is an important issue, because it either undermines the experimental investigations or it brings another perspective to the issue, viz. motivation through congeniality.

Tinker and Paterson (1942) noted a marked agreement between legibility and 'pleasingness' for different typographical arrangements which included, *inter alia*, styles of typeface, and concluded that judged legibility may be accepted as equivalent to pleasingness. However, they also raise questions regarding this close relationship, enquiring whether readers put a high aesthetic value on arrangements believed to facilitate ease and speed of reading or judge an arrangement to be legible because it is pleasing to the eye.

The question of 'congeniality' will be returned to in chapter 2.

It was noted earlier that 'American Typewriter' typeface was less readily read than other typefaces and it was suggested that this may be related to the non-proportional nature of standard typewriter faces. However, proportional spacing typewriters have been available since the 1930's, and many of the daisy-wheel printers associated with electronic typewriting and word processing systems are capable of operating either in a unit-space (10, 12, or 15 characters per inch) mode or in a proportional-spacing mode. Since typewritten material accounts for a substantial part of the printed instructional materials used in education, any advantage associated with proportional spacing (or disadvantage associated with single unit spacing) is important.

Payne (1967) conducted two experiments (original and replication) in which test material consisting of several passages taken from the Davis Reading Test and typed in two versions — one set with proportional spacing (IBM modern) and the other with standard spacing (IBM Prestige Elite) — was administered



to 190 adult readers. Results showed a significant difference in reading speed in favour of proportional spacing, although comprehension scores were not significantly different.

Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond.

Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond.

fig 1.12 Samples of proportional and standard spacing

As there was a greater difference in reading speed in favour of proportional spacing for the more difficult passages, the investigators hypothesise that proportional spacing increases the readability of 'hard' material more than it increases the readability of 'easy' material, arguing that this is consistent with findings by Smith and Dechant (1961) that readers adjust their speed to the difficulty of the material to be read.

#### 1.2.1.2 Research relating to typestyle

Since it is possible to have within each typeface a variety of typestyles, in particular roman and italic styles and different weights of each, and, since the previously cited research does not seem to indicate significant differences in legibility between most major typefaces, it is important to check what differences in legibility might exist between typestyles such as roman and italic because the typographical differences are frequently more gross than those between typefaces.

Tinker (1963) reports that there was evidence in the work of Starch (1914) that italic print was read more slowly than ordinary lower case and, in the first controlled experiment conducted by Tinker and Paterson (1928), it was demonstrated that italic print was read more slowly, but by only 2.7 per cent. However, in a more extensive experiment, Tinker (1955) demonstrated that italic print retards reading by a small but statistically significant amount. He also points out that 96% of adult readers judge roman lower case to be read more easily than italics. The conclusion offered by Tinker (1963) is that



the use of italics should be restricted to those rare occasions when added emphasis is needed.

Burt (1959), in discussing italic typestyle, says

“... much obviously depends on the reader’s implicit notion of the functions of such a type – a point too frequently ignored”. (p. 50)

This issue of the context within which italics should or could be used will be explored in the discussion section at the end of this chapter.

Although Roethlein (1912) showed that individual letters and groups of letters (‘nonsense’ groups) in bold face could be perceived at a greater distance than ordinary lower case print and although Luckiesh and Moss (1940) found similar results but with no difference in speed of reading which was confirmed by Paterson and Tinker (1940), there was also evidence in the latter investigation that readers did not prefer bold face, and it is concluded, therefore, that bold face can be used safely for emphasis in such situations as book titles and section headings without loss of legibility (Tinker 1963).

There is nothing absolute about boldness: medium weight in one typeface may well be equal to bold in another. The important issue would therefore seem to be the reader’s ability to distinguish between two weights of the same typeface on the same page when, presumably, the heavier weight is being used for emphasis, a proper name, a title, a heading or some such thing, i.e. bold face is being used as a typographical cueing device, and this issue will be further discussed in chapter 5.

The comparison of capitals and lower case within a typeface is a very much more important issue. Although Starch (1914) had reported that text set in Roman lower case was read 10 per cent faster than similar material set in all capitals, it was not until Tinker and Paterson (1928) carried out a controlled study and Tinker (1955) investigated the effects of prolonged exposure that more generalisable conclusions could be drawn. There seems to be no doubt that reading speed in all capitals is between 9 and 19 per cent slower, depending on the duration of the passage and, again there is no doubt, that readers judge lower case letters to be faster and easier to read.



Although professionally produced books rarely, if ever, reproduce whole areas of text in all-capitals format, it is not uncommon in 'locally' produced materials such as procedure manuals, laboratory sheets, and other forms of printed and projected instructional matter to make extensive use of all-capital presentation. While there is a tendency on the part of teachers (or local 'producers') to argue that single or even a few words in capitals is helpful as readers/viewers are conditioned to pay more attention to capitals than to lower-case, the research evidence from Breland and Breland (1944) into the use of all-capitals and lower-case material for newspaper headlines clearly shows that, on the basis of correct identification of words after a 'glance', there is a 19 per cent loss in reading headlines set in all-capitals in comparison with lower-case.

An investigation by Hvistendahl (1961) to determine the readability difference between the traditional capital-and-lower-case headlines (in which the first letter of every important word is capitalised) and lower-case headlines (in which only the words normally capitalised in the sentence are capitalised) indicated no significant difference, although there is a tendency for the mean regarding time to be less for the lower-case headlines.

The reasons for the improved readability/legibility of lower-case compared with capitals have been extensively investigated. Tinker (1932) investigated the influence of form of type on the perception of words printed in lower-case and in capitals as one of the factors involved in the greater legibility of lower-case printing and concluded that total word form is more important in perceiving words in lower-case than in all-capitals where perception occurs largely by letters. Since reading by word units is a characteristic of mature readers, the presence of distinctive total word form appears to facilitate reading by word units and is, thus, one of the factors contributing to faster reading of lower-case type. In an eye-movement study by Tinker and Paterson (1939), fixation frequency and perception time were significantly greater for the reading of all-capital print.



fig 1.13 'Word form' comparison (Tinker, 1963, p 60)



It is fairly obvious that the upper half of a printed line gives more clues to word form than the lower half, and this probably contributes to the more ready recognition of words in lower case than in upper case.

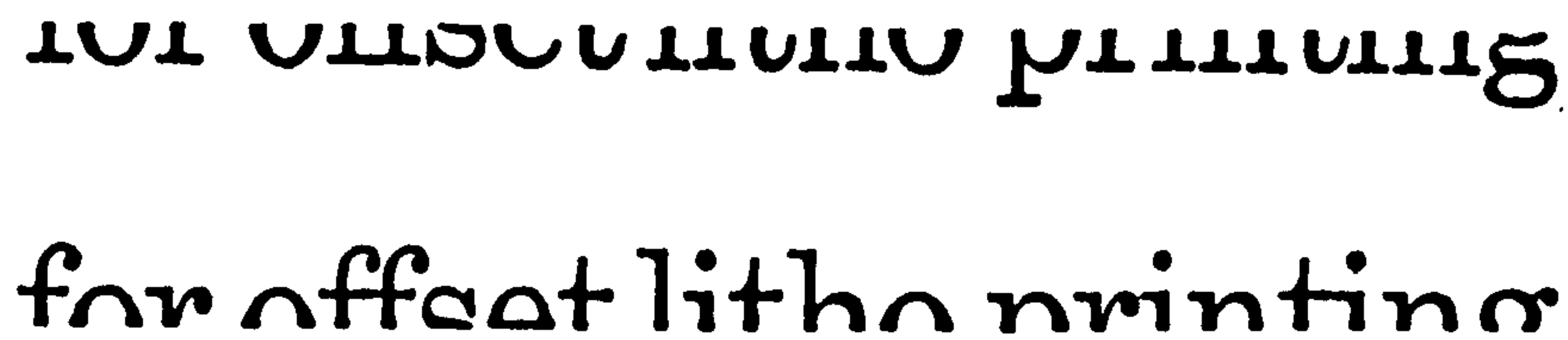


fig 1.14 'Word form' from the lower and upper halves of lower-case printing

Kolers (1969) has pointed out that more information is available from the right-hand side of a letter than from the left-hand side, but there is no indication whether the effect is more noticeable in lower or upper case.

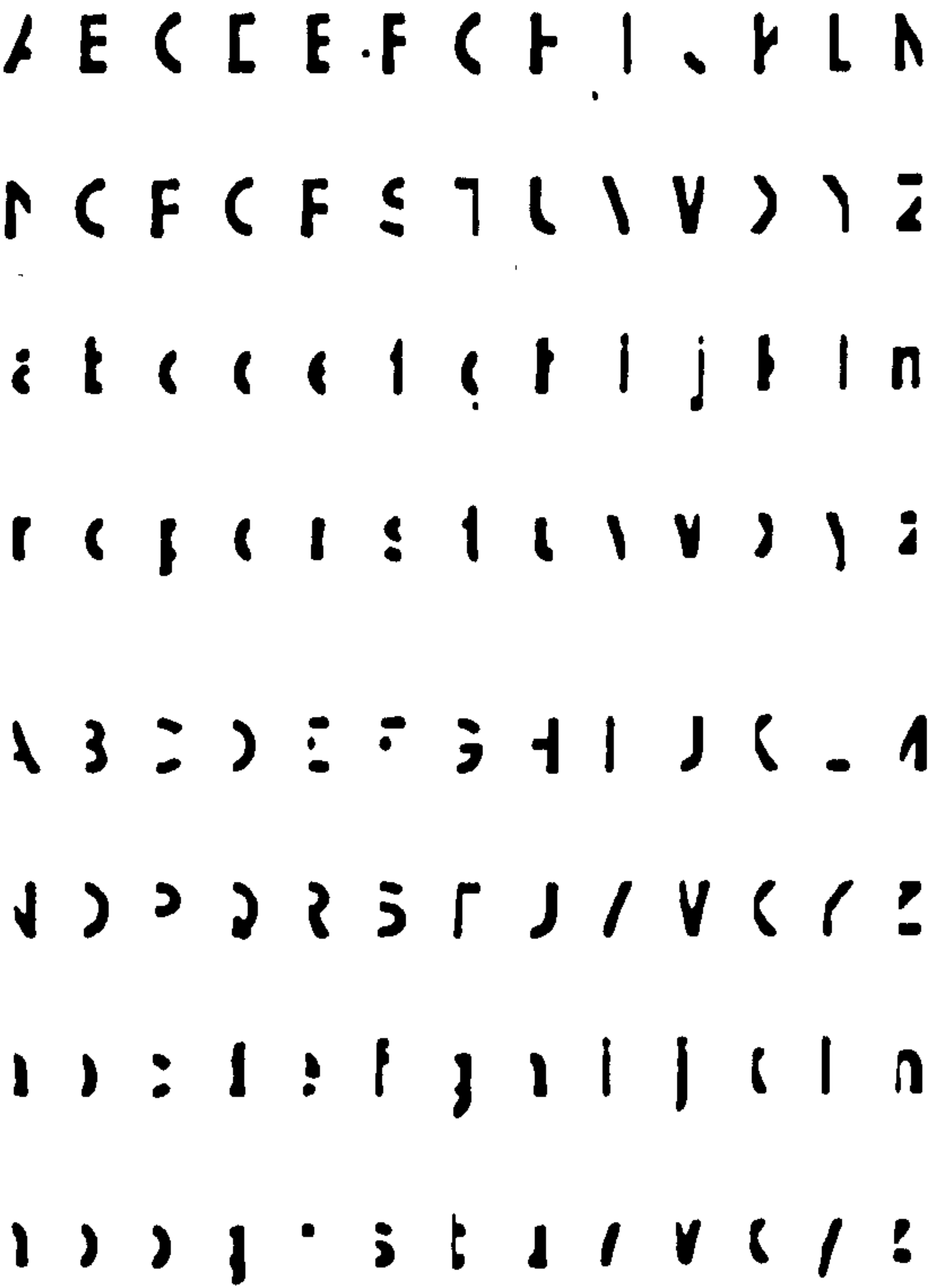


fig 1.15 Obliteration of right-half and left-half of letters

Very radical alteration would be needed to exploit this phenomenon, and it is unlikely to be of significance in the design and development of print as a medium of instruction. Nevertheless, it is interesting to note that Abelman, as cited by Kolers, has developed a typeface which incorporates this aspect.





fig 1.16 Typeface developed by Jerome Abelman of Bell Telephone Laboratories.

## 1.2.2 Size of type, length of line, and interlinear spacing

These three parameters are taken together because, although investigations have been carried out on each separately (and are here reviewed), the research clearly shows that their interaction is at least as important as their individual contributions.

### 1.2.2.1 Size of type

Regardless of the length of line or the spacing between the lines, there will be limiting sizes of type below which or above which it is uncomfortable or impossible to read continuous text.

Paterson and Tinker (1940) noted that American non-scientific magazines showed a heavy concentration at 9 and 10 point sizes, whereas of American scientific journals, two thirds were printed in 10 point and 19 per cent were in 11 point. Foreign scientific journals were found to employ the same type sizes with a tendency toward 11 point, and the large majority of textbooks employed 10, 11, or 12 point with a preference for 11 point.



Burt (1959) makes reference to a British Association committee report produced in 1917 as a result of an investigation into “the influence of school books upon eyesight” in which the minimum size of type for children was identified, but points out that it is preferable to formulate standards in terms of optimum sizes. Accordingly, he recommends a range of sizes for children — from 24 point for under 7’s to 11 point for over 12’s — and identified 10 point, with an x-height of 0.062 inches, as the most legible size for adult readers. The typeface used for adult readers was Times Roman, and it should be noted that, according to Burt, this is roughly equivalent to 11 point Baskerville and 12 point Bembo.

Paterson and Tinker (1929; 1940) used speed-of-reading methods and eye-movement methods to determine the influence of type size on legibility of print, concluding that 10 point was the optimum size, although in some of the tests, 11 point was shown to be the most legible. Reader preference was certainly for 11 point.

**8 point**

16. This band of men and women set sail for the new world where they could live in peace. There was great rejoicing when

**9 point**

16. This band of men and women set sail for the new world where they could live in peace. There was great rejoicing when

**10 point**

16. This band of men and women set sail for the new world where they could live in peace. There was

**11 point**

16. This band of men and women set sail for the new world where they could live in peace. There was

**12 point**

16. This band of men and women set sail for the new world where they could live in peace.

fig 1.17 Five sizes of type, Granjon, set solid  
on 19 pica width (Tinker, 1963, p 70)

#### 1.2.2.2 Length of line

Burt (1959) indicates what he considers to be the most suitable length of line for children of varying ages, drawing attention to the limiting condition being a matter of the number of letters rather than the visible inches. On this



basis, the range is from 30 letters in a line of 4 inches for the under 7's to 60 letters in a line of 4 inches for the over 12's or, in terms of 'visible inches', 5 inches for the under 7's to 4½ inches for the over 12's. His experiments with adults led him to conclude that lines shorter than 20 picas or longer than 33 picas diminished speed and ease of reading. He adds:

“For literary material the narrower measure is desirable (say 3½ – 4 inches); for scientific the wider. For a scientific journal intended for highly educated readers, who of course tend to skim rather than read word by word, a measure of 5 inches seems preferable”. (p.14)

Although Burt does not offer any justification (other than assertion) for this conclusion, the implications for purposive reading may, in fact, be valid, but this issue will be considered at a later stage.

Paterson and Tinker (1940) surveyed a total of 1500 journals and books to determine current practice with reference to line width. They noted that with double-column printing, the line widths used in non-scientific journals spread evenly from 14 – 22 picas but that in scientific journals, the spread was from 13 – 18 picas. In single-column printing, journals used 23 – 28 pica line widths, with most textbooks having 19 – 24 pica widths.

**9 picas.**

6. Mr. Smith gave a news-  
boy a quarter for a paper

**13 picas**

6. Mr. Smith gave a newsboy a quar-  
ter for a paper and left without his

**17 picas**

6. Mr. Smith gave a newsboy a quarter for a paper  
and left without his change. When the boy ran and

**21 picas**

6. Mr. Smith gave a newsboy a quarter for a paper and left  
without his change. When the boy ran and told him he said he

**25 picas**

6. Mr. Smith gave a newsboy a quarter for a paper and left without  
his change. When the boy ran and told him he said he had never

**29 picas**

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When  
the boy ran and told him he said he had never seen such dishonesty. 7. It was a cold day

fig 1.18 Line widths in 8pt Scotch Roman, set solid (Tinker, 1963, p 75)

In a series of experiments Paterson and Tinker (1940) investigated the legibility of various type sizes for a range of lengths of line set solid.



The main conclusions from these studies are summarised as follows:

- For 10 point type set solid, materials in line widths between 17 and 27 picas are equally legible.
- For 12 point type set solid, line widths ranging from 17 to 37 picas are equally legible.
- For 8 point type set solid, line widths ranging from 13 to 25 picas are equally legible.
- For 6 point type set solid, line widths ranging from 9 to 25 picas are equally legible.
- For very long lines of type, eye-movement measures reveal less efficient reading, particularly regressions following the backsweep to the beginning of a new line.

#### **1.2.2.3 Interlinear spacing (leading)**

The survey of printing practice conducted by Paterson and Tinker (1940) indicated that, with the exception of American non-scientific journals, there is a marked tendency to use 2 point leading. Burt (1959) states categorically that leading greatly enhances the legibility of small type by aiding the eye in picking up the right lines as it moves back from the end of one line to the beginning of the next. His investigations, however, were limited to showing that one or two points of leading on 8, 9, or 10 point text could appreciably

##### **Set solid**

6. Mr. Smith gave a newsboy a quarter for a paper  
and left without his change. When the boy ran and

##### **1 point leading**

6. Mr. Smith gave a newsboy a quarter for a paper  
and left without his change. When the boy ran and

##### **2 point leading**

6. Mr. Smith gave a newsboy a quarter for a paper  
and left without his change. When the boy ran and

##### **4 point leading**

6. Mr. Smith gave a newsboy a quarter for a paper  
and left without his change. When the boy ran and  
fig 1.19 Scotch Roman 10pt set solid and with 1,2,  
and 4pt leading (Tinker, 1963, p 90)



increase the ease of reading. Luckiesh and Moss (1938), in investigating leading in 10 point type set in a 21 pica line, concluded that 3 point leading was optimum, whereas Paterson and Tinker (1932) concluded and later confirmed (1940) that, for 10 point type set in a 19 pica line, the optimal leading was 2 point.

The same studies show that a small amount of leading is helpful with 8 point type but that there is not such noticeable effect when 12 point type is leaded.

#### **1.2.2.4 The inter-relationship of type size, length of line, and interlinear spacing**

Burt (1959) noted that, in the course of his experiments, it soon became obvious that the procedure adopted by most psychological investigators, viz., studying the effects of the variables separately — size, style, length, and leading — is quite inconclusive, citing the fact that, for example, 5 inch lines of 9 point set solid are harder to read than 10 point but, when set with 2 point leading, are just as easy.

Tinker (1963) suggests that most of the investigations into the individual variables lead up to an investigation of leading and line width in relation to type size and points out that such an investigation requires a very large number of readers. In fact he used 11,420 readers in a series of investigations using 6, 8, 9, 10, 11, and 12 point type, each in five line widths and four degrees of leading, at the end of which he felt able to direct the attention of printers to 'safety zones' for each type size, that is, provide the limits of variation in line width and leading that could be used for a given type size without appreciable loss of legibility.

##### ***6 Point***

14-pica line width with 2 to 4-point leading

21-pica line with 1 to 4-point leading

28-pica line with 2 to 4-point leading

##### ***8 Point***

14-pica line with 2 to 4-point leading

21-pica line with 2 to 4-point leading

28-pica line with 1 to 4-point leading

36-pica line with 2 to 4-point leading



*9 Point*

14-pica line with 1 to 4-point leading

18-pica line with 1 to 4-point leading

30-pica line with 1 to 4-point leading

*10 Point*

14-pica line with 1 to 4-point leading

19-pica-line with 2 to 4-point leading

31-pica line with 2-point leading (marginal)

*11 Point*

16-pica line with 1 to 2-point leading

25-pica line with or without leading

34-pica line with 1 to 2-point leading

*12 Point*

17-pica line with 1 to 4-point leading

25-pica line with or without leading

33-pica line with 1 to 4-point leading

fig 1.20 Safety zones as suggested by Tinker

Watts and Nisbet (1974) have argued that no criterion, in isolation, can provide a suitable measure of legibility.

They say:

“The scientific accuracy of oculomotor patterns and visibility measurements provide useful insights into the perceptual and visual mechanisms involved in reading print. They may not provide an accurate measure of the processes involved in the normal reading situation”.

(p. 48)

Warde (1933) has stated that “What the book critic calls readability is not a synonym for what the optician calls legibility”. Burt (1959) in supporting this view notes that nearly all readers in his investigation

“... tended to read with greater facility the kind of types that they preferred, and were inclined to confuse intrinsic legibility with their private aesthetic preferences. Preference depends largely upon custom; and ... almost everyone reads most easily matter set up in the style and size to which he has become habituated”.

(p. 18)



The vast majority of locally-produced printed materials used in teaching are prepared on typewriters which usually means that type-size is limited to either 10 pitch or 12 pitch.

The widespread availability of photocopiers with a reduction facility or photo-litho facilities has resulted in typed material frequently being reduced to 70.7% of its original linear size.

Stewart (1981) has shown the effect of such photo reduction but has not attempted to assess its effect on readability and learning.

#### 10 pitch typewriter

This encompasses the formation of the initial complex of ribosome, mRNA and amino acyl tRNA molecules and the synthesis of the first peptide bond. Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond. As noted earlier, the ribosome has two binding sites, the A and P sites. The A site has a high affinity for an amino acyl tRNA molecule but the P site has little or no affinity.

#### 10 pitch typewriter reduced to 70.7%

This encompasses the formation of the initial complex of ribosome, mRNA and amino acyl tRNA molecules and the synthesis of the first peptide bond. Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond. As noted earlier, the ribosome has two binding sites, the A and P sites. The A site has a high affinity for an amino acyl tRNA molecule but the P site has little or no affinity.

fig 1.21 10 pitch typewritten material at original size and reduced to 70.7%

When 10 pitch typewritten material is reduced as shown, the size is roughly equivalent to 9–10 point. When 12 pitch typewritten material is reduced, the size is roughly equivalent to 7–8 point. With single spacing on the typewriter, which means the same interlinear spacing for both 10 and 12 pitch, the effect on reduced copy is to have the 10 pitch (now effectively 9–10 point) set solid and the 12 pitch (now effectively 7–8 point) with about 1 point of leading.



### 12 pitch typewriter

This encompasses the formation of the initial complex of ribosome, mRNA and amino acyl tRNA molecules and the synthesis of the first peptide bond. Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond. As noted earlier, the ribosome has two binding sites, the A and P sites. The A site has a high affinity for an amino acyl tRNA molecule but the P site has little or no affinity.

### 12 pitch typewriter reduced to 70.7%

This encompasses the formation of the initial complex of ribosome, mRNA and amino acyl tRNA molecules and the synthesis of the first peptide bond. Obviously, the presence of more than one amino acyl tRNA in the complex is required for the synthesis of a peptide bond. As noted earlier, the ribosome has two binding sites, the A and P sites. The A site has a high affinity for an amino acyl tRNA molecule but the P site has little or no affinity.

fig 1.22 12 pitch typewritten material at original size and reduced to 70.7%

## 1.2.3 Justification

There is one typographical factor which needs to be considered, but which was not covered by either Tinker or Burt, and it is one in which the evidence from scientific investigations and from reader preferences needs to be discussed. The question of whether lines in text should have uniform length (i.e. justified) or be of unequal length (i.e. unjustified) has been investigated more recently.

Justification is achieved by increasing the space between words in a line so that they form a common right hand margin. Occasionally it is necessary to increase the spacing between letters. It is frequently necessary in justified type to split words by hyphenation. Those who have investigated justified/unjustified print have tended to concentrate on these three factors — word space, letter space and hyphenation — and to determine whether they resulted in slower reading.



Gregory and Poulton (1970) used three different types of materials — justified, unjustified with broken words, and unjustified with no broken words — and required the readers (who were of three different reading abilities) to answer open-ended questions about the passage. Two different line lengths (averaging seven and twelve words) were used. The style of printing with the shorter line made no difference for good readers, but for poorer readers the justified style resulted in a significantly worse performance. With the longer line (averaging twelve words) no disadvantage of justification was found. In lines containing 12 words the variation in spacing between the words is hardly noticeable and it is, perhaps, not surprising that any possible disadvantage of justification should disappear.

Hartley and Burnhill (1971) investigated three different arrangements of unjustified typography — line endings were determined by syntactic considerations, text with about one third of the lines ending with hyphenated words, and unjustified double column formats of different widths — but found no significant differences in any arrangements as regards reading speed or comprehension. In a study of newspaper typography, Davenport and Smith (1965) found that justification of lines did not affect how accurately or how quickly newspapers are read. Macdonald-Ross and Waller (1975) describe justification as a “medieval convention” and regard it as a formal constraint not particularly appropriate to the highly structured nature of the texts with which they were concerned, viz. Open University texts. Acknowledging that research evidence shows little significant difference in legibility between justified and unjustified styles, they point out, however, that although the initial cost of unjustified setting is little different from justified setting, corrections are significantly easier and cheaper.

Hartley and Burnhill (1978) write of “erratic word spacing” when referring to justified copy, stating that it is not only unnecessary but that it also increases the cost of type-setting. Their statement that “legibility is impaired when the printer causes the word spacing to be changed from line to line in order to force out the lines to a fixed length” is, as it stands, not consistent with the research without the addition of conditions.

There does seem to be a tendency in the absence of firm scientific evidence to champion a cause by reference to cost-saving benefits. Perhaps there is



room for reader expectation and preference to be considered in this issue, possibly in the context of ‘congeniality’ in chapter 2.



# **1 Principles and practice in legibility – a discussion of the issues in chapter 1**

## **1.1 Introduction**

In making recommendations for the application of research findings, Rehe (1974) adopted three levels:

1. Recommendations based on research results and supported by at least two research findings which have investigated the same typographic variables and produced similar results.
2. Proposals which are based on only one research finding.
3. Proposals based on recommendations made by researchers but not necessarily supported by experimental evidence.

The research findings in this chapter can certainly be divided into two categories – findings whose implications are inescapable, and findings which have, at least, to be given consideration – but is it possible to derive from these findings particular principles and, even, a general principle, concerning legibility?

## **1.2 The issue of typeface**

The findings of Paterson and Tinker (1932) that only American Typewriter and Cloister Black typefaces were read significantly more slowly than Scotch Roman suggest that only ‘abnormal’ typefaces, either in the degree of ornateness or lack of proportionality, are likely to cause problems and that most ‘normal’ typefaces are quite acceptable. The conflicting evidence of Poulton (1965) and Robinson et al (1971) when set against the unsubstantiated claim of Burt (1959) and the judgement of Watts and Nisbet (1974) suggests that, basically, there is no significant difference between serif and sans serif typefaces except, possibly, in the case of very small typeface. This is certainly consistent with the previously noted findings regarding ‘normal’ typefaces. Perhaps it should be noted that, although Robinson et al (1971) concluded that serifs are important in preserving the image of small letters, both of the typefaces on which they undertook investigation – IBM Courier



and IBM Artisan — are non-proportional and are, thus, 'abnormal'. However, since the investigation was into single letter legibility, and Vernon (1929) has pointed out that the confusion of individual letters is of little significance in the reading of meaningful materials, the difference in legibility between serif and sans serif typefaces is probably insignificant.

It needs to be recognised, however, that there are substantially more gross differences than those between serif and sans serif letters to be found in the output of modern printing devices such as computer-connected printers. In the educational world, the quality of print provided by the ubiquitous IBM Selectric 'golf-ball' typewriter using a total transfer film ribbon has come to be accepted as the norm and the standard to be maintained. Myers (1980) has pointed out that the quality associated with such typewritten material represents a resolution of 200 pixels (pels) per cm and that the resolution drops to only 100 pels/cm when a fabric ribbon is used. He also notes that photocomposers can achieve 320 pels/cm and that this is considered to be the lower limit of graphics art quality, with quality printing frequently requiring a process with twice this resolution.

The computer-related printing devices to which educational institutions usually have access often do not approach the standard of 200 pels/cm. For example, dot matrix printers reach only 25–50 pels/cm, thermal printers achieve between 40–80 pels/cm, and ink jet printers manage 50–150 pels/cm. Laser printers begin to get closer to the quality required by reproducing 125 pels/cm and daisy-wheel printers are, of course, in the acceptable quality region providing total transfer film ribbons are used.

Cohen (1984) complains that since electronics entered the world of typography humans have had to put up with the consequence of standards of legibility being set aside, but welcomes the fact that 'quality is striking back' with the advent of digital laser printers. Brown (1982) also welcomes the laser printers, noting that not only can they produce good quality print, but they also have the flexibility needed to produce a potentially unlimited range of special characters including mathematical symbols and Greek characters. Perhaps the emerging hardware will at least make possible the maintaining of standards associated with optimal legibility.



The possibility that legibility may be related to familiarity (Poulton, 1972), or pleasingness (Tinker & Paterson, 1942) suggests that even in the case of poorly formed letters such as are found in computer-related printers, legibility is not the hard and fast issue the other evidence would indicate. Nevertheless, it is probably justifiable to induce the following principle:

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“If a typeface is fully formed, well proportioned, within and between characters, it will have maximum legibility”.

---

### 1.3 The issue of typestyle

Investigations into the use of italics compared with normal roman type (Starch, 1914; Tinker & Paterson, 1928; Tinker, 1955; Tinker, 1963) clearly point to the greater legibility, as measured by speed of reading, of normal roman lower case, although the comment by Burt (1959) concerning the function of italics needs to be borne in mind. Although italics can be used for emphasis and, thus, as a typographical cueing device, it has to be remembered that there are subject areas where, by convention, italics are already used for a particular purpose, e.g. in chemistry to indicate isomerism, such as *cis* or *trans* isomers and in the biological and medical sciences to indicate latin names such as *E. Coli*. In such cases it would be confusing to attempt to use italics for emphasis as can be seen in Hall, Harden, Marcus, and Jackson (1977) where italics is used to indicate a sub-heading (in colour), a question, an explanation, or an instruction, although, in general, italics are used to present additional information of various kinds.

The multiple use of bold typeface can be equally confusing. Certainly the research on use of bold typeface (Paterson & Tinker, 1940; Tinker, 1963) suggests that bold face can be used effectively as a typographical cueing device without loss of legibility.

Such is not, however, the case with upper case letters although their use is frequently seen as useful typographical practice for emphasising words or phrases. All the research (Starch, 1914; Tinker & Paterson, 1928; Tinker, 1932; Tinker & Paterson, 1939; Tinker 1955; Breland & Breland, 1944;



Hvistendahl, 1961) strongly supports the use of lower-case letters in preference to upper case, even when used for emphasis.

From the research literature concerning typestyle, two principles can be derived; one in relation to legibility and one to typographical cueing.

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“If normal weight lower-case typestyle is used, there will be maximum legibility”.

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“If different slant or weight of type is used, there will be an increase in emphasis, provided such use of type is not associated conventionally with some other purpose”.

---

## **1.4 The issue of size of type, length of line, and interlinear spacing**

Despite the tendency of researchers to investigate each of the three parameters separately, it is clear from the evidence produced in this research that the interaction between the parameters is of fundamental importance since, in instructional text, none of them can exist in isolation.

Nevertheless, it is clear from the work of Paterson and Tinker (1929; 1940) and Burt (1959) that 11 pt type is the most common and the most popular for journals and textbooks and could, thus, be considered to be the most useful, and probably most legible size of type to use in instructional text. It is also clear from the same sources that, for 11 pt type, line widths ranging from a minimum of 17 picas (71 mm) to a maximum of 32 picas (135 mm) are acceptable, although shorter lines seem to be acceptable in double column pages, but long lines of type result in eye-movement regressions after the backsweep to the beginning of a new line. There seems also, on the evidence of the same researchers together with that of Luckiesh and Moss (1938) to be wide support for two points of leading making the type more legible.

When the three parameters are taken together, as in the work of Tinker (1963), it becomes clear that, for 11 pt type, a 25 picas (105 mm) line



is optimum when the type is set solid but that the line length can be either decreased to 16 picas (67 mm) or increased to 34 picas (144 mm) when 1–2 pt of leading is added.

Given that instructional text can be prepared on typewriters and word processors as well as on conventional typesetting systems and that neither type size nor interlinear spacing can be finely manipulated, extra care obviously needs to be taken with in-house, teacher-prepared, printed instructional materials. Some of the newer daisy wheel printers (and electronic typewriters) produce the same size letters in either 10 or 12 pitch, the former resulting in the letters impacting on each other and the latter resulting in unusually large spaces between the letters. Unfortunately, there does not seem, as yet, to have been any research conducted on these conditions, but it seems obvious that neither condition is likely to contribute to the legibility of the text.

Perhaps the most useful principle that can be derived in relation to type size, length of line, and interlinear spacing is:

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“If text is set in 11 point type, within a line length of 18–32 picas and with 2 pt leading, it will have optimal legibility”.

---

## **1.5 The issue of justified setting**

The research findings regarding justification are inconclusive with Gregory and Poulton (1970) noting that for lines of twelve words (around the optimum length of line for 11 pt type) there was no difference in comprehension between the reading of justified and unjustified text, and with Hartley and Burnhill (1971) and Davenport and Smith (1965) citing similar results. Nevertheless, Hartley (1978) has criticised justification, particularly where the spacing between words is increased beyond 25% of the type size, and Romano (1984) has indicated that spacing greater than the minimum letter spacing (i.e. that associated with a letter ‘i’) is less than optimal although he does not cite any research in support of this.



The criticisms by Hartley and Burnhill (1978) and Macdonald-Ross and Waller (1975), based as they are on the cost of typesetting justified text, are not really valid since most typesetting and, even, wordprocessing, systems create justified text as easily and quickly as they create unjustified text. However, this ease of production, particularly in relation to wordprocessing systems, is a major source of difficulty since the space between words is frequently increased by a factor of 5–10, making the text difficult to read. Eye fixations are likely to be made on the spaces rather than on the words!

#### 6.2.4.1 Abstracting and Indexing Services: Printed Versions

##### (i) Advantages:-

- (a) The services are readily available to all library users.
- (b) Assistance from the Library Staff is not essential, once the initial introduction has been made.

##### (ii) Disadvantages:-

- (a) Cost  
Most of the major services are expensive.
- (b) Storage space  
Abstracting and indexing services take up a proportionately larger share of the available shelf space per volume than do other serials.

fig 1.23 Example of automatic justification by wordprocessor

Readers often expect text to be justified and, if this can be done without undue hyphenation of words and/or inordinate increase of space between words, there seems to be no reason why it should not be done.

Perhaps a reasonable principle concerning justification could be stated thus:

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“If text is justified without excessive hyphenation and/or increase of inter-word spacing, legibility will be at least as good as unjustified text and may be more readable”.

---



## 1.6 The issue of layout

Hartley (1978) states that

“page size is to typographic planning as site size is to the design of buildings: it places manageable limits on what can be done by way of arranging sensibly the prefabricated parts”.

(p 9)

Ignoring, at this stage, the requirements of the layout relating to information processing and comprehension, and considering only the implications from typographical principles, it is clear that the optimal legibility in relation to length of line determines, for a given page size, the likely layout of the page. Since most instructional materials produced ‘in house’ are likely to be produced on A4 paper (210 mm x 297 mm) using typeface around 10 or 11 pt, it is clear that the maximum length of line which would be within the expected legibility standard discussed earlier is about two thirds of the width of the page and, as Stewart (1981) points out, the possibilities are to have either a double column page (as in many journals) or an asymmetrical arrangement with the body of the text utilising only two thirds of the width of the page. The possibilities regarding the use of the remaining third will be considered in chapter 5, but in the meantime a working principle could be stated as:

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“If the layout of a page is determined by the empirical evidence regarding typographic characteristics, the page will be more legible than if these characteristics are ignored”.

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## 1.7 Conclusion

The evidence from the research, as reviewed and discussed in this chapter suggests very strongly that the adoption of certain typographical criteria is likely to lead to text being more legible than when these criteria are not adhered to. The legibility of a text is an intermediary between the reader and the text and unless the text is legible, it is unlikely to be read, let alone comprehended.



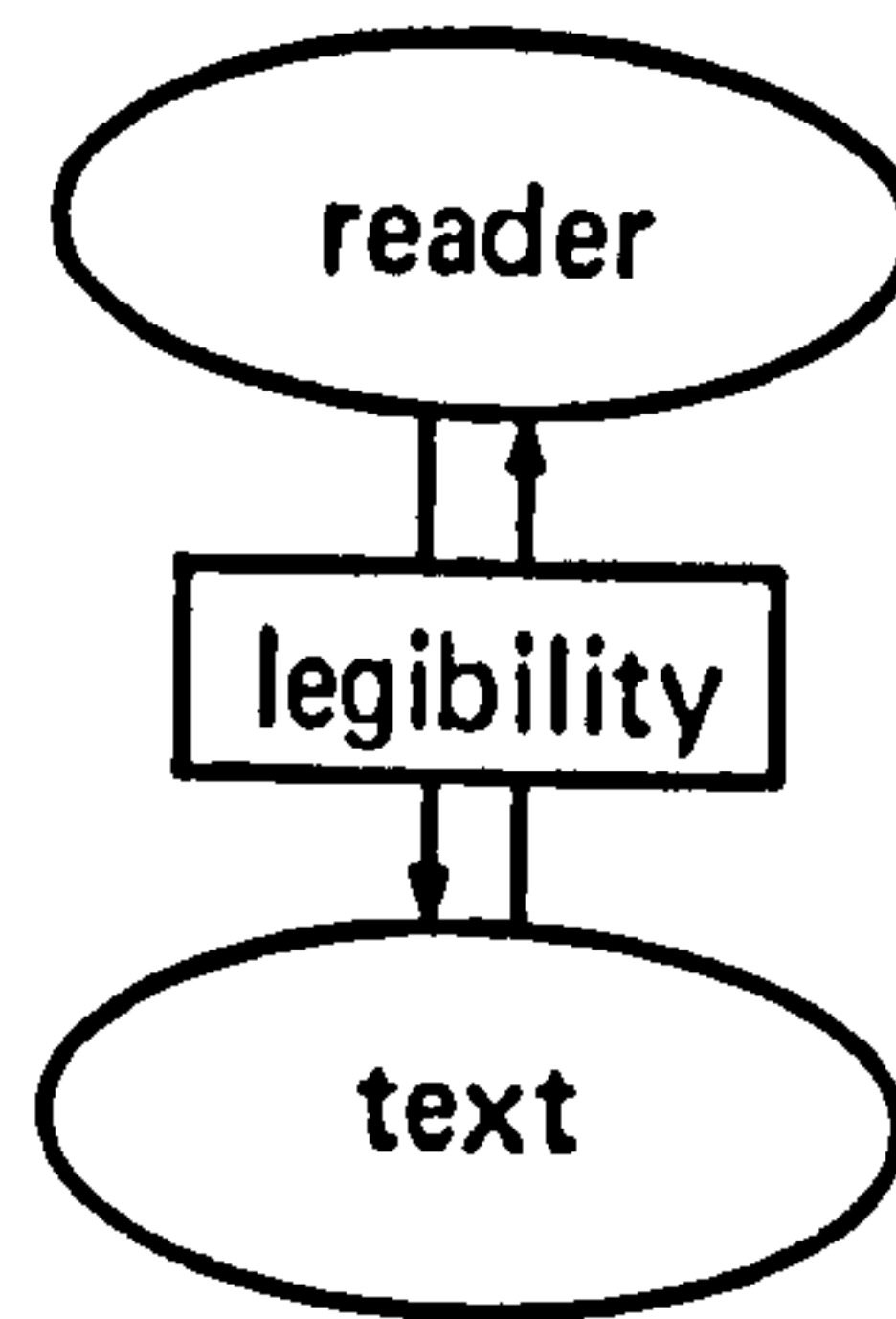


fig 1.24

The principles of legibility and layout derived from the various text-based parameters are, therefore, of considerable importance.

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Typeface:	“If a typeface is fully formed, well proportioned, within and between characters, it will have maximum legibility”.
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Typestyle:	“If normal weight lower-case typestyle is used, there will be maximum legibility”.
	“If different slant or weight of type is used, there will be an increase in emphasis provided such use of type is not associated conventionally with some other purpose”.

---

Size of type, length of line, and interlinear spacing:	“If text is set in 11 point type, within a line length of 18–32 picas and with 2 pt leading, it will have optimal legibility”.
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Justification:	“If text is justified without excessive hyphenation and/or increase of inter-word spacing, legibility will be at least as good as unjustified text and may be more readable”.
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Layout:	“If the layout of a page is determined by the empirical evidence regarding typographic characteristics, the page will be more legible than if these characteristics are ignored”.
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Research on legibility has yielded fairly consistent information which is valid irrespective of any theoretical position concerning learning from



text, and it is important to recognise the fundamental premise that the first step in reading for understanding must rest on the legibility of the material concerned. Only when legibility is established through the application of the identified principles can other issues be considered.

Unfortunately the application of these principles is not always to be found in educational practice, with the most widespread lack of application being in the use of lines of type which are substantially longer than the research would indicate as being appropriate. Within the framework of the premise outlined above, not only is it necessary to identify the importance of legibility as the first step in reading for understanding, it is necessary to recognise that if relatively simple and straightforward physical parameters for the design of text are not applied in accordance with established principles, it is unlikely that other less empirically based and more theoretically derived principles will be put into practice.

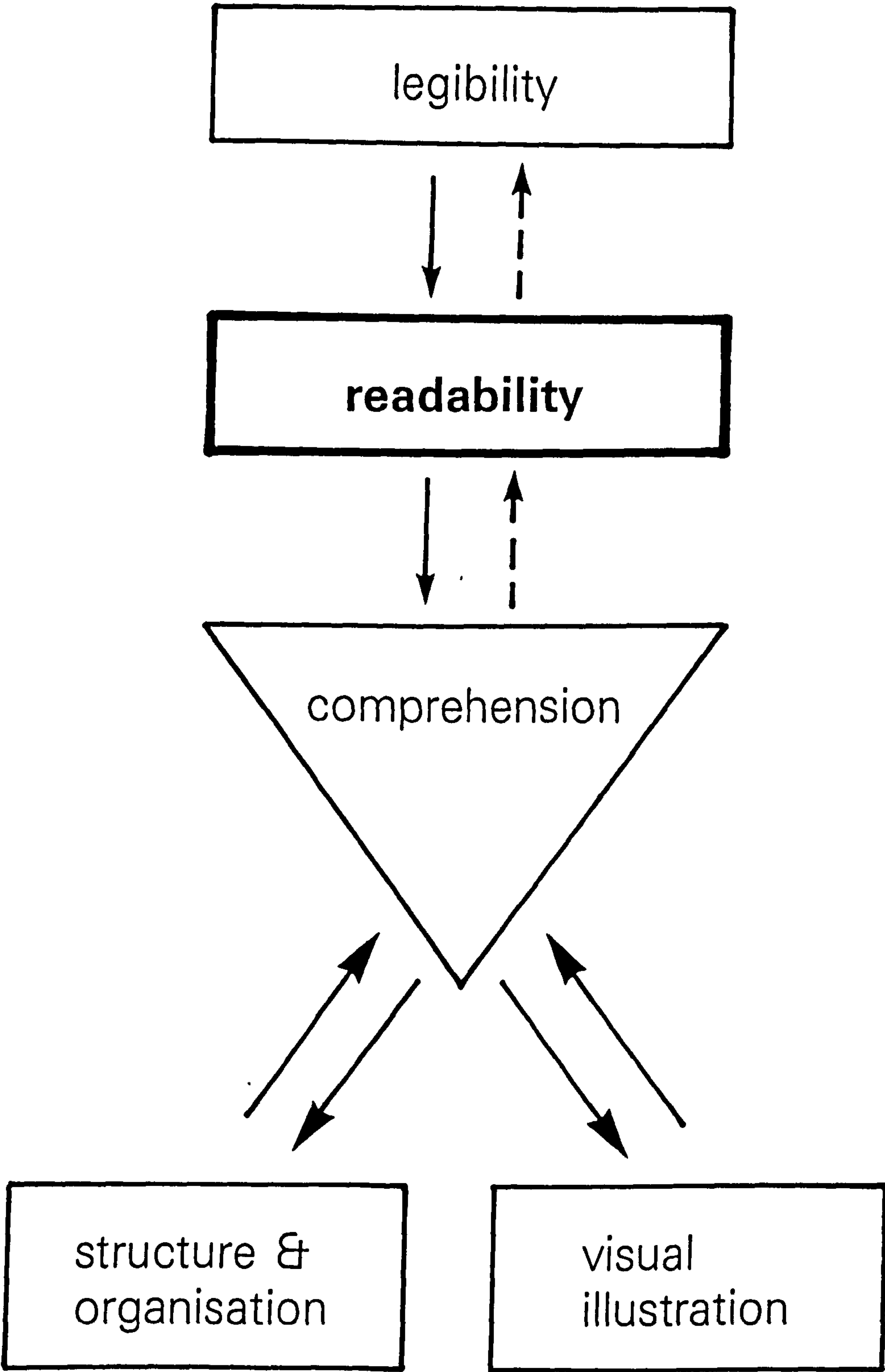
## **1.8 Postscript**

Reference was made in this chapter, on more than one occasion, to the work of Sir Cyril Burt (Burt, 1959), some of which was accepted without comment but other aspects of which were noted as being statements without empirical evidence. Hartley and Rooum (1983) have, however, re-examined Burt's contribution to the study of typography in the areas of the spacing of words and text on the page, the effects of serifs on reading speed, the effects of typefaces on reading speed and comprehension, the effects of typesizes and line lengths on reading speed and comprehension, and preferences for typefaces. They concluded that Burt's contribution to typographic practice was marred by the same defects as can be found in his other work, but acknowledged that many of the conclusions that Burt came to were not out of line with current thinking even although they often went beyond the data given.



<b>2 From legibility to readability</b>	
<b>2.1</b>	<b>Introduction</b>
<b>2.2</b>	<b>Affective aspects of readability</b>
2.2.1	Motivation and readability
2.2.2	Congeniality and readability
2.2.3	Communication in relation to readability and congeniality
<b>2.3</b>	<b>Cognitive aspects of readability</b>
2.3.1	Measures of readability
2.3.1.1	readability formulae
2.3.1.2	non-formula measures
2.3.1.3	comparison and application
2.3.2	Critical review of readability measures
<b>Discussion of issues in chapter 2</b>	







## 2. Chapter orientation

“If a text is not readable, it won’t be understood”

The intention behind the principle stated above is a suggestion that the more *readable* a text is, the more likely it is to be understood. The fact that ‘readability’ was, for many years, virtually synonymous with ‘legibility’ suggests that legibility is, at least, associated with readability, but readability goes far beyond legibility, and it is the dimensions of readability beyond legibility which are pursued in this chapter.

From analysis of a definition and description of the concept of readability it is clear that several aspects of the reading process together with their interactions are involved. It is also clear that interactions can be text-based reader-based, or be between text and reader. These various interactions constitute, in effect, affective and cognitive aspects of readability, and it is from each of these perspectives that research relating to readability is reviewed.

Affective aspects of readability examined are motivation, congeniality, and communication, and they are considered within a framework suggested by Zajonc (1980) which contends that the emotional system is a pre-cognitive process responding quickly and holistically.

Cognitive aspects of readability considered are concerned with the difficulty that a reader may have in understanding a text and, in particular, with measures used for assessment of that difficulty which, in turn, are critically appraised in relation to the ‘comprehension’ element they purport to include.

The research relating to affective and cognitive aspects of readability is then discussed and principles are derived with respect to motivation and semantic/syntactic structure of text. The need for a clearer theoretical approach to readability, based on a better understanding of the comprehension process, is acknowledged.



## 2 From legibility to readability

### 2.1 Introduction

Tinker (1965) points out that, around 1940, 'readability' came to be regarded as a more descriptive and meaningful word than 'legibility' but that, with the advent of 'readability formulas' devised to measure the difficulty of reading material, an entirely different meaning developed for 'readability'. Readability is, thus, not just another term for legibility.

Dale and Chall (1949) define readability as

“the sum total (including interactions) of all those elements within a given piece of printed material that affects the success which a group of readers have with it. The success is the extent to which they understand it, read it at optimum speed and find it interesting”

(p 23)

Gilliland (1972) notes that this definition stresses three aspects of the reading process: comprehension, fluency, and interest, and points out that these three elements interact with each other to affect readability. The interactions to which Dale and Chall (1949) refer, however, are interactions *within* the printed material. The issues of comprehension, fluency, and interest to which Gilliland (1972) refers, not only interact with each other as he suggests, but could, conceivably, involve interactions between the reader and the printed materials.

Klare (1963) states that the term 'readability' has come to be used in three ways:

- (1) to indicate legibility of either handwriting or typography;
- (2) to indicate ease of reading due to either the interest-value or the pleasantness of writing; and
- (3) to indicate ease of understanding or comprehension due to the style of writing.

He notes, however, that most of the recent research has concentrated on the last aspect which, together with the widespread publicity given to readability



formulas designed to measure comprehensibility, has made the third use the most common. In a later review he indicates that the study of readability is an active research area, with well over a thousand publications from the 1920s to the present and that, from the beginning, 'readability' has meant 'understandable' and the emphasis on this meaning (as opposed to 'legible' or 'interesting') has grown with the research (Klare, 1982).

It must be noted, therefore, that in moving from the concept of *legibility* and its associated principles to the concept of *readability* and the principles which may develop from that, there is a transition from the physical detail of the letter or word or, even, arrangement of words, into another dimension relating to the cumulative effect on comprehension of letters combined into words, words into sentences, sentences into paragraphs, and paragraphs into pages of instructional materials.

The first of the three usages of the term 'readability', viz. an indication of the legibility of typography, was dealt with in chapter 1. The purpose of this chapter is to examine the research relating to the two other uses of the term in their relationship to the facilitation of comprehension, and this will be done by following a model of the relationship of readability and comprehension proposed by Klare (1984a) in which he identified what he con-

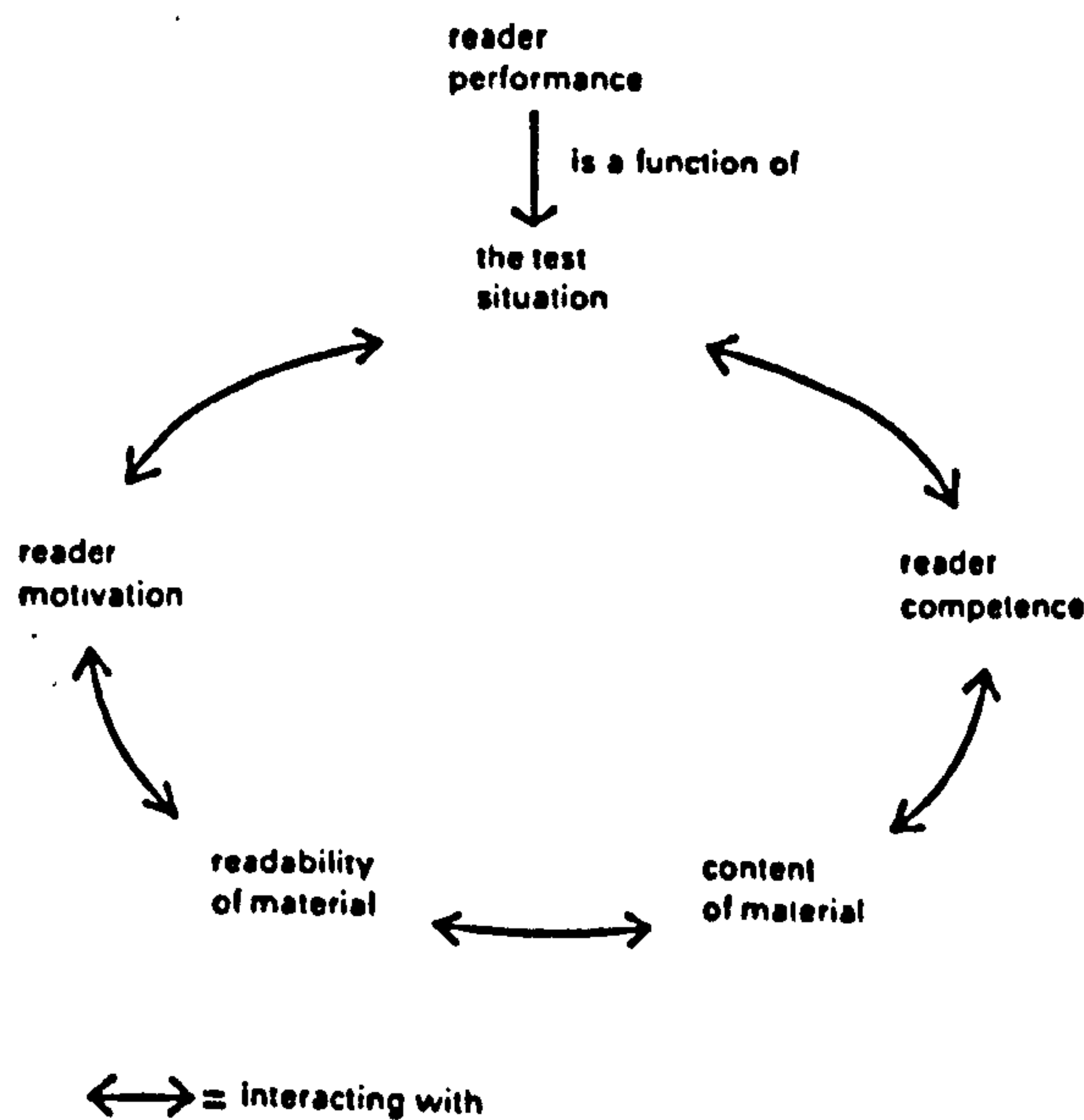


fig 2.1 The relationship of readability and comprehension. (Klare 1984a, p 484)

sidered to be the two most important issues, viz. the relationship of motivation and readability, and the relationship of content and readability



to comprehension. The issues are, in essence, affective and cognitive aspects of readability, and it is within these separate frameworks that the research will be considered although it is acknowledged that there will be some interaction between them and this will be discussed as necessary.

## **2.2 Affective aspects of readability**

The point has been made by Zajonc (1980) that affect is considered by most contemporary theories to be post-cognitive, to occur only after considerable cognitive operations have been accomplished, a perspective with which he disagrees, arguing that affective reactions can occur without extensive perceptual and cognitive encoding. He concludes that affect and cognition are under the control of separate and partially independent systems that can influence each other in a variety of ways, and that both constitute independent sources of effects in information processing. This is a significant perspective because,

“If there is indeed a separation between affect and cognition, then it is not surprising that research on preferences, attitudes, attractions, impressions, aesthetic judgments and similar affective responses — research that commonly has invoked cognitive mediators -- has not been terribly successful”

(Zajonc, 1980, p 158)

Bereiter (1985) has noted that interest seems to be growing in the idea that the emotions represent a system in their own right for dealing with information, a system that interacts with the more commonly delineated cognitive system but that has distinct properties of its own. The emotional system, Zajonc (1980) observes, responds quickly, holistically, in terms of approach and avoidance, whereas the cognitive system responds slowly and analytically, in terms of identification and interpretation. Support for these ideas has come from Bastick (1982) who has assigned to the emotional system the basis of intuitive thought, with the cognitive system serving purposes of testing and verification, and from Pribram (1980) who has emphasised the interaction between attentional controls arising from lower brain centres which respond in the manner associated with the emotional system and



those from higher brain centres which bring stored knowledge to bear on states of attention.

### **2.2.1 Motivation and readability**

Although it is widely accepted that motivation is an important prerequisite to learning and, as Smith and Dechant (1961) point out “without motivation learning seldom, if ever, occurs” (p 269), it has to be acknowledged that, as Wigfield and Asher (1984) observed, “researchers interested in the development of .... motivational processes generally have not explored how such processes operate in particular .... contexts such as reading” (p 423).

Before reviewing the ‘motivation literature’ which is specific to text, it will probably be more helpful to consider the issue of motivation in general and infer, from that, relevance for printed materials, then consider the specific findings in relation to print and set them in the context of general motivation principles.

Hamachek (1973) suggests that motivation is a *process* that can

- (a) lead students into experiences in which learning can occur;
- (b) energise and activate students and keep them reasonably alert;
- (c) keep their attention focused in one direction at a time.

In a recent review of the subject, Ball (1982) refers to the fact that most of the research on motivation has been set within the context of the psychologist’s understanding of motivation as the process involved in the arousing, directing, and sustaining of behaviour and emphasises five points about motivation.

1. Motivation is a hypothetical construct which can be inferred from a person’s behaviour in a particular environment.
2. The concept of motivation should not be over used as an explanatory device.



3. Motivation is only one of many constructs presumably affecting a person's behaviour.
4. Motivation concerns many processes that are perhaps related.
5. Motivation in education necessarily leads to questions about values.

In noting the many processes that may be involved he refers, in particular, to *curiosity, locus of control, achievement motivation, anxiety, self-esteem, and attribution*, but also notes that there has to be an integration of these processes.

Day (1984) has referred to an 'infinite array of theories' of motivation, but highlights *curiosity, achievement motivation, anxiety, and competence motivation* as intrinsic motivations relevant to the educational process.

While curiosity is recognised as one of the oldest motivational factors investigated, it has been noted by Vidler (1977a) that there is no clear, acceptable, definition of it. He also notes that educational implications based on the study of curiosity are necessarily limited in the absence of answers even to some of the most basic questions about curiosity, but Berlyne (1963) describes curiosity as a state of tension induced by an environment high in uncertainty and response conflicts that leads to many possible forms of exploration. He argues that environmental factors that induce curiosity are those high in collative variability such as incongruity, novelty, complexity, difficulty, and contradiction. Day (1984) points out that the feature of interest to education is the notion that collative variability not only induces a motivation to explore (curiosity) but also directs that motivation towards those features in the environment which are high in collative variability. Thus the individual will be attracted to the aspect of the environment which is novel or complex and will explore it until uncertainty has been reduced, the goal of the exploration being information acquisition and the result being learning.

Locus of control has been explained as the perceived causality of behavioural outcomes with, at one extreme (internal) the individual thinking of himself as being responsible for his own behaviour, and at the other extreme



(external) the individual seeing luck or circumstances beyond his control as responsible for his behaviour. Attribution of responsibility is obviously a closely related concept and stems from a search for understanding which involves asking 'why' questions and leads to attributional responses — attributing causes to success or failure outcomes.

Weiner (1979), in order to systematise the attributed major causes of success or failure (e.g. ability, effort, task difficulty), proposed a three-dimensional table involving locus of control (internal or external), stability (stable or unstable), and level of control (controllable or uncontrollable), with ability being seen as stable or uncontrollable, effort as stable and controllable, and task difficulty as external to the learner but stable and uncontrollable from the learner's view point.

Fanelli (1977) has investigated locus of control and suggests that if people think their success is caused by ability (internal), then feelings of competence and confidence are experienced, but if success is seen as resulting from external factors such as help from others, then gratitude and similar emotions are usually experienced. A generalisation made by Ball (1982) is that students with an internal locus of control tend to have a somewhat higher need for achievement and are more persistent than students with an external locus of control.

The motive called 'need for achievement' has been extensively researched (under the heading of *achievement motivation*) and refers, as Vidler (1977b) has pointed out, to a pattern of actions and feelings connected to striving to achieve some internalised standard of excellence in performance. Halperin and Abrams (1978) found support for the notion of an attribution model of achievement motivation in that previous performance and attributions explained almost all of the variations in the final examination predictions of undergraduates in an economics course, and Wigfield and Asher (1984), in recognising that the attribution model emphasises the role of cognition in achievement motivation, have argued that there are important developmental differences in reasoning about achievement outcomes, and that other achievement related constructs such as expectancies and values have been shown to be important predictors of achievement motivation in real-world settings.



It is generally believed that a student's behaviour is a function of the student's self-concept and that self-esteem is a worthwhile goal in itself as well as being, perhaps, a cause of scholastic achievement, but Scheirer and Kraut (1979) found overwhelmingly negative evidence for a causal connection between self-concept and academic achievement and suggest caution among educators and theorists who have assumed that enhancing a person's feelings about himself would lead to academic achievement. Shavelson and Bolus (1982) showed that self-concept can be distinguished from academic achievement and that the relationship between grades and subject-matter self-concept is stronger than the relationship between grades and academic self-concept. They also noted the causal predominance of self-concept over achievement. Ball (1982) has noted that although self-concept is clearly involved in attribution, achievement motivation, anxiety, and other motivational concepts, its very obviousness seems to have resulted in insufficient critical study.

Dulin (1978), from a reading education perspective, identified four meanings of 'affect' with respect to reading text, viz.:

- (a) affect as attitude toward reading;
- (b) affect as motivation to read;
- (c) affect as preference for certain reading materials, and
- (d) affect as specific response to reading.

The affect aspect of reading refers, therefore, to:

- (a) the over all, long term *attitudes* individuals and groups hold toward reading;
- (b) the levels of immediate *motivation* to read operating within individuals and groups at particular times and under particular conditions;
- (c) the pattern of *preference* for particular reading materials operative among certain readers or groups of readers; and
- (d) the particular patterns of emotional or affective *response* that occur when readers are confronted with various characteristics of style or print format within reading materials.

Examination of the motivational issues discussed indicates that most could, to some extent, be associated with aspects of text, either in *what* is said, or



*how* it is said. Very little of what has been discussed, however, with the exception of the last point in Dulin's (1978) analysis, can be associated with the overall effect of layout and the facilitating of a desire to read material.

Gilliland (1972) recognises that the initial factor in a person which affects his reading is the degree of interest which he shows in it, and suggests that such interest can be because of either an emotional reaction, an affective response, or an intellectual stimulus, or cognitive reaction, but notes that while material may be read primarily for pleasure, it may happen also to satisfy intellectual curiosity. Entin (1980) found a cumulative effect of readability and interest and comprehension, and Klare (1984a) has interpreted this as further evidence of the effect of motivation by altering reader interest. The role of motivation has also been stressed by Fry (1975) and by Klare (1976a), and Fass and Schumacher (1978) have shown experimentally that motivation can interact with readability to affect comprehension.

In discussion of the issues raised in motivation studies, the emphasis is usually on either characteristics of the students or the creation of conditions within a learning environment (usually a classroom) which will maintain or increase motivation. It is difficult to see how factors other than the 'interest' factor can readily contribute to the design aspects of printed materials for instruction. The main conclusion can only be that interest, pleasingness, attractiveness, congeniality, and related issues are the only factors which are likely to contribute to motivation in relation to learning from text. Within the text itself, it may well be possible to structure the material so that it exploits some of the other factors and this will be returned to later.

There are other factors related to motivation which seem to affect readability and potential for comprehension. Klare (1963) suggests that a reader's level of motivation can involve a 'set to learn' factor, described as a readiness to learn related to motivation, and further suggests that a person *required* to read will have a strong set to learn, while a person reading *voluntarily* will usually have a weaker set to learn. He also argues that the kind of level of the reader's motivation will partially determine whether more readable material produces greater understanding, learning, and retention, citing his own unpublished studies to show that the reader must have a strong set to



learn before the advantages of a more readable over a less readable version become apparent. Purpose in reading is, therefore, something which has to be taken into consideration.

In a discussion of perception principles, Fleming and Levie (1978) state that

“perception is strongly affected by what we expect or are ‘set’ to perceive. This influences both what we select and how we organise and interpret it”.

(p 12)

They cite, as an example, that when the first chapter of a book begins with a brief synopsis and ends with a series of questions, one expects the subsequent chapters to be similarly patterned.

Perhaps there is a need to examine the nature of information given at the beginning of a chapter, not so that the reader expects other chapters to begin similarly but rather that motivation might be heightened through the determination of purpose and the identification of relevance and meaningfulness. This theme will be returned to in chapter 5.

The issue of perception in a more general sense and also in the particular aspect of illustration in text will be pursued in chapter 4.

### **2.2.2 Congeniality and readability**

At several points in chapter 1 it was suggested that congeniality may be an important consideration in relation to legibility: equally, it may be an important affective aspect in relation to readability.

As noted earlier, Poulton (1972) suggested that the advantages of one typeface over another may be due to familiarity, citing the case where groups of scientists read most easily a particular typeface with which they were already familiar through scientific journals. Similarly, Tinker and Paterson (1942) noted a marked agreement between legibility and ‘pleasingness’ for different typographical arrangements and concluded that judged legibility may be accepted as equivalent to pleasingness.



It was also noted that Burt (1959) claimed that nearly all readers in his investigation tended to read with greater facility the kind of types that they preferred or to which they had become habituated, and it was suggested earlier that the issue of 'justification' might also be related to reader expectation and preference. The implications for readability are clear — irrespective of the semantic and syntactic criteria of readability there are other factors which are going to affect the facility with which a reader can cope with printed material, and these factors include the pleasingness or congeniality of the typeface and the layout used for the material.

Zachrisson (1965) suggests that contact, craftsmanship, aesthetic considerations, and functional considerations have traditionally influenced typographic style and quotes (or rather translates) from Lindberg that

“works by a number of natural scientists, scholars, and philosophers have been given their often highly accessible, pedagogically inspiring typography and illustration in spite of, and contrary to, and not aided by, traditional printing styles”.

(p 73)

Although Knuttel (1951) believes that most readers are susceptible to the effect of the whole page, to the arrangement of the type rather than to the aesthetic qualities of each individual letter, it has to be acknowledged that much of the investigation in the area of congeniality relates only to typeface preference.

This is evidenced in the work of Burt (1959) who collected examples of the commoner type faces in use at that time and submitted them to people of both sexes with a request that they arrange them in order of preference. No mention was made about the differences being aesthetic as he and his co-workers were interested in discovering whether judgments were comparable with other modes of aesthetic appreciation. It was concluded from the investigation that the observed 'bipolar' factor — one group preferring old faces (a group which consisted essentially of students and lecturers in a faculty of arts) and the other preferring modern faces (a group which contained regular readers of scientific and mathematical works and a large proportion of the non-academic readers ) — implied that different kinds of type are suited to different kinds of task, and that individual deviations



from the general order of preference were due, in part, to an effect of habituation.

A further investigation apparently suggested that a preference for older type faces is associated with what Burt calls 'romantic' tendencies in other forms of artistic appreciation, while the preference for modern type faces tends to be associated with a 'classical' taste.

In relation to legibility and preference, it was concluded that, in practice,

"legibility is not merely a matter of the size and shape of the black marks on the white paper or of the physiological efficiency of the eye; there is also what might be called a 'psychosomatic' influence at work; printed matter seems more legible, and reading becomes more accurate and quick, when the material is set in a type which the reader, perhaps without realising it, finds aesthetically pleasing".

(p 28)

Haskins (1958) investigated the appropriateness of typefaces in regard to headings for various magazine articles, all of which were printed in the same bold type. His results showed that some typefaces had a wider applicability than others, reflecting their familiarity and their legibility. He found that Cheltenham and Bodoni were preferred for crime stories, Futura Bold for sports, and Bodoni for medicine.

Kastl and Child (1968), noting that typefaces used in books and advertisements seem often to be chosen to emphasize or convey certain moods, investigated some of the physical attributes of type which apparently make mood communication possible. They looked at the influence of four typeface variables — angular v. curved, bold v. light, simple v. ornate, and serif v. sans-serif — on judgements of emotional meaning in 40 college students. It was found that, in general, moods such as 'sprightly', 'dreamy', and 'soaring' tend to be matched to curved, light, ornate and possibly sans-serif type; while moods such as 'sad', 'dignified', and 'dramatic' are matched to angular, bold, and possibly serif type.

Tannenbaum, Jacobson, and Norris (1964), acknowledging that a communication message has at least two distinctive components — content and form



or structure (or *what* is said and *how* it is said) — attempted to determine whether typography can communicate connotative variations. They used three groups of subject with differing knowledge of typography and, although there were differences between the groups, the authors claim that the evidence shows that there is a substantial basis for the use of typography as a code for the communication of connotative variations.

Becker, Heinrich, von Sichowsky, and Wendt (1970) investigated the influence of typeface and leading on perceived appealingness of a printed page and concluded that

- (a) different typefaces need different amounts of leading to allow the composition of most appealing printed pages;
- (b) sans-serif and italics may need one point more leading than roman types;
- (c) unjustified composition requires neither more nor less leading than justified composition; and
- (d) neither of these two styles of composition is considered more attractive than the other.

Bell and Sullivan (1981) investigated student preference for typography by presenting a paragraph in a number of typestyles, sizes, and leadings, as a result of which they identified preference for medium rather than bold, 11 pt rather than 10 pt, and 2 pt rather than 1 pt leading. This work was criticised by Hartley (1982a) on the grounds that the findings for the various typographic settings of a single paragraph were limited because the students judged the paragraph out of context and because typographic decision-making about layout cannot be done solely on the basis of one method of evaluation. In support of his argument he refers to his own work where tests of readability, reading speed, and recall indicated one layout as being more effective than another and that a stated preference for the more effective layout is regarded only as supporting evidence.

Interestingly, Hartley and Trueman (1981) note that although a considerable literature now documents how typographical layout can be manipulated to improve the comprehension of instructional text and, similarly, a considerable literature now documents how text can be re-written in order to make it easier to understand, little has been done to partial out the



contributions that changes in layout and changes in readability can make to the effectiveness of a particular text. In order to do this, they asked readers for their preferences for versions of text which varied in terms of layout, readability, or both of these features, and concluded that subjective preferences can, in fact, provide additional information about the effectiveness of changes to text but that this information cannot be relied upon too greatly if final judgement is required.

Wrolstad (1960), in recognising that typography functions at two levels in the communication process — at the reading or verbal level and at the design or non-verbal level — conducted an experimental study designed primarily to investigate communication between the typographer and his audience at the design or non-verbal level, the intention being to draw together in one multi-factor experimental design variables important in this particular communication process in order to examine the effects of these variables and their interactions on audience response to typographic design. The independent variables were *age*, *education*, and *sex* of the subject; *symmetry* of typographic design (symmetric and asymmetric approaches to typography); and *principles* of typographic design (balance, contrast, proportion, rhythm, and unity). The study posed two general questions:

- (a) do adults prefer examples of good typography when paired with examples of poor typography?
- (b) what are the effects on these preferences of the five variables and their interactions?

Zachrisson (1965) noted that there was a lack of pertinent results from Wrolstad's work, suggesting that the "good" material was really mediocre and this confused the issue, and that the categorisation (balance, contrast, proportion, rhythm) is nebulous. However, inspired by Wrolstad's efforts, he conducted his own investigation where the criterion was congeniality rather than excellence. He was able to conclude that there is a relation between *typographic design* and its *theme* or *message* as judged both by experts and non-experts and, from this, imply that the case for typography as a vehicle of a congenial effect is strengthened.



### 2.2.3 Communication in relation to readability and congeniality

As noted earlier, Tannenbaum et al (1964) discussed typeface connotation in the context of communication. They argue that basic to the selection of typeface is the notion that typefaces have some communication capacity, constituting a code capable of communicating different meanings between two or more people.

The communication model of Lasswell (1948), "*who says what in which channel to whom with what effect*", at least suggests that there is an intended outcome in any communication; that of Berlo (1960), the S-M-C-R model (source-message-channel-receiver), argues that a message has to be encoded by the source and decoded by the receiver; and that of Gerbner (1956), the Interaction Model, provides a perceptual dimension, pointing out that perception is selective and that in an ideal process there could be "valid perceptions freely selected in a representative context of pertinent evidence".

Tannenbaum et al (1964) argue that for any set of symbols to serve as a communicating code, two basic requirements must be met: variations in the code must be systematically related to variations in the meanings intended to be communicated, and users of the code, encoder and decoder alike, must have substantial agreement in the meaning assigned to these variations. This is consistent with the comments of Hartley and Trueman (1981) that "preference data can be quite sensitive to the effects of training in using documents with different layouts".

In suggesting areas for further research Tannenbaum et al highlight a need for the acquiring of a detailed knowledge of the intrinsic connotative associations of the basic elements of typography in the development of a systematic code so that typography may be used as a fundamental aid in the central function of written message, the communication of meaning and, in particular, connotative meaning. This issue is relevant to the use of typographical cueing, and will be discussed in chapter 5.

The majority of the research reviewed has been concerned with the affective dimension of typeface, but there has been, at least, a suggestion that there is



probably a connotative effect of the over all layout of a page including the headings, sub-headings, body text and illustration, and this matter will be explored further in chapter 5.

Although the main focus of concern in the above review has been with the affective communicative aspects of the physical parameters of text, it has to be recognised that the content of the message can have an affective dimension. This has been highlighted by Coke (Coke, 1981; Coke & Koether, 1983a, 1983b, 1984, 1985) who observed that writing styles have an affective impact on readers and that readers' affective reactions contributed directly to their expectations about the stylistic clarity and reading ease of documents. In some cases, these expectations were contrary to predictions of reading ease based on the lexical and syntactic complexity of passages, the topic which will be discussed in the next section.

## **2.3 Cognitive aspects of readability**

Harris and Jacobson (1979) cite the work of Herbert Spencer published in 1852 on the topic of 'Philosophy of Style' as a convincing introduction to the subject of readability, and note that Spencer uncovered a dilemma arising from the different requirements for conveying the affective and cognitive impact of the message since the affective component benefits from stylistic variety which affects the reader's interest and mood while the cognitive component benefits from the economy and efficiency of short, concrete words, short sentences, and simple style. Within the context of communication, as Richaudeau (1985) points out, for a message expressed by a 'transmitter' to be effectively received and decoded by a 'receiver', the author of a text must use words and grammatical constructions with which the reader is already familiar. This theme has also been highlighted by Gilliland (1972) who suggests that readability studies should be of immediate concern to writers where the intention is

"to communicate expressly facts, theories,  
impressions, attitudes and values" (p 15)

and where an ability to do this may be influenced by

"the knowledge which he has of the reading  
ability of his potential readers, and by his



knowledge of the way in which such things  
as sentence construction and the arrange-  
ment of ideas can influence understanding”.

(p 15)

Harrison (1980a) has stated that

“Unlike some areas of psychological re-  
search . . . . work on readability is not  
‘pure’ research: it is applied or it is nothing”.

(p 10)

Perhaps this is so, or certainly should be so, but, as Davison (1985) has noted, the term ‘readability’ is generally used to refer to the assessment of the difficulty that a reader of a certain level of skill may have in reading a piece of connected written discourse, or text, with the difficulty being measured in terms of how well readers are able to understand it by giving correct answers to questions about the texts. She notes, further, that the most commonly used method of measuring readability in the last 50 years has been the application of one or more readability formulae. Klare (1963) draws attention to the fact, however, that such readability formulae were not designed to measure all the important aspects of writing, measuring, rather, only one aspect of writing, namely *style*, and then only one aspect of style, namely *difficulty*. Nevertheless, style difficulty is an important cognitive issue related, as it seems to be, to reading speed, acceptability, understanding, and learning.

### **2.3.1 Measures of readability**

Although methods of determining readability were devised in the first third of the twentieth century, it was not until the time of the second world war that they became reasonably efficient and relatively simple to use. Of the very many formulae developed, only a few will be discussed here because they are sufficient to illustrate the concept of readability and its relevance to a study of the design of print as a medium of instruction.



### 2.3.1.1 Readability formulae

In essence, a readability formula assigns to a piece of text a numerical estimate of the reading skill a person needs to understand the material. Most formulae are based on two procedures: determination of word length and sentence length.

The most widely used readability formula is that of Flesch (1943, 1948, 1950) and it is of particular value in relation to printed materials for adults as it does not emphasise vocabulary in the way that other earlier formulae did. After considerable development, he proposed two formulae, Reading Ease and Human Interest.

The essence of these formulae is as follows:

#### ○ Reading Ease

- systematically select 100 word samples from the material to be rated;
- determine the number of syllables per 100 words (wl);
- determine the average number of words per sentence (sl); and
- apply these to the undernoted reading ease equation:  
$$RE = 206.835 - 0.846 \text{ wl} - 1.015 \text{ sl}$$

#### ○ Human Interest

- systematically select 100 word samples as above;
- count the number of personal words per 100 words (pw);
- count the number of personal sentences per 100 sentences (ps); and
- apply these in the undernoted human interest equation:  
$$HI = 3.635 \text{ pw} + 0.314 \text{ ps}$$

Flesch (1949) explains that the reading ease score falls between 0 (practically unreadable) and 100 (easy for any literate person) and the human interest score is on a scale from 0 (no human interest) to 100 (full of human interest).

The second most frequently used readability formula is the Dale-Chall (1948a, 1948b) formula which was designed, as Flesch's revisions had been, to correct shortcomings in the original Flesch formula. The procedure for using is to



- select 100 word samples throughout the material to be rated;
- compute the average sentence length in words ( $X_2$ );
- compute the percentage of words outside the Dale list of 3000 ( $X_1$ , or Dale score); and
- apply in the formula

$$X_{c_{50}} = 0.1579X_1 + 0.0496X_2 + 3.6365$$

(where  $X_{c_{50}}$  refers to the reading grade score of a person who could answer correctly one half of the test questions on a passage).

Other formulae were developed, primarily as improvements on existing formulae. For example, Farr, Jenkins, and Paterson (1951) developed a modification of the Flesch Reading Ease formula by proposing a simplification that required the syllable count then used being replaced by a count of one-syllable words to reduce analysis time and remove the need for a knowledge of syllabication on the part of the analyst, and Gunning (1952) proposed a formula which is similar to that of Flesch, but in which the syllable count is replaced by a count of words having three or more syllables. The resulting “Fog Index” is the reading grade level required for understanding the material.

Powers, Sumner, and Kears (1958) re-examined the four readability formulae described above and concluded that the Dale-Chall formula is a much more powerful tool for predicting reading difficulty, and that the Flesch formula is the best one of those not using a word-list.

A later review by Klare (1974) examined recalculations and revisions of existing formulae, and looked at new formulae which had been proposed for general-purpose and special-purpose use. It was noted that Flesch, Dale-Chall, Farr-Jenkins-Paterson, and the Fog Index were still relevant and widely used. The newer formulae tended to be more specialised but one, the SMOG grading, developed by McLaughlin (1969), which utilizes the number of words of three or more syllables in the formula

$$\text{SMOG grading} = 3 + \sqrt{\text{polysyllable count}}$$

had general applicability.



All of the readability formulae described above have used the various McCall-Crabbs *Standard Test Lessons in Reading* (McCall and Crabbs, 1925, 1950, 1961) as a criterion because, as Klare (1974) points out, these lessons have been convenient statistically due to the large number of reading passages covering a wide range of difficulty, resting upon extensive testing, and providing detailed grade scores.

Klare (1984b) notes that, by 1973, formula designers had tried well over 200 different language variables and had, in fact, developed almost as many different formulas, and he summarises the trends in readability research as follows:

- “ ● Early emphasis on word frequency as an indicator of word difficulty supplied the basis for the first objective measures of readability, the first readability formulas.
- Readability formulas evolved quickly into statistical regression equations involving a number of different language variables which could be subsumed under word (semantic) or sentence (syntactic) factors.
- Attempts to involve variables other than semantic or syntactic (e.g. format, organization, content) in formulas failed almost entirely, but attempts to improve upon these two major sources of variance have continued.
- Developers began to provide formulas which yielded grade-level scales so that mismatches between readers' tested ability and school-text readability could be assessed more easily. Various writers have, however, questioned the validity of grade-level scales.
- Early criticisms of the criteria for formula development led first to the use of the multiple-choice-based McCall and Crabbs *Standard Test Lessons in Reading*, which has recently received its own share of criticism. Later work evolved in two directions: use of the cloze procedure as an alternative criterion and specialized criterion development for specialized formulas.
- Users found early formulas tedious to apply (and sometimes, therefore, also unreliable); efficiency grew in importance as formulas became more widely used (and led, in turn, to still wider usage). Two major



directions have emerged: manual application aids and computer programs". (p 687–688)

As noted earlier, 'understanding' was initially measured by use of standard test lessons and the application of multiple choice questions, but the emergence of the cloze procedure developed by Taylor (1953) as a convenient test of readability — a criterion of readability rather than a predictor of readability — led to other readability formulae being developed which were not based on the McCall-Crabbs *Lessons*. Examples of these are the formulae of Coleman (1965) and Bormuth (1969) which, because of the large number of passages covering a wide range of difficulty involved, enabled predictive formulae to be developed. Nevertheless, Miller (1972, 1974) has shown that formulae using cloze scores as a criterion consistently yield higher predictive validity coefficients than those using multiple choice test scores of the sort provided by the McCall-Crabbs *Standard Text Lessons in Reading*.

As Klare, Sinaiko, and Stolurow (1972) point out, a cloze test measures how well a reader understands a given passage: it can measure how well the reader already knows something; it can measure what can be called 'redundancy utilization' (Weaver and Kingston, 1963) in what is unfamiliar material; and it can measure readability.

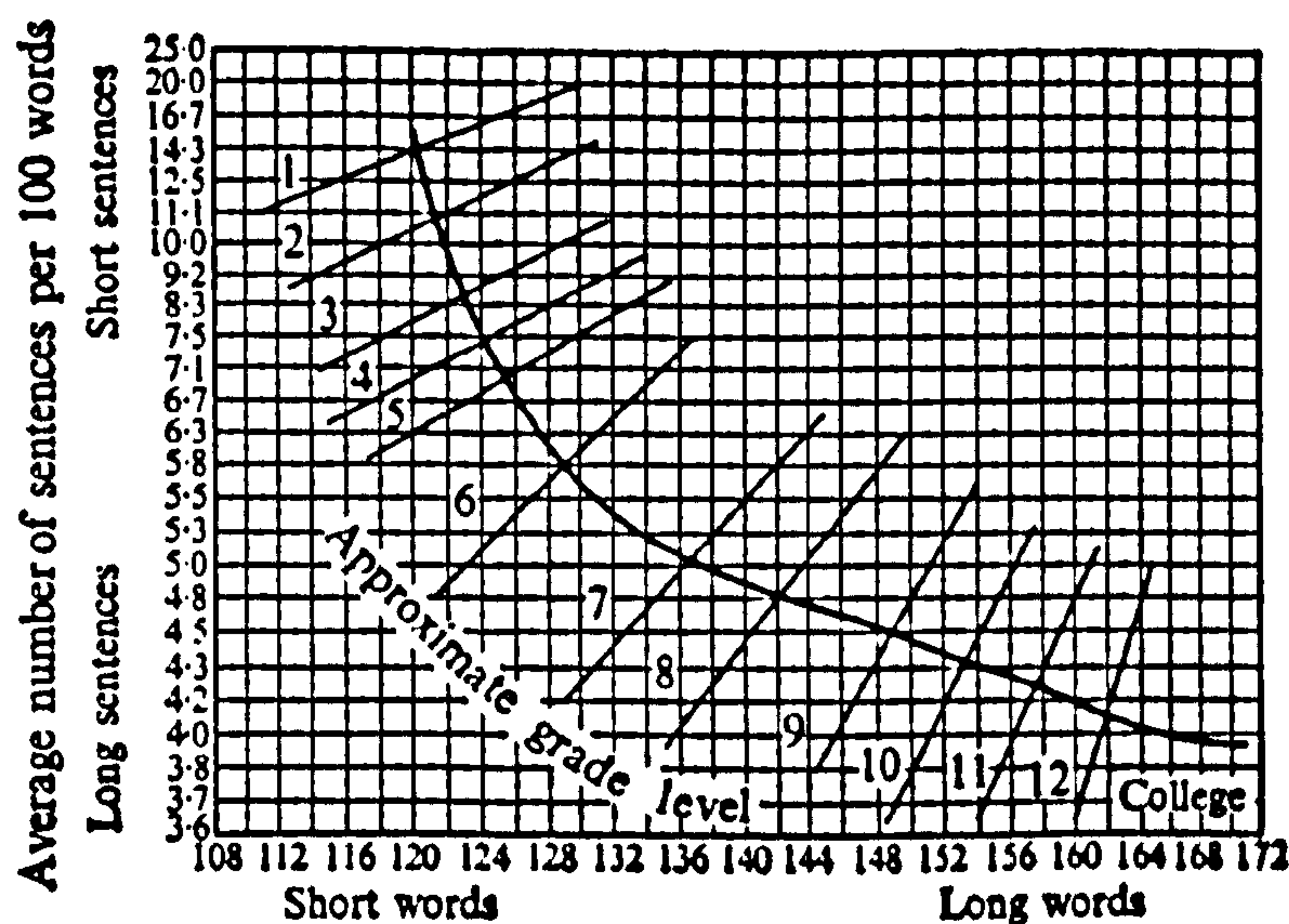
Based on the concept of 'closure' and a tendency to 'close' incomplete figures, the procedure involves the deletion of every  $n$ th word, preferably every 5th word, in passages with a request that readers fill in the blanks. A word is scored as correct only if it is the same as the word deleted. It seems to be widely agreed that the cloze procedure measures the relative comprehensibility or intelligibility of written material and that it does this well. Vaughan and Meredith (1978) have substantiated its reliability, and several cloze-based reading comprehension tests have been published [NFER (1977), College Entrance Examination Board (1980)]. Hines and Warren (1978) have developed a computerised technique for producing cloze text material.

Despite the apparently widespread agreement regarding measure of comprehensibility, what is meant by comprehension is not made clear and, since only the use of the exact word is acceptable in the cloze procedure, it would appear that comprehension may be equated with recall, and this is something which will be returned to later in the chapter.



### 2.3.1.2 Non-formula measures

Fry (1968, 1977) developed what he called a readability formula but which is really a graph for predicting readability. The user counts the number of syllables per 100 words and the number of words per sentence and enters these in the graph, then takes the readability score from the graph (fig 2:2).



Graph for estimating readability by Edward Fry, Rutgers University Reading Centre.

fig 2.2

According to Klare (1982) the Fry graph is the most frequently used approach in education because of its convenience, and ease of application, and Longo (1982) has confirmed its validity in relation to the college levels.

The desire for ease and convenience led to the development of a Readability Estimate by Raygor (1977) which, according to Baldwin and Kaufman (1979), is even quicker to use presumably because it relies upon a count of words of six or more letters compared to Fry's use of a count of syllables, since both involve a sentence-length count and use a graph to get grade-level scores.

Less objective methods of assessing readability have been attempted involving variations in style other than style difficulty. Di Vesta (1954) compared three styles of writing — popular and personal, formal expository (as in textbooks), and study guide (training material in study units) — but found that style of writing had no effect upon either achievement test scores or retention test scores.



It is worth noting that the judgment of readers can be used effectively: the works of Schwartz, Sparkman & Deese (1970), Coke (1973), Carver (1974), and Gillen, Kendall, and Finch (1977), suggest that readers can provide sensitive and reliable judgments of readability which have very high predictive validity coefficients. However, it has been noted by Jorgensen (1975) and by Miller and Marshall (1978) that teachers assign varying grade level difficulty ratings to passages with a known grade placement. Harrison (1980b) has pointed out that judgments of this type are often six to nine age-levels apart, and Palmatier and Strader (1977) found that high school teachers were not competent to make decisions as to reading difficulty.

Nevertheless, as Klare (1982) indicates,

“These studies provide encouraging evidence that human judges can indeed be accurate, and at the same time provide discouraging evidence of why this procedure has never really caught on. Reliable text rating procedures that are appropriate for use in evaluating shorter pieces of reading material cannot be adapted easily to the longer pieces of reading material most teachers want to evaluate”.

(p 1521)

The use of human judges of readability was pursued by Carver (1974, 1975–76) and by Singer (1975). Carver’s system, called the Rauding Scale, involves the average judgment of three qualified raters who have matched a passage against an anchor set of six passages. That of Singer is known as the SEER (Singer Eyeball Estimate of Readability) technique and involves the judgment of one or two judges matching a sample of text against one of two readability scales. Froese (1979, 1980) compared the two methods and found the SEER approach better than the Rauding approach, but only when using several raters rather than the single rater advocated by Singer. However, Duffelmeyer (1982) found the Rauding Scale to be better than the SEER technique when compared with established formula values such as Dale and Chall.

### **2.3.1.3 Comparison and application**

With so many named ways of measuring readability there were, inevitably, comparisons such as that described above between various formulae and non-



formulae methods. In some cases it would take the form of a new or revised measure and would automatically make comparison with existing, established, systems. Examples of this are to be found in the Lix and Rix method of Anderson (1983), the checklist approach of Irwin and Davis (1980) and the ThUS (Thought Unit Sentences) approach of Lowe (1979). Alternatively, it could be a minor improvement on existing systems as exemplified by Powers and Ross (1959) who developed diagrams for calculating readability scores based on Flesch, Dale-Chall, Farr-Jenkins-Paterson, and Gunning, and Maginnis (1982) who developed a 'Smogometer' for easier, faster, and more reliable SMOG readability ratings. Others, such as that of Miller (1972) were straightforward comparisons of readability formulae with respect to their predictive validities. There have also been reflections by the originators of particular formulae many years after the introduction of their systems, so that Gunning (1968) was able to conclude that during more than twenty years the Fog Index had helped many writers to keep their writing from going beyond the bounds of complexity, and Chall (1979) could assert that the existing formulas could be useful to publishers, educators, and students, although she added the caveat "if used with understanding and moderation".

Despite any advice of caution from their originators, the practical uses of readability formulae increased greatly with, according to Chall (1981), applications not only in textbook selection and development but in adult literacy, and, according to Sticht (1975a), in training programmes for the armed forces and even in consumer information (Chall, 1979), but not without expressions of concern over their possible misuse.

Sticht (1975b), concerned with the readability of job materials, has argued that the major usefulness of an appropriate readability index is that it permits an immediate estimation of the reading ability level required to understand a passage using only clerical operations, but he does acknowledge that technical material presents problems. Funkhouser and Maccoby (1971, 1975) however, successfully applied several readability yardsticks including Dale-Chall, Flesch, and Farr-Jenkins-Paterson, to articles on enzymology in an attempt to communicate specialised science information to a lay audience, but it is interesting to note that 'organisation' of the text was an important variable, a point also made by Huggins and Adams (1980). Trapini and Walmsley (1981), in attempting to simplify documents in accordance with readability formulae,



concluded that the choice of readability formula could affect which linguistic variables are used to determine a readability level, and, more importantly, which of these (either alone or in combination) can be changed to reduce the apparent readability level of a document. The readability formulae are differentially affected by the presence or absence of particular linguistic components.

Application of readability formulae to textbook selection and adaptation has been widespread but has been questioned by Davison, Kantor, Hannah, Hermon, Lutz, and Salzillo (1980) who argue that those who adapt need to be sensitive to the demands of discourse structure as well as to readability formulae, and by Davison (1981) who argued that changes should be made in a text because of inherent difficulty in the text and not just to influence the score that the text will receive via readability formulae. McConnell (1982), in reviewing the use of readability formulae in the selection of college economics textbooks, suggests that serious questions are raised about the usefulness of readability formulae since they exclude critical qualitative variables that affect reader comprehension. Campbell (1979) argues that matching readers with textbooks requires more than reliance on readability formulae since many factors influence how difficult it is for a student to read a given textbook. MacGinitie (1984) identifies the practice of using readability formulae as a basis for modifying or creating texts as one which threatens to make the use of readability formulae more harmful than helpful, and Davison (1984) concludes that readability formulae have a generally negative and harmful effect on the writing and revising of texts to be used as reading materials.

Clearly the application of readability indices has highlighted serious problems and a critical appraisal of their effectiveness is justified.

### **2.3.2 Critical review of readability measures**

Early criticism of readability measures came from Bormuth (1969) who identified an urgent need to undertake systematic analysis of the comprehension processes. This emphasis on the need to understand the comprehension



process is more radical than the criticism frequently associated with readability formulae. The comment by Powell (1981) that the weaknesses of readability formulae can be overcome with knowledge and care and that, although not a substitute for good writing, they can help a good writer to polish his product, is fairly typical of a large group of writers on the subject. Even this level of criticism does not seem to be heeded, with Lister (1982) discussing the application of readability formulae without even a word of caution. Lange (1982) claims that it is not the use of readability formulae that presents problems, but the use of the formulae either as the only evaluation of a text or as the starting point for adapting a text.

Selzer (1981, 1983) argues that readability research has oversimplified and does not incorporate individual reading differences, and that readability formulae, despite their good intentions, do not assist in reaching the goal of clear, efficient, useful, and comprehensible writing. Battison and Goswami (1981) assert that, *inter alia*, readability formulae do not measure organisation, effectiveness, or relevance to the audience, and Redish (1981) argues that a readability formula cannot replace good training in how to write clear, well-organised, audience-focused material.

The view that readability formulae can be useful if properly applied is dismissed by Duffy (1985) who argues that there are few, if any, proper applications of existing readability formulae that are of practical use. Bruce, Rubin and Starr (1981a, 1981b) claim that nearly all uses of readability formulae violate the basic assumptions on their applicability and that the real factors that affect readability are elements such as the background knowledge of the reader relative to the knowledge presumed by the writer, the purpose of the reader relative to the purpose of the writer, and the purpose of the person who is presenting the text to the reader. The prediction of the comprehensibility of a document on the basis of either a match between the document's readability and the subject's reading level has been shown by Walmsley, Scott, and Lehrer (1981) to be very unreliable, a finding which is consistent with that of Wright (1980) that no characteristic of the text can predict how easily it can be read.

In an expression of reservation regarding the use of readability formulae as good predictors of readability, de Beaugrande (1984) notes



“First, it is far from certain that *structural* factors must correspond to *experiential* ones . . . . Second, the structural measures imply that the processing of the surface text is a constant value in all instances of reading comprehension . . . . Third, the correlation between surface structure and purpose of reading is still opaque”. (p 162)

However, he does acknowledge that it might be necessary to retain the older formulae but to alter the interpretation of them; to regard them not as complete measures of readability, but as practical measures of reading ease.

Klare (1981) has acknowledged that readability measures may well have been oversold; publicity has made them known; and their convenience, efficiency, and apparent generality of scale have resulted in their being not only widely used but uncritically applied. He cites criticism of their application outside the field of education, including that by Kern (1979) who questioned their use with military material, that by Charrow and Charrow (1979) in relation to legal material, and the various writers in Joenk (1981) concerning technical material, as contributing to widespread mistrust of readability formulae. Klare (1981) argues that an alternative to abandoning formulae is to select and apply them with care, particularly in relation to *when* they are used, *how* they are used, and *why* they are used. This approach does not, however, tackle the basic arguments against the use of readability measures.

Rubin (1981) has criticised standard readability formulae because they are based on ‘low-level’ text characteristics such as number of words per sentence or number of syllables per sentence, arguing, rather, that there is a need to focus on the *concept* communicated by the text. How arguments are presented, what place examples play in an exposition and what inferences must be made by the reader, are seen as ‘high-level’ characteristics which contribute to a notion of ‘conceptual readability’. Goetz (1981) places ‘conceptual readability’ in the larger context of the determinants of comprehensibility. He recognises that, while physical attributes of a text such as those associated with readability formulae may contribute to a text’s difficulty, there is a need to look beyond the obvious surface characteristics for optimal prediction. He argues that an understanding of the real causes of comprehension diffi-



culties which might lead to the improvement of text or readers will require the development of hypothetical constructs which go beyond the surface characteristics of text.

“The difficulty or ease with which a reader will comprehend a text depends at least upon:

- (a) the underlying conceptual difficulty of the topic or content of the text;
- (b) how clearly the content is expressed; and
- (c) the extent to which the reader has the requisite knowledge of the world, knowledge of the language, and knowledge of the comprehension process itself”. (p 51)

A similar emphasis on readability being more than text-based is made by Tamor (1981) who suggests that a combination of text-based and performance-based operationalisations of the notion of text difficulty, or readability, needs to be considered, which he describes as ‘subjective’ text difficulty and which is related to different matches between the subject’s skills and knowledge and the demands of the text. Irwin (1980) has also pointed out that text structure alone cannot determine readability and that all considerations of readability must include reader-related factors such as prior knowledge, attitude, and motivation.

Within the growing criticism of existing readability formulae, as Klare (1984b) points out, the current structure-of-text orientation in reading research offers a significant new direction for the development of new formulae and new ‘non-formulae’. As Venezky (1984) notes, regarding the questioning of readability formulae,

“ . . . little can be concluded definitely except that whatever faults these formulas have, they have become permanent fixtures in the instructional landscape”. (p 25)

Kintsch and Vipond (1979) have pointed out that the problem of predicting reader comprehension is not with the formulae but with the theories within which the formulae operate, and they argue strongly for a clearer theoretical approach to readability. Given the evidence reviewed in this chapter, that theoretical approach can only be found in a better understanding of the comprehension process and the reading process which results in comprehension.



Klare (1984a) alleges that the state of confusion in the area of comprehension clearly affects the area of readability and cites in support of his claim, the fact that different readability formulae predict anywhere from 50% to 100% comprehension on the McCall-Crabbs Test Passages, depending upon which formula is chosen. Using cloze procedure, they can predict anywhere from 35% to 55% comprehension. Sadly, however, most users think that readability formulae are predicting 'comprehension'. As Klare (1984a) states,

“ . . . until we know better what goes into comprehension, we can hardly be expected to help would-be producers of readable writing . . .”.

(p 493)



## **2 Principles and practice in readability**

### **– a discussion of the issues in chapter 2**

#### **2.1 Introduction**

The identification of cognitive and affective aspects of readability is a useful distinction but it would be a mistake to ignore their interaction. McLaughlin (1974) argues that 'readability' is generally taken to mean that quality of written material which induces a reader to go on reading, and that readability is a matter of willingness to read material rather than ability to comprehend it. Harris and Jacobson (1979) lament that the contribution of graphics to the comprehensibility of the cognitive and affective components of a message has received little attention and needs a great deal of study, as does the interaction of the graphic design with the textual material. Clearly the cognitive and affective aspects of readability are related, despite the paucity of research in that area. In attempting to derive relevant principles for readability and identify their implications for practice, attention will be paid first to affective and cognitive aspects separately, then to potential interaction or totality.

#### **2.2 The issue of affective aspects of readability**

The framework established by Zajonc (1980), Pribam (1980), Bastick (1982), and Bereiter (1985) of separate, but related, affective and cognitive systems is relevant to the present discussion. In particular, Zajonc's (1980) contention that the emotional system responds quickly and holistically, and that it is a pre-cognitive process, has relevance for the design of print since it could have direct effect upon the two affective aspects of readability identified, viz. motivation and congeniality.

##### **2.2.1 Motivation and readability**

Within the framework of motivation in general as reviewed earlier, Dulin's (1978) analysis of the topic from the perspective of reading education



highlights key issues for the designer of printed instructional materials. While the over all, long term attitudes individuals hold toward reading and the levels of immediate motivation to read operating within individuals at particular times and under particular conditions are very much *reader-based*, the two other affect aspects which Dulin identified, viz. the pattern of preference for particular reading materials operative among readers, and the particular patterns of emotional or affective response that occur when readers are confronted with various characteristics of style or print format within reading materials, could be considered to be either *reader-based* or *text-based* in that they could be *text-induced*. Taken in conjunction with Gilliland's (1972) claim that an affective response can trigger a degree of interest which is, in turn, the initial factor which affects a person's reading, it is clear that there is a case for the design of printed materials in such a way that motivational factors are exploited, that interest is aroused, and that readability, in the sense of willingness to read, is increased.

The evidence from Entin (1980), Fry (1975), Fass and Schumacher (1978) and Klare (1976a, 1984a) concerning the interaction of motivation and readability resulting in improved comprehension reinforces the importance of attention to this affective aspect of readability. From the evidence reviewed and in the light of the above discussion of motivation, the following principle is derived.

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"If a text is designed to generate optimum readability,  
reader motivation will be enhanced".

---

Such a principle emphasises the text-induced aspect of readability and, further, the interactive nature of readability. It posits that whatever initial motivation exists can be heightened through the design of text which is, in an affective sense, 'readable', and that readability will, in turn be improved because of the increased motivation. Application of this principle in practice requires, therefore, that considerable attention be directed to those aspects of the text which contribute to its affective dimension.



## 2.2.2 Congeniality and readability

Every reader has been conscious at one time or another, if not of a desire to read something because of typographical appeal, then of a desire *not* to read something because of the lack of typographical appeal. In the extensive review of literature undertaken as part of this thesis it was observed that some of the publications by organisations concerned professionally with the teaching of reading were particularly uncongenial due to the choice of typeface and the layout on the page. "Physician, heal thyself!" (St. Luke 4:23). Given the earlier discussion regarding the importance of motivation, congeniality needs to be considered, primarily, as a factor which can both initiate and sustain motivation to read and, through motivation, to affect comprehension.

The research reviewed in relation to acceptability of typeface suggests that, if readers are accustomed to a particular typeface or associate typefaces with particular applications, this needs to be taken into consideration in the design of the printed message. Such an approach is, of course consistent with a communications model approach or a systems approach to instruction and is, respectively, identification of *what* is being said to *whom*, or the design of instruction for an identified target population. Unfortunately, recognition of this factor is more common in the field of commercial communications than in instructional design. Perhaps education has still to learn of the basis for the use of typography as a code for the communication of connotative variations as described by Tannenbaum et al (1964). The relationship between typographic design and its theme or message has been established as has the case for using typography as a vehicle of congenial effect (Zachrisson, 1965). Sadly, recognition has not been sufficiently widespread, due, in part, to the generally low level of recognition of the importance of affective aspects of readability in general. Nevertheless, from the review of research and its discussion, the following principle relating to congeniality can be derived.

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"If typestyle and layout are appropriate to the topic and the readership, motivation to read will be enhanced".

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The application of this principle in practice is obviously difficult and could readily result in acceptance of the *status quo* on the grounds that custom is established and change in custom would lead to loss of congeniality. There are, in effect, two competing criteria for congeniality; the topic determines, to an extent, the appropriateness of typestyle and layout, and the readership determines, likewise, what is appropriate not only to the readership but to the readership's perception of the topic. If the readership and the topic are being brought together for the first time, the tradition of the topic is not significant and only the reader and his/her ideas of relevance of text need to be taken into consideration. On the other hand, if the readership has established links with the topic both the nature of the topic and the expectations of the reader are of significance, in which case appropriateness may well mean conformity with established practice.

## **2.3 The issue of cognitive aspects of readability**

Within the context of 'readability' being interpreted as ease of understanding owing to the style of writing, Klare (1984b) identifies the importance of readability as an area of research as resting upon three related considerations:

- (a) the amount of reading a technological society requires for success;
- (b) the observed decline in reading skills (in U.S. high schools); and
- (c) the partial solution to the pincer-like attack of increased reading combined with decreased reading skills by making writing easier to understand.

Nevertheless, he acknowledges that

"a procession of critics, from general commentators to respected scholars, have questioned both the validity and the value of readability measures".

(p 682)

An anonymous reviewer of a paper submitted for an educational technology conference made the following comment.

"Your paper was hard to read. The ideas are not complicated, but your style is. Check your



writing with a readability formula, like the Gunning Fog Index. (The average index on your first three and last three paragraphs was about 24. It should be around 12–14)''.

If the ideas were not complicated and could obviously be readily understood from the text, conformity with established readability index norms is really of little consequence. Nevertheless, this indiscriminate, and uncritical use of readability indices is common: the real need in the discussion is therefore to identify the usefulness of readability indices and the limitations of their usefulness, particularly in relation to any general principles which can be derived.

As Klare (1984a) indicates, almost all readability formulae have been concerned primarily with predicting the comprehensibility of visually presented language. He readily acknowledges that the first major purpose of readability research is to distinguish between samples of writing which are more or less readable (i.e. the *prediction* of readable writing), but that a second major purpose is to decide how to write readably or to change writing to make it more readable (i.e. the *production* of readable writing). Prediction research has, as Klare (1984b) notes, a largely psychometric orientation, but production research has a largely psycholinguistic orientation. It has to be recognised that the prediction of comprehension scores using available indices can yield very high correlations (Klare, 1984a; Davison, 1985) although Britton (1985) has suggested that the nature of comprehension scores predicted by readability formulae, giving as many as six decimal places, gives a strong impression of mathematical precision which cannot be justified.

Ignoring the widespread misuse of readability indices, there remains the problem of basic conceptual issues, much of it associated with what is meant by 'comprehension'. Kintsch and Vipond (1979) have argued strongly for a clearer theoretical approach to readability, and some of the more recent developments of readability formulae have been grounded in the emerging understanding of the concept of comprehension. Thus Miller and Kintsch (1980) have developed a formula that takes account of coherence between propositions, and Rubin (1981) has proposed that formulae need to take into account how arguments are presented and what inferences must



be made by the reader. Amiran and Jones (1982) have proposed a new definition of readability based on high-level text characteristics such as structure, texture, and information density of the text. However, these developments will be discussed after the issue of comprehension has been explored.

In the meantime, it has to be recognised that individual readers do have particular reading abilities. Whether these can be categorised as good/bad or whether they need to be graded in some more detailed way is not necessarily germane to this discussion. What is crucial is that there does need to be a match between the reading demand of the material being designed and the reading ability of the individual for whom it is being designed. If the surface criteria of word and sentence length give some indication of the difficulty of the material, so be it — there is no reason why such a measure should not be made. What does seem inappropriate is to attempt to relate that measure to an allegedly homogeneous group of readers who happen to be the same age or in the same stage of education. Perhaps a more crude distinction between broad groups of reader ability would suffice, given the coarse nature of the guidelines which can be developed from consideration of only surface features, or low-level characteristics, of the text.

At this stage of the discussion, an appropriate principle with respect to readability, particularly given the current practice in readability, might be

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“If the semantic and syntactic structure of the text is matched to the vocabulary and reading ability of the reader, there is more likely to be meaningful interaction between reader and text”.

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## **2.4 Conclusion**

Despite the widespread criticism associated with readability research due, almost entirely, to the misuse of and extravagant claims for readability indices, it is clear that readability is an important issue in the design of



text as an instructional medium. The affective aspect of readability can, potentially, induce emotional and motivational factors which are crucial to the arousing of interest and the focusing of attention which, in turn, are prerequisites to the facilitation of comprehension. The content and, in particular, the way in which the content is structured (one aspect of which is style) is also implicated in the reading comprehension process. Thus, the two aspects of readability are critically related to comprehension (however comprehension is defined) and it would not be overstating the case to draw a general principle of readability viz:

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“If a text is readable, it is more likely to be understandable”.

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The specific principle derived earlier, viz:

“If the semantic and syntactic structure of the text is matched to the vocabulary and reading ability of the reader, there is more likely to be meaningful interaction between reader and text”

is really an explanation of readability based on the surface features of the text and an individual’s ability to process these surface features, and is, certainly, valid and is one which needs to be taken into consideration. As noted in the introduction, educational practice tends to regard the concept of readability as a major factor in the design of instructional text, with many computer programs having been written to predict readability and, even, to help produce text to a given level of readability. It is important, therefore, that there should be clear understanding of what can and cannot be achieved through the utilisation of readability measures.

Like legibility, readability intervenes between a reader and a text but, unlike legibility, readability is not only text-based since the outcome of reading — understanding/comprehension — does not lie in the text. Readability is, in effect, created in an interaction between text-based and reader-based dimensions. The following diagram (fig 2.3) usefully summarises the current position.



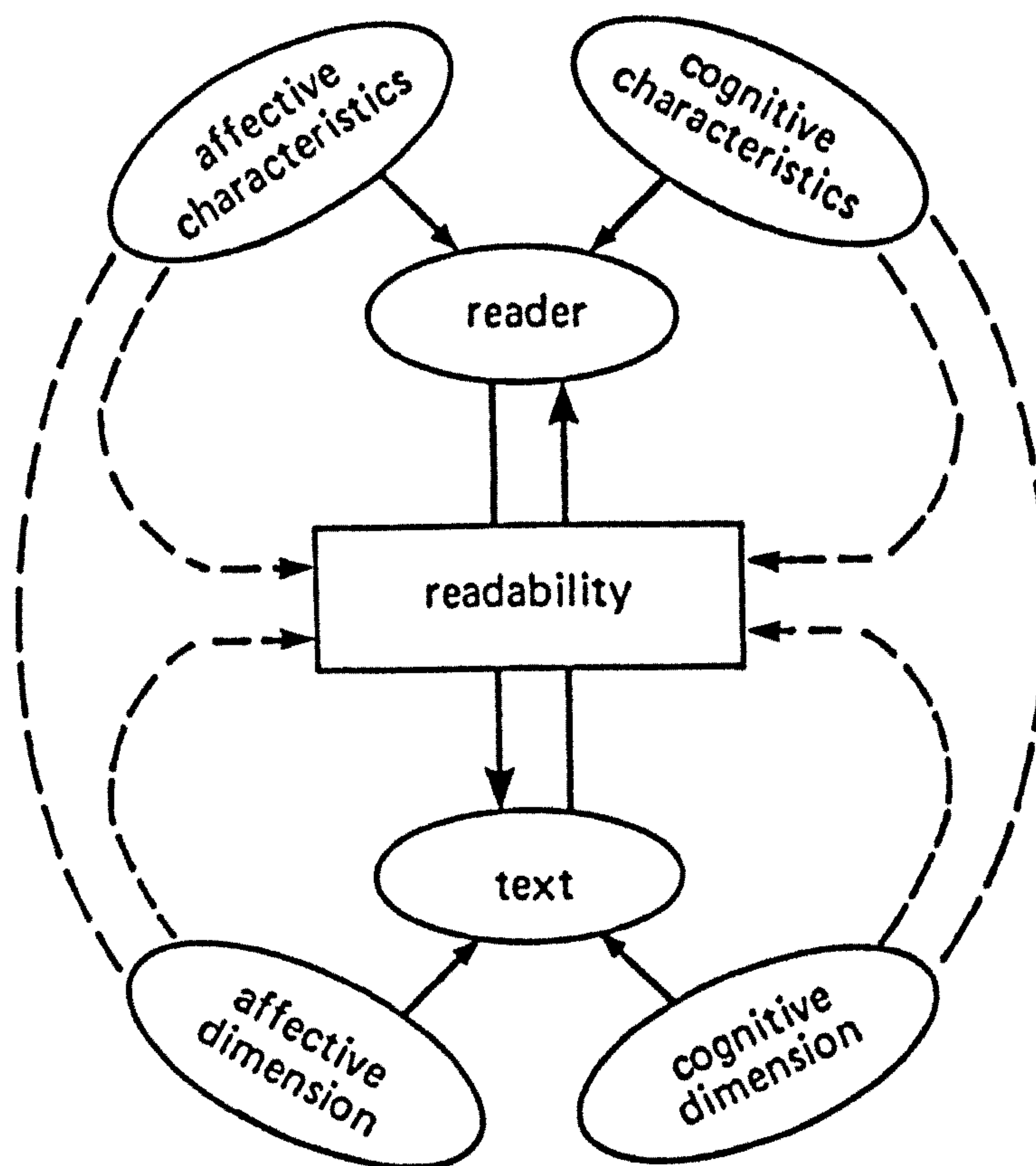


fig 2.3



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## **3 From readability to comprehension**

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### **3.1 Introduction**

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### **3.2 Reading comprehension**

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#### **3.2.1 The contribution of linguistics theory and psycholinguistics**

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#### **3.2.2 The contribution of cognitive psychology**

- 3.2.2.1 representations and formal models of text structure
- macrostructure
  - propositional representations
  - schema-based processes
  - reconciling macrostructure, propositional representation, and schema theory

#### **3.2.3 The contribution from models of reading**

- 3.2.3.1 the Gough model
- 3.2.3.2 the La Berge & Samuels model
- 3.2.3.3 the Rumelhart model
- 3.2.3.4 an independent-process model
- 3.2.3.5 the Kintsch model
- 3.2.3.6 the Stanovich model
- 3.2.3.7 the Just & Carpenter model
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#### **3.2.4 Other issues in comprehension**

- 3.2.4.1 generative processes
- 3.2.4.2 elaboration and comprehension
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#### **3.2.5 The contribution from eye-movement research**

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#### **3.2.6 Levels/depth of processing**

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#### **3.2.7 Imagery**

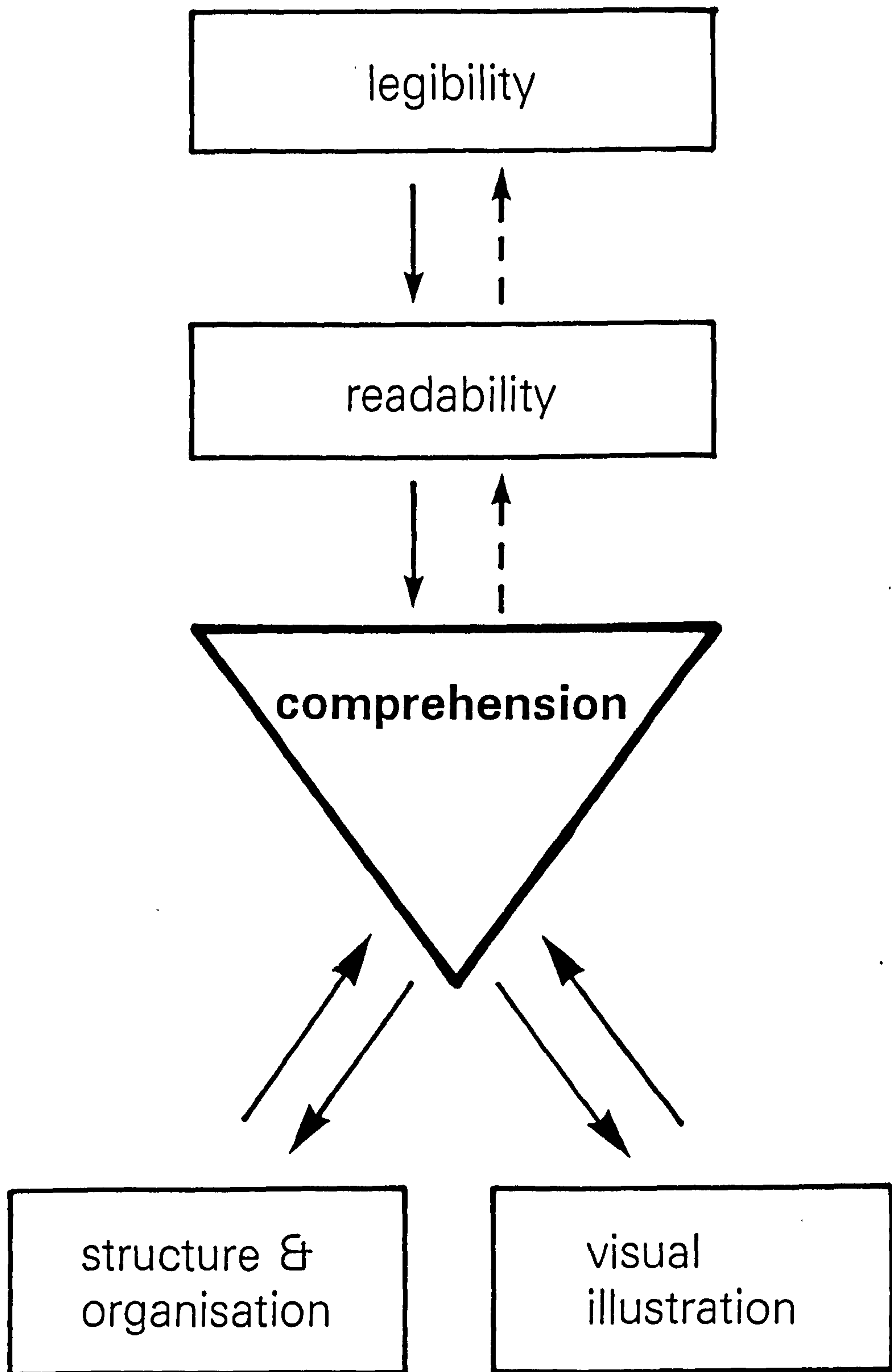
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**Discussion of the issues  
in chapter 3**

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### 3. Chapter orientation

The notion of readability, while concerned, ostensibly, with 'comprehension', assumes a conceptualisation of comprehension which is clearly inadequate for the purpose of the design of instructional text.

Accepting the validity of the principle

“If it isn't comprehensible, it won't result  
in meaningful learning”.

the purpose of this chapter is to explore the available research to identify not only a clearer theoretical framework for readability but a theoretical framework for the reading comprehension process which will provide a foundation upon which other aspects of textual design can be constructed.

Accordingly, the theoretical framework for the reading comprehension process is developed from a study of the contributions made by linguistic theory and psycholinguistics, cognitive psychology, eye-movement research, research related to levels/depths of processing, and imagery. The respective contributions are then discussed and principles derived with respect to text-based, reader-based, and interaction variables in the reading comprehension process. Reading comprehension is acknowledged to be a very complex issue and, as a co-requisite with meaningful learning, an essential goal in the design of instructional text.



### **3 From readability to comprehension**

#### **3.1 Introduction**

Kintsch and Vipond (1979) have pointed out that psychologists no longer care about readability and cite the fact that, as indexed by number of references in *Psychological Abstracts*, interest in readability peaked in the 1950's but has been at zero for a decade. Educators, on the other hand do still care and, as evidenced in *Education Index* there was strong interest throughout the 1960's and 1970's. They suggest, however, that much of the research on readability has been practical and unanalytical so that there are now techniques for measuring readability but little understanding of what is being measured.

In a similar vein Simons (1971) argues that readability research has shed very little light on reading comprehension because there has been a tendency to use comprehension tests which lack construct validity and the characteristics of written matter that have been found to correlate with comprehension difficulty can be questioned.

Samuels and Eisenberg (1981) point out that the factors used in the readability formulas cannot indicate why texts having the same readability levels may vary widely in the degree to which they can be comprehended.

A statement by Kintsch and Vipond (1979) is particularly apt and delightful.

“By taking a more complex approach to text structure and text processing, cognitive science may make contact with the art of education and may even prevent readability from going the way of all Flesch”.

(p 334)

According to Chall and Stahl (1982), during the 1970's large scale studies of reading comprehension were undertaken, influenced by a variety of disciplines including linguistics, psycholinguistics, and cognitive psychology, and it is the contribution of these disciplines to an understanding of reading comprehension which must be examined at this stage since it is clear that a clarification of what is meant by comprehension and an understanding of the comprehension process will be fundamental to any attempt to identify



principles relevant to the design of printed materials as a medium of instruction.

## 3.2 Reading comprehension

In his proposal for a new perspective in reading comprehension, Simons (1971) evaluated seven major approaches on the basis of the degree to which they have contributed to an understanding of the basic process. These are, in addition to the readability approach, the skills approach, the measurement approach, the factor analytic approach, the correlational approach, the introspective approach, and the models approach.

The shortcomings of *readability approaches* have already been referred to, but Simons does suggest that an understanding of the reading comprehension process will answer questions such as: What is it about sentence structure and vocabulary load that influences comprehension difficulty?

He argues that the *skills approach* has not been helpful because of a basic confusion over the precise behaviour and cognitive domain of these skills which has led to the naming of skills which are global and vague in nature and which have failed to distinguish between reading and thinking and between the objects and the processes of comprehension.

With regard to the *measurement approach* he asserts that traditional and Cloze tests both suffer from a lack of construct validity and that the degree to which they are measuring other variables extraneous to comprehension cannot be determined until a better description of the comprehension process is provided.

The *factor analytic approach* is dismissed rather curtly by concluding that the studies carried out by a number of workers found that "reading comprehension was composed of the same skills that reading comprehension tests measure" and that, unless the 'mental skills' which have to be performed during the process of reading can be identified, factor analysis is not helpful.



In a similar way he dismisses the *correlational approach* because, as they employ standardised reading tests as measures of reading comprehension, they *ipso facto* define reading comprehension in terms of the skills the tests purport to measure.

With regard to the *introspective approach*, he notes that, as mental processes such as reading comprehension take place at great speed, they are not generally open to introspection.

Simons criticized the theoretical models of that period, partly because they were based upon an inadequate theory of language, but he did recognise that the *models approach* did offer possibilities provided they were based upon more sophisticated studies of language.

In fact, in summing up the research he states that

“the accumulated knowledge of comprehension  
does not go much beyond Thorndike’s  
description written in 1917”

(p 354)

a reference to an earlier quoted statement of Thorndike’s (1917) which described reading comprehension as

“..... a very complex procedure, involving  
a weighing of each of many elements in a sentence,  
their organization in the proper relations to one  
another, the selection of certain of their connotations  
and the rejection of others, and the cooperation  
of many forces to produce the final response”

(p 323)

Since Simons argues that the beginnings of a theory of language comprehension lie in linguistic theory and psycholinguistic research and that these promise a new perspective on reading comprehension, it is appropriate for the development of the present study and for chronological validity to begin with such an examination.

### **3.2.1 The contribution of linguistics theory and psycholinguistics**

Ruddell (1976) claims that the role of psycholinguistics in studying language-skills learning is undoubtedly more powerful than either that of linguistics or psychology considered separately. He suggests that, as psycholinguistics is concerned with the development of an understanding and explanation of



language processing, and reading is a complex psycholinguistic behaviour which consists of decoding written language units, processing the resulting language counterparts through structural and semantic dimensions, and interpreting the deep structure data relative to an individual's established objectives, the relationship between psycholinguistics and reading is apparent.

Carroll (1978), however, points out that

“Up to the present time, probably very few children, and even fewer adults, have learned to read by virtue of any specific benefits or insights that psycholinguistics might have yielded.”

(p 11)

Psycholinguistics has been defined by Carroll as the psychological study of the way human beings learn and use language, with experimental psycholinguistics having to do with the processes by which mature users of language produce and understand utterances (single words or sentences) in spoken or written form, and developmental psycholinguistics being concerned with the study of how children acquire their native language. A further subdivision, neurolinguistics, has to do with the functioning of the brain and the nervous system generally in producing and understanding language, but Carroll warns that it is perhaps unrealistic to separate the different specialisations from one another, suggesting, rather, that they need to be related to the broader field of cognitive psychology which is concerned with a study of the processes of the human mind, in attending to, receiving, mentally manipulating, transforming, storing, and transmitting information.

In fact, the development from linguistics through psycholinguistics allied to cognitive psychology is quite marked as the study of reading and reading comprehension has proceeded.

From the mid 1950's, in a movement led by Chomsky (1957) linguistics developed as a discipline concerned not just with 'surface structure' (i.e. the structure of speech or writing used in communication) but with 'deep structure' (i.e. the structure of the ideas and meanings which underlie the surface structure). The earlier school of linguistics was concerned, primarily, with phonology and morphology whereas the newer school of linguistics became concerned with transformational generative grammar, the variation in sentence structure and the explaining of these variations.



It has been noted by Ruddell (1976) that transformational and semantic theories have proposed the viewing of language at several levels : a surface structure level which encompasses morphemic and syntactic structures; a structural and semantic level which makes provision for processing language for interpretation; and a least-understood level concerned with the deep structure of language where it is hypothesised that the syntactic and semantic components of the language are integrated for language interpretation and stored in memory.

Since facilitation of comprehension of the ideas and meanings underlying the words and sentences used is clearly fundamental to the design of printed instructional materials, the development of linguistic and psycholinguistic theories of reading comprehension could be of considerable significance.

Goodman (1967) has characterised reading as a psycholinguistic guessing game involving tentative information processing, but in a later review (Goodman, 1984) he acknowledges the contribution of other disciplines and concludes that reading is a meaning-seeking, selective, and constructive process in which readers use the least amount of available text information necessary in relation to their existing linguistic and conceptual structures to get to meaning. He further concludes that reading is a cyclical psycholinguistic process since perceptual processing depends on optical input, syntactic processing operates on perceptual input, and semantic processing depends on syntactic input.

“Each cycle is tentative and partial, melting into the next. Inference and prediction make it possible to leap toward meaning without fully completing the optical, perceptual, and syntactic cycles. Yet the reader, once sense is achieved, has the sense of having seen every graphic feature, identified every pattern and word, assigned every syntactic pattern.” (p 107)

Pearson (1976) questioned the validity of the psycholinguistic approach which, he argued, attempted to use a grammatical model as a psychological model. He investigated explicit claims and implicit assumptions emerging from research and theoretical positions in the field of transformational-generative grammar, noting, in particular, the claim of the *deep structure*



*model* that as surface structure form approaches deep structure form, comprehension is facilitated in contrast with the diametrically opposed *chunk model* which claims that comprehension consists of synthesising atomistic propositions into larger conceptual or semantic units rather than analysing complex units into atomistic propositions. The results of his investigations appear to favour the chunk model, and he concludes that, in general, any psychological model which attempts to explain the way in which verbal data are processed must begin with a semantic representation of the total relations involved rather than a syntactic description of the units which make up the relations. As he summarised the issue

“Some content must be put into the head  
before syntactic processing can occur” (p 99)

The concept of “levels of processing” was proposed by Craik & Lockhart (1972) as a framework for memory research and, although widely referred to in comprehension studies has, as Lachman & Lachman (1979) point out, figured only minimally in language comprehension research theory. They note that, in psycholinguistics, comprehension has never been equated with exact recall, being viewed, rather, as changing the input and is concerned with transformations, recordings, inferences, and integrations. In fact, they argue that,

“levels of processing seem to end  
just about where comprehension begins” (p 184)

and suggest that, although comprehension tasks can be ordered on a dimension called “depth” or “levels” it is not clear what relationship, if any, obtains between that dimension and the one involved in levels-of-processing research and the research analysis such research supports.

Perfetti (1977), in acknowledging the view of Craik & Lockhart (1972) that memory is best seen as the operation of different processing levels rather than as strictly storage and transfer of information, has proposed three levels of comprehension or at least levels of sentence processing, where level I is the lowest level of interest for reading, level II is the most basic comprehension level (and termed the “semantic-syntactic” level) and level III is the interpretive level and differs from level II primarily in its integrative quality and is, thus, comprehension of a sentence with respect to something beyond the sentence. Level II, thus, demands basic linguistic competence and level III demands “thinking” or at least some construction of



ideas. From the point of view of the psycholinguistic principles involved in these levels of reading comprehension, Perfetti identifies decoding, meaning analysis, and memory for discourse and suggests that characteristic levels of comprehension are involved in these processes, but claims that decoding and language comprehension are the major ingredients of reading comprehension, and that access of meaning automatically accompanies decoding.

In tracing the intellectual family tree of psycholinguistics, Lachman & Lachman (1979) identify mainstream psycholinguistics as being within information-processing

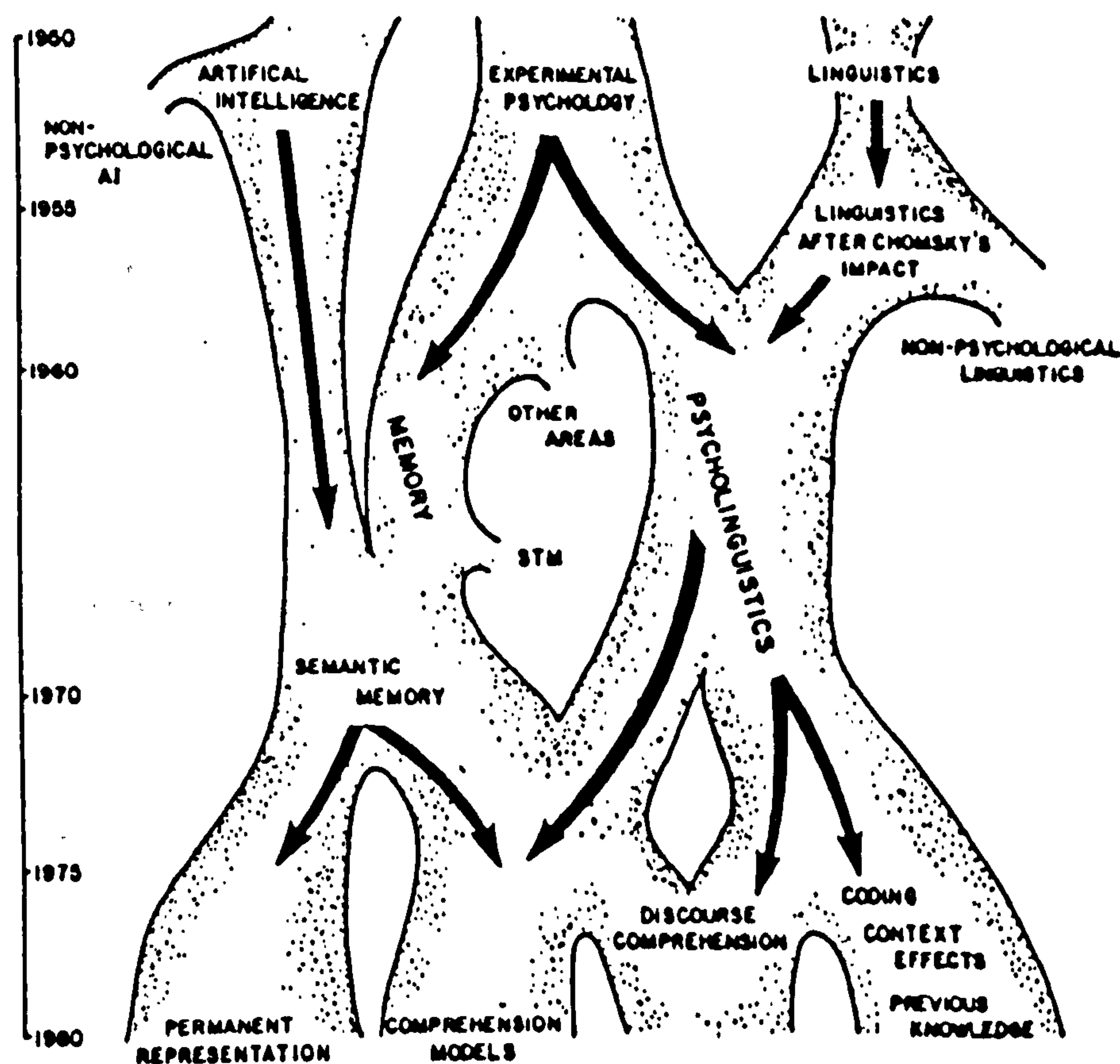


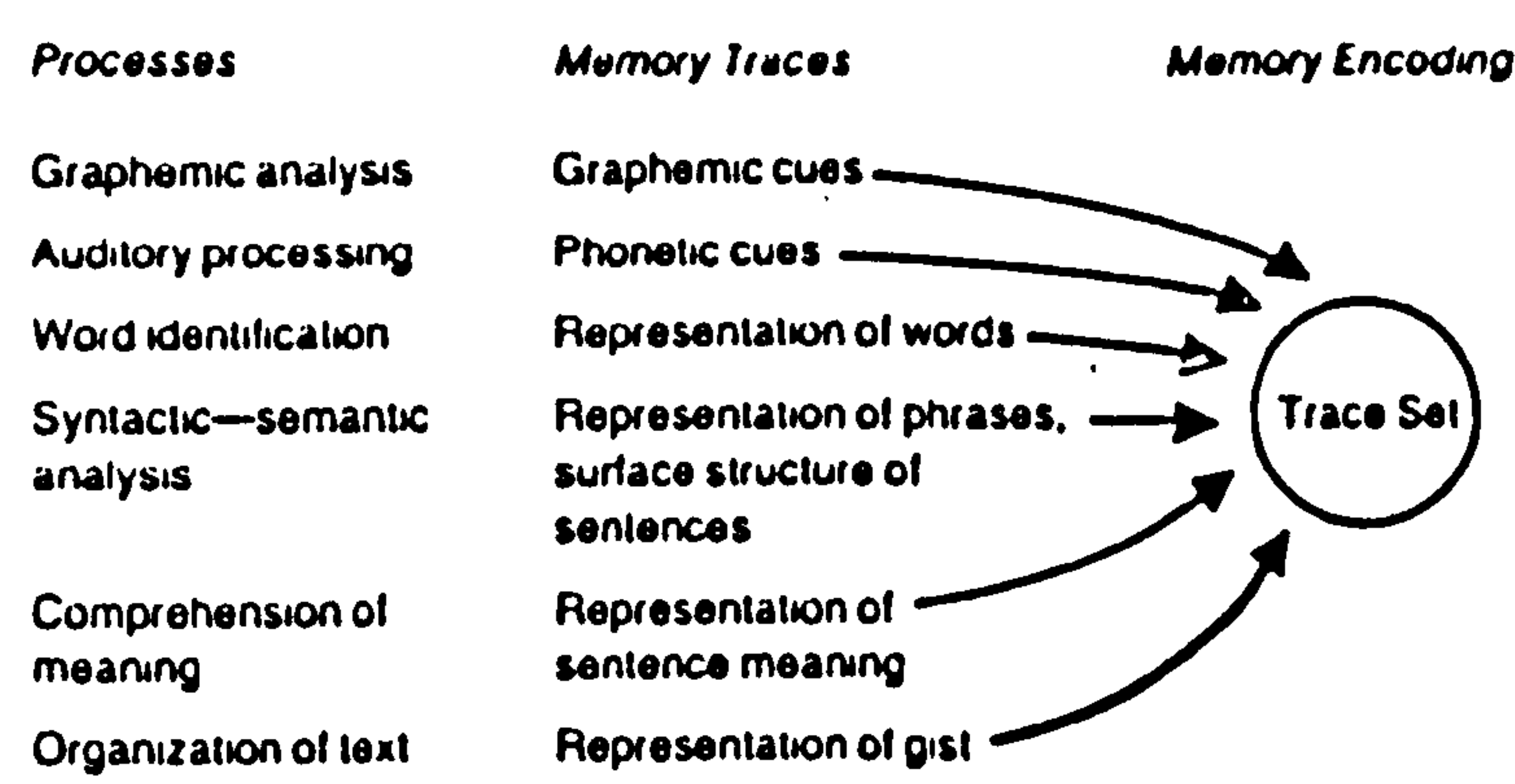
fig 3.1 Roots: Intellectual antecedents of various areas of information-processing psychology. (Lachman & Lachman, 1979, p 185)

psychology and being concerned, despite a trend towards increasing research on discourse and narratives, with the isolated sentence as the unit of analysis although acknowledging that no serious psychological theory of the comprehension process can fail to take account of extralinguistic factors. They argue that most contemporary psycholinguistic research on comprehension concerns the *synthesised code* and that psycholinguists are interested primarily in the formation of the code which is heavily influenced by semantic memory processes and the way in which it differs from the literal stimulus.



The synthesised code, according to the Lachmans, has three important characteristics. The semantic content of the code can be recalled on paraphrase even when surface structures have been lost; the code does not require continued attention for its maintenance; and it is likely to be in a form compatible with permanent memory. They recognise that, although the synthesised code can be conveniently represented propositionally, there appear to be perceptual dimensions to its form that are not well understood.

Kintsch (1979), in reviewing ideas presented by the Lachmans and by Perfetti, is sceptical of Perfetti's levels and suggests, rather, stages of comprehension in reading as shown in fig 3.2, arguing that, in a typical reading



**fig 3.2** An outline of stages of comprehension in reading, the memory traces arising from these processes, and their selection for encoding in memory. The thickness of the arrows indicates the likelihood that particular types of memory traces will be encoded in memory for long-term retention under standard reading conditions. (From Kintsch, 1977).

context most activity occurs at the highest comprehension level — gist comprehension — and therefore, most of the memorial consequences would be expected at that level. It has been suggested by Kintsch (1975) that the processes indicated above operate in parallel, the main reason being the repeated demonstrations that even in tasks that do not require a semantic analysis, there is a parallel access to the semantic domain prior to response generation, but Craik (1979) questions the whole idea of levels being accessed in parallel rather than serially by asking "if this is so, in what sense are they 'levels'?" He does, however, reinforce the concept of 'depth of processing' by arguing that it is still a useful way of expressing the idea that analysis of an event takes place gradually, and that the qualitatively different internal forms of representation of the stimulus can be ordered from those concerned with sensory, 'surface' qualities to those concerned with the abstract, symbolic properties of the event.



Kintsch (1979) pleads for a deeper processing than that usually associated with semantic processing arguing that the role of a text is to serve as a stimulus for the construction of a complex edifice in the reader's mind where a representation of the text itself is part of that edifice but where other parts are added from the reader's store of knowledge about the topic under discussion. He further argues that

"In comprehending a text, we are concerned not only with local comprehension but also with a more global, 'gist' comprehension" (p 220)

and goes on to propose that the macrostructure of a text corresponds to the intuitive notion of 'gist'. In his model, the memory of a text consists of a propositional representation of its meaning (the microstructure) plus the inferences necessary to assure the coherence of this propositional network, and the various levels of the macrostructure, where different readers with different knowledge bases and different goals produce different macrostructures for any given text.

The contribution of psycholinguistics to an understanding of reading comprehension is discussed on page 129.

### **3.2.2 The contribution of cognitive psychology**

In tracing the evolution of Kintsch's 'text representations', Singer (1982a) points out that the emphasis on psycholinguistic research has progressed linearly from the word, to the sentence, and finally to the text as the input stimulus for investigations of language comprehension, citing, in passing, the revolution in linguistics led by Chomsky which resulted in the transformational-generative grammar paradigm, the influence of Van Dijk and Kintsch which resulted in the study of meaning and the processing of discourse, and the earlier influence of Bartlett which resulted in a recognition that the reader interacted with text in the construction of meaning. Psychologists, he claims, used the interactive model of comprehension to develop their own ways of representing and processing text, including the macrostructure hypothesis of Van Dijk, the text representation theories of Kintsch, and the schema theories of Rumelhart.

Each of these, and their many variants, is worth considering in greater detail.



### **3.2.2.1 Representations and formal models of text structure**

Reder (1978) has drawn attention to the fact that many theorists concerned with finding an adequate representation of a prose passage maintain that doing so is a necessary prerequisite to other research on prose comprehension. She also points out that each representational theory is concerned with either expository text or stories, rarely both. Kintsch (1982) indicates that text representation is a component of a theory of how people process text and is, thus, a component of theories of comprehension. The reason why there are so many different text representations is because there are many theories of comprehension.

#### **Macrostructures**

Within a framework of a model of cognitive information processing, Van Dijk (1977) outlined a theory of 'macro-structures' and identified the macro-rules underlying the global interpretation of discourse. He argues that comprehension probably takes place at several levels, such that lower-level information is organised, reduced, and represented at higher levels, and that these processes involve the use of macro-rules, the input to which is the micro-structure and the output from which is the macro-structure. Macro-structures help to explain the ability to summarise discourse, and in general to use information from discourse for other cognitive tasks, even if the individual propositions of the discourse are no longer accessible.

Macro-rules are needed to obtain the macro-structure from the micro-structure by transforming one proposition sequence into another 'at another level' of description. Since there are several levels of description of any event, macro-rules must be recursive so that they can be applied to organise global meanings into still higher-level global meaning. Thus, it follows that the notion of macro-structure is relative to an underlying level of propositional representation which, in turn, may be a macro-structure with respect to still more specific levels of representation.

The macro-rules identified by Van Dijk are:

- (a) GENERALIZATION, since a macro-structure is typically more general than its corresponding micro-structure;



- (b) **DELETION**, since full propositions may be deleted from a given text base;
- (c) **INTEGRATION**, since there is the possibility that macro-information may be directly expressed in the discourse (sometimes known as **SELECTION** since it selects macro-propositions from the text base); and
- (d) **CONSTRUCTION**, which may be regarded as a variant of **INTEGRATION** but which has no input proposition that organises other propositions.

The macro-rule of **CONSTRUCTION** is probably the most characteristic of all macro-rules since it organises micro-information by combining sequences of propositions that function as one unit at some macro-level. It reduces information without simply deleting it, and it introduces information at the macro-level that is 'new' in the sense of not being part of the text base or entailed by individual propositions of the text base.

Reder (1978) notes that, although the notion of macro-structures is a useful one and the experimental evidence is suggestive, it is necessary to ask how many of the possible set of outcomes from the experiments would be considered as consistent with the notion of macro-structures. On the other hand, Brown and Day (1983), in investigating the development of ability to use macrorules for paraphrasing expository texts, provided empirical confirmation of the Van Dijk theory of prose comprehension.

According to Van Dijk (1977), discourses may be assigned another kind of global structures which he calls 'super structures' to distinguish them from semantic macro-structures. Super-structures are organising principles of discourse with a hierarchical character which roughly defines the global syntax of the text compared with the macro-structures which define the 'content' of the text. Frederiksen (1977) equates these conventional patterns of organisation with other conventional structures such as "story schemas" (Rumelhart), "scripts" (Schank and Abelson) and "frames" (Minsky) and highlights the importance of conventional macro-structures in accounting for coherence in discourse because they assign conventional roles to macro-structure propositions. The interpretation of "frames" adopted by Van Dijk (1977) is more extensive because he considers frames



to be knowledge representations about the “world” which enable the performance of such basic cognitive acts as perception and language comprehension; they can also be thought of as conceptual networks that contain embedded pointers to other frames. He proposes that frames define units or chunks of concepts which are not essentially, but *typically*, related and that they are, thus, higher-level organising principles, unifying concepts of various types and at various levels of representation under the constraint of typicality and normality.

In summarising the strategies for discourse comprehension, Van Dijk (1977) includes the following

- macro-structure formation takes place in the course of reading the text, not *a posteriori*
- immediate summarising of the discourse only involves the reproduction and expression of some level of macro-structure
- whatever is retained from the text base and stored in episodic memory is organised by the macro-structure of the passage or of the whole discourse
- the macro-structure is the basis for recall of the discourse immediately after presentation
- explicit discourse cues such as titles, initial summaries, and declaration of content/intent facilitate selection of correct macro-structures
- expressions which can be regarded as topic markers or the use of italic or bold print can also facilitate selection of correct macro-structures.

### **Propositional Representations**

Kintsch (1982) argues that “meaning” is the result of an interaction between a text and a comprehender and that the purpose of models is to describe this interaction, or at least salient aspects of it. Arguing that the text representation is a starting point in the description, he states that

“the text representation . . . . is usually fairly close to the surface structures of the text. The model then does things with this surface representation of the texts — things that we



believe parallel the comprehension operation in the human comprehender — so that this surface representation becomes progressively changed, less dependent on the surface features of the text, and more shaped by the comprehender's operations and his goals. The meaning of a text is thus defined only for a particular comprehension episode, and depends as much on the reader's background and goals as on the characteristics of the text itself". (p 88)

According to Kintsch, all current work on text that he is aware of uses propositional representations. In an earlier paper, Kintsch (1977) expressed the view that the final skill of the fluent reader is the highly developed process of acquiring information from a richly saturated visual display and that the process of acquiring information during reading can be characterised as the extraction of propositions from the text and the organisation of these propositions into coherent, well-structured text bases.

Reder (1978) identifies the fundamental unit of Kintsch's analysis as the proposition and notes that a text is, thus, an ordered list of propositions which are connected together by means of a repetition rule in which one proposition is referred to by a super-ordinate proposition that contains the subordinate as an argument, so forming a hierarchical structure. Pace (1982) points out that Kintsch utilises a special class of "connective propositions" to relate ideas across separate sentences by coordinating the other propositions in a text and providing textual coherence.

The issue of coherence is taken up by Frederiksen (1977), arguing that the property that makes discourse more than a collection of unrelated simple sentences is coherence, and that a major objective of discourse studies is to explain what makes a text coherent, identifying one aspect of textual coherence as the manner in which a discourse communicates a point of view with respect to its propositional content. He acknowledges, however, that an account of coherence in discourse which relates textual to propositional coherence is not within sight, and that two problems have to be solved — the development of a more integrated account of coherence in discourse and the describing how the cognitive system discovers coherence in understanding discourse.



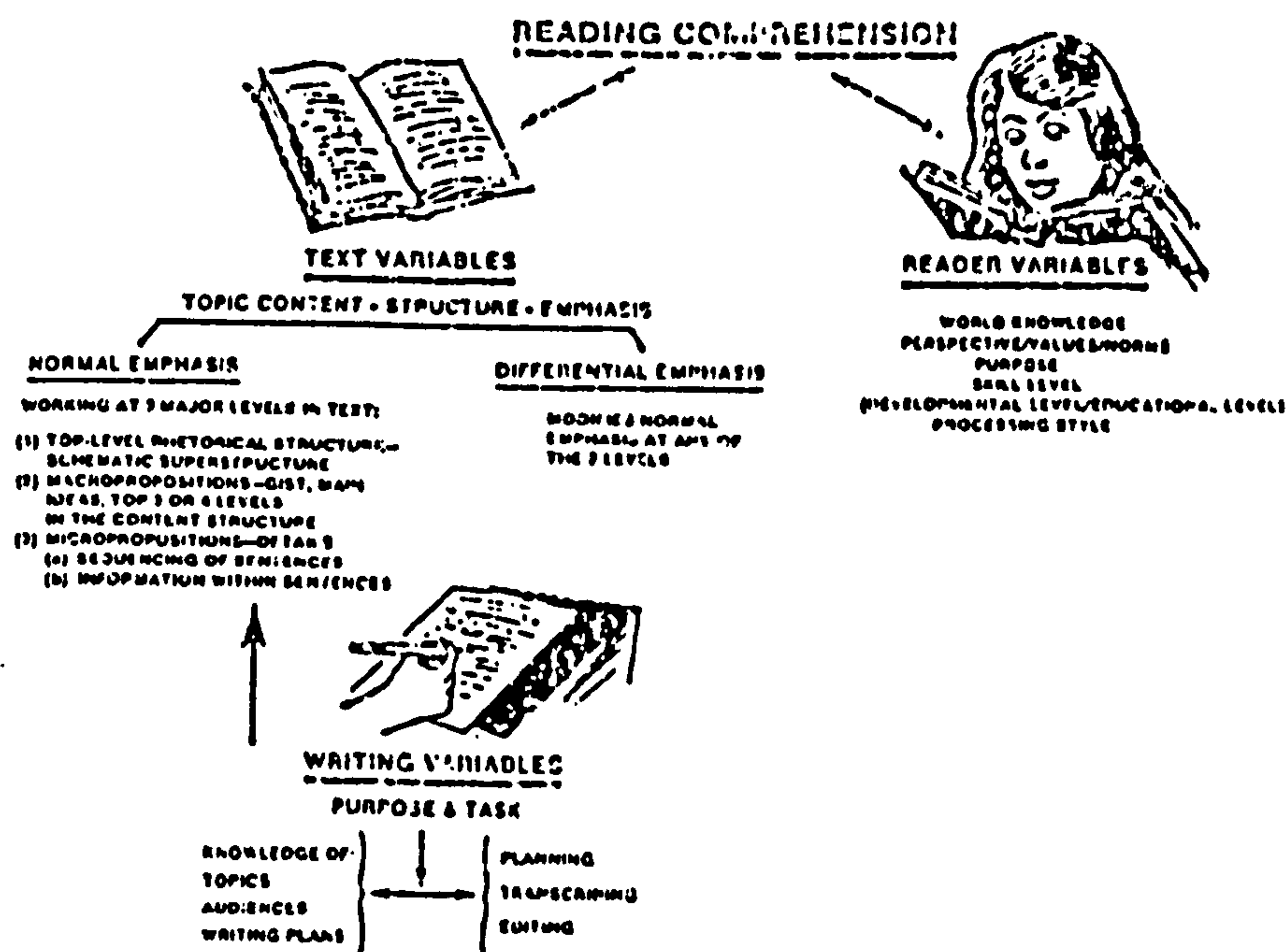
Kintsch (1982) has pointed out that much of the research has been concerned with stories and that what is needed is an explicit extension of comprehension models to educationally important text types such as expository prose, and he predicts that future comprehension models that are able to deal with expository prose will provide text representations in which content is represented in some propositional format. Black (1985) has claimed that the memory structures relating to expository text fall into three classes — coherence relations linking pairs of propositions, higher-level cognitive units integrating groups of propositions, and memory retrieval structures that provide an overall indexing scheme for organising these propositions and higher-level cognitive units — which he relates as being roughly equivalent to Kintsch & van Dijk's (1978) distinctions between microstructure, macropropositions, and macrostructures respectively. Schnotz (1984) has pointed out that the relation between propositions will become an integrative part of the memory structure with greater probability, the smaller the temporal distance between the propositions is in the text, and that text organisation therefore affects temporal distance between propositions and, hence, the coherence of the text.

The work of Meyer (1975, 1977a, 1977b) goes beyond indicating the relationship between propositions, identifying the content structure or organisation of information in a passage as the most powerful variable related to recall, with her data suggesting that the recall protocols of college students are organised in manners similar to the original passages and that readers, in general, use as a strategy the ready-made organisational structure of the passage. As Reder (1978) points out, Meyer has developed the first representation that actually seems concerned with passage level information rather than sentence level material.

A major element of the work of Meyer was identification of the importance of 'height' in content structure and she concluded that elements 'high' in a passage are given more processing time than elements lower in the passage. This is not dissimilar to the concept of 'staging' described by Clements (1979) as a dimension of prose structure which identifies the relative prominence given to various segments of prose discourse and which, he suggests, might influence both acquisition and retrieval processes. More recent work by Meyer (Meyer, Brandt, & Bluth, 1980, and Meyer & Freedle, 1984) draws



upon linguistics and rhetoric to present evidence for five basic ways of organising discourse, the more organised of which are claimed to promote more efficient processing of text, and this issue will be returned to in the discussion of this chapter. The model of reading outlined by Meyer is best summed up in fig 3.3 (Meyer, 1981).



Scheme of the writer, text, and reader variables that influence reading comprehension (from Meyer, 1981).

fig 3.3 The Meyer model of reading

It has been argued by Spiro, Bruce, and Brewer (1980) that the interaction of text-based and knowledge-based processes and of levels within each is essential to reading comprehension, and it has been noted by Frederiksen (1977) that an adequate account of comprehension ultimately will have to involve a

“detailed explication both of how text-based comprehension utilizes textual and propositional information and the role of schema-based processes in comprehension.”

(p 319)

Anderson and Pearson (1984) argue that an aspect of particular importance to reading comprehension is the issue of how the reader's *schemata*, or knowledge already stored in memory, function in the process of interpreting new information and allowing it to enter and become a part of the knowledge store. The role of schema in the interaction of new information and old knowledge is worth exploring at this point.



### **Schema-based processes**

According to Rumelhart (1980) the term 'schema' comes into psychology most directly from Bartlett (1932), and he argues that schemata are the building blocks of cognition as they are the fundamental elements upon which all information processing depends. Adams and Collins (1979) argue that schema theory — which they see as having developed from the combined efforts of cognitive psychologists, linguists, and specialists in artificial intelligence and variously referred to as 'frames' (Minsky, 1975), 'scripts' (Schank & Abelson, 1977) and schemata (Bobrow & Norman, 1975; Rumelhart & Ortony, 1977) — for the first time, provides a structure powerful enough to support the interactions among different levels of processing in reading. They state that

“The goal of schema theory is to specify the interface between the reader and the text — to specify how the reader’s knowledge interacts with and shapes the information on the page and to specify how that knowledge must be organized to support the interaction.”

(p3)

Rumelhart (1980) explains that a schema theory is basically a theory about knowledge. Schemata (the plural of schema) can be likened to theories in that their central function is in the construction of an interpretation of an event, object, or situation (i.e. in the process of comprehension), and that, with respect to text, the total set of schemata instantiated at a particular moment in time constitutes a model of the situation depicted by the text. If a promising schema fails to account for some aspect of a situation, the option remains of either accepting the schema as adequate in spite of its flawed account or of rejecting the schema as inadequate and looking for another possibility. In this sense, the process of comprehension is analagous to hypothesis testing or evaluation of goodness to fit. Readers are thus said to have understood the text when they are able to find a configuration of hypotheses (schemata) that offers a coherent account for the various aspects of the text.

Rumelhart and Ortony (1977) list the four major characteristics of schemata as:

- schemata have variables;
- schemata can embed, one with another;



- schemata represent knowledge at all levels of abstraction; and
- schemata represent knowledge rather than definitions.

Rumelhart (1980) adds two more general features of schemata:

- schemata are active processes, and
- schemata are recognition devices where processing is aimed at the evaluation of their goodness of fit to the data being processed.

Spiro (1980) refers to a large volume of research in recent years leading to the inescapable conclusion that comprehension is a constructive process, meaning that explicit information in a text is insufficient for the specification of the meaning of that text and that the complete meaning is constructed by combining information from the various sources that comprise the content of the text, a central role among the impinging contextual factors being the pre-existing knowledge the comprehender brings to bear to inform the understanding of a given text. This emphasis is also found in Anderson (1980) where it is claimed that the knowledge a person already possesses has a potent influence on what he or she will learn and remember from exposure to discourse. The meaning of a text thus arises in an interaction between the characteristics of the message and the reader's existing knowledge and analysis of content.

This highlights the sources of activation for schemata: they can either be top-down or bottom-up or, as Bobrow and Norman (1975) have identified, as conceptually-driven or data-driven. Conceptually-driven processing is, as Rumelhart (1980) describes it, expectation-driven processing. Conceptually-driven activation goes from whole to part, whereas data-driven activation goes from part to whole. It has to be noted, however, that in schema-directed processing, both top-down and bottom-up activation take place.

The meaning of a communication depends, according to Anderson, Reynolds, Schallert, and Goetz (1977), in a fundamental way on a person's knowledge of the world and his/her analysis of the context as well as the characteristics of the message. They conclude that

"more important than structures which are in some sense 'in' a text are knowledge structures the reader brings to the text"

(p 369)

and that a person can, at a very early stage in processing, invoke high-level



schemata which lead to one interpretation to a passage without any consideration of other possible interpretations.

Given that the process of understanding discourse is the process of finding a configuration of schemata that offers an adequate account of the passage in question, Rumelhart (1980) suggests three reasons implicit in schema theory as to why a reader may fail to correctly understand a passage.

1. The reader may not have the appropriate schema. In this case he or she simply cannot understand the concept being communicated.
2. The reader may have the appropriate schemata, but the clues provided by the author may be insufficient to suggest them. Here again the reader will not understand the text but, with appropriate additional cues, may come to understand it.
3. The reader may find a consistent interpretation of the text but may not find the one intended by the author. In this case, the reader will “understand” the text but will misunderstand the author.

(p 48)

Anderson (1980) claims that there is evidence from research that a schema operation when a passage is read affects the encoding, possibly by directing attention to text elements that are significant in the light of that schema; that the schema affects remembering, probably by providing the plan for searching memory; and that schemata probably also provide the basis for inferential elaboration when a passage is read, and inferential reconstruction when there are gaps or inconsistencies in memory.

Adams and Collins (1979) argue that comprehension depends on the readers' ability to appropriately interrelate their knowledge and the textual information and that the power of schema-theoretic models of reading lies in their capacity to support these interactions through a single, stratified knowledge structure and a few basic processing mechanisms.

Having analysed the research on schema theory, Schallert (1982) identifies a number of propositions about schema theory, the two major of which are:



- schemata are abstract structures that represent what one holds to be generally true about the world, and
- comprehension proceeds as values for the variables of a schema are determined, as a schema is substantiated.

She emphasises that, just as meaning is not in the message, it is also not in the comprehender's schemata. Meaning, in her view, is formed as a result of the dynamic interaction between existing abstract knowledge structures and the clues available from the message. In her evaluation of schema theory, she argues that there are two reasons why schema theory has not offered much by way of describing how people learn from informative texts. The first is because the research used to test schema theories has tended to use artificial passages which do not resemble natural prose, and the second, more important, is because schema based research has generally ignored the main purpose of informative text, which is to inform the reader, to cause a change in schemata and ways of looking at reality.

Jonassen (1985a) claims that mental constructs or schemata are developed to represent objects, actions, events, settings, or abstract ideas. In the area of world knowledge, Black (1985) has identified four essential kinds of knowledge for expository text, viz., knowledge about human actions, knowledge about physical events, knowledge about objects and locations, and knowledge about human reasoning. Perhaps the most abstract of texts are scientific and technical texts and it has been suggested by Britton, Glynn and Smith (1985) that such texts, because of their complexity and organisational unpredictability, are likely to be subject to bottom-up processing rather than top-down processing. But, of course, as Rumelhart (1980) noted, in schema-directed processing, both top-down and bottom-up activation take place. Kieras (1985) argues that in the processing of technical prose, 'bottom-up' processing predominates and he suggests that the schema notion seems to have very little applicability to the comprehension of technical prose.

Anderson and Pearson (1984) have argued that one of the key processes in a schema-theoretic account of cognitive processing is *inferencing* which they consider to be central to the over all process of comprehension. Flood (1981) has noted that some theorists and researchers have begun to define inference in such a way that it is virtually synonymous with reading comprehension.



Inference, like comprehension, cannot, according to Flood (1981), exist solely within a text, but must involve active processing so that, as Schank (1975) has shown, the text can act as a stimulant for inference-generation, it can, as Anderson (1976) has argued, stimulate the reader's previously acquired cognitive structures, background knowledge, and experience.

### **Reconciling macrostructures, propositional representations, and schema theory**

Kintsch and van Dijk (1978), noting that readability cannot be considered a property of texts alone, but one of text-reader interaction, and, further, that the semantic structure of a discourse is characterised at two levels (the microstructure and the macrostructure) concerned with the structure of individual propositions and their relations and the more global structure of the discourse as a whole, assert that the role of the schema is to determine which microproposition or generalisations of micropropositions are relevant and, thus, which parts of the text will form its gist. They assume that text comprehension is always controlled by a specific schema and that, if a reader's goals are vague, and the text being read lacks a conventional structure, different schemata might be set up by different readers, in an unpredictable manner. The idea of 'goal-directed' reading is alluded to by Rumelhart (1980) who indicates that the information-seeking process must go hand in hand with the information-interpretation process, as schemata do not only indicate 'what to see', but also 'where to see it'.

Frederiksen (1977) argues that the occurrence of a particular macro-structure proposition does not imply that it was generated by schema-based inference if, in fact, it is possible to generate the macro-proposition by means of text-based inferences. In discussion of the question "To what extent is discourse comprehension text-based and to what extent is it schema-based?" he says:

"An extreme interpretation of a schema-based process would require that people have a great deal of knowledge about the structure of many different kinds of discourse, with discourse comprehension consisting mostly of an attempt to fit schemata to texts. An extreme text-based system would be one in



which discourse macrostructures are generated solely by applying inferential operations to propositions as they are 'recovered' from a text. On the one hand we have a conception of the language user as controlled principally by his stored knowledge, and on the other by the text and situation. What seems likely is that we can alter the manner in which we process discourse to meet the demands of specific communicative tasks".

(p 319)

Schallert (1982) believes that some aspects of currently available text analysis systems come close to reflecting reader and author-based text structures, citing Kintsch's macropropositions and Meyer's top level rhetorical predicates, and contends that these discourse analysis procedures are valuable for describing text characteristics and for judging what people are learning from a message, while being compatible with a schema theory view of the comprehension process.

A discussion of the contribution to an understanding of the reading comprehension process of the various cognitive psychology approaches is carried out on page 131.

### **3.2.3 The contribution from models of reading**

Kamil (1978) highlights the difference between a theory and a model, stating that theories are testable, whereas models are vehicles for verification. He further suggests that there may be many models that can be applied to the same theory or set of data. Samuels and Kamil (1984) note that serious attempts at building explicit models of the reading process, from the time the eye meets the page until the reader experiences the 'click of comprehension', have a history of little more than 30 years, and they identify some of the factors which have affected model-building activity including

- (a) the changes that occurred in language research and the psychological study of mental processes, and
- (b) the advent of what has come to be known as the psycholinguistic perspective.

It is acknowledged that most reading models do not provide full descriptions of comprehension processes (Kamil, 1978), nevertheless, it is their contribution to comprehension that will be considered here.



### **3.2.3.1 The Gough Model**

The model proposed by Gough (1976) is of the 'bottom-up' variety, with reading proceeding letter by letter to word formation, then to phonemic representations. The processing stages are serial, with lexical units being grouped into sentential forms to be interpreted by Merlin, the magical processor of syntactic and semantic information. Higher-level comprehension processes take place in 'Merlin' and interpreted sentences are stored in TPWSGWT AU (The Place Where Sentences Go When They Are Understood). Subsequently, it was acknowledged that, of the five stages through which the printed word and sentences pass en route to their comprehension, little new could be said about the deeper stages of reading, about primary memory, and how the meanings deposited there are combined into propositions (Gough & Cosky, 1977).

### **3.2.3.2 The La Berge & Samuels Model**

A main feature of the model proposed by La Berge & Samuels (1974) is that it was the first reading model to use the concept of 'automacity', a theory which assumes that reading is divided into two general skills — word recognition or decoding, and comprehension — and that, as decoding comes to require less attention, more attention can be diverted to comprehension processes. It is a 'bottom-up' model with reading being initiated by a visual input and terminated by a semantic interpretation. It was acknowledged by Samuels and Eisenberg (1981) that the model lacked a description of the comprehension process and that research since the model was formulated had contributed substantially to an understanding of the comprehension process. They recognised that factors both external and internal to the reader — such as physical characteristics of the text; readability and style; the knowledge base, and cognitive resources — could influence comprehension, and concluded that

“we experience the 'click' of comprehension when there is a match between textual information coming from outside the head and concepts stored inside the head . . . thus, contrary to conventional wisdom which states that comprehension is the process of getting meaning from a page, it is viewed here as an interactive process of bringing meaning to a text as well as getting meaning from a text.”

(p 59/60)



Neither the Gough nor the La Berge & Samuels models contributes anything to an understanding of the process of comprehension but they do contribute to an understanding of the process of reading and factors within this which may affect comprehension and these will be returned to at a later stage of the discussion.

### **3.2.3.3 The Rumelhart Model**

Rumelhart (1977a) recognised that reading was at once a 'perceptual' and a 'cognitive' process and the model which he proposed provided, therefore, for both 'bottom-up' and 'top-down' processing, enabling the reader to begin with graphemic input to guide the extraction of meaning, or, alternatively, to assume features and proceed to meaning (hypotheses) first, moving to verification of features and word patterns later. The processing stages are interactive, and it is assumed that processing of text is parallel rather than serial. It was within this model that the concept of 'schemata' was introduced, and, as already observed, Rumelhart's work has contributed substantially to an understanding of the comprehension process.

### **3.2.3.4 An independent-process model**

Calfee and Spector (1981) attempted to develop a comprehensive model of 'natural reading', based on the independent-process theory proposed by Sternberg (1963) which assumes that the mental activities that underlie performance on a task comprise a relatively small set of independent and separable cognitive processes. In developing the model they took into consideration the research on comprehension carried out during the 1970's, and proposed, in essence, a model which entails two independent processes — microanalysis and macroanalysis. Microanalysis handles detail and macroanalysis operates on structures at the discourse level.

"Macroanalysis is the process for detecting the thematic structure of a text, for organizing the details of the text according to this structure, for linking previous experience to the theme, and for guiding the reproduction of the text during recall. Microanalysis is the process for untangling and reweaving the web of details within the primary structural elements of a text."

(p 20)



However, they argue that separate strands make sense only if the nature of the cognitive processes that are engaged by those strands can be identified and they urge research based on the concept of independent processes in reading, particularly to provide guidance in organising reading instruction.

#### **3.2.3.5 The Kintsch Model**

This is probably the only model which focuses exclusively on comprehension processes. The most complete version of the model was proposed by Kintsch and van Dijk (1978), but improvements have been made by Kintsch and Vipond (1979), Miller and Kintsch (1980), Bates, Kintsch, Fletcher, and Giuliani (1980), and Kozminsky, Kintsch, and Bourne (1981). The Kintsch model specifies three types of operations: first, the meaning elements of a text are organised into a coherent whole; second, another set of operations compresses the full meaning of the text into its gist; and third, new texts are generated from the memorial consequences of the comprehension processes.

Input to the model is a set of propositions representing the semantic surface structure of the text which is characterised at two different levels by the microstructure and the macrostructure. A discourse is coherent only if its respective sentences and propositions are connected and if they are also organised at the macrostructure level. The reader's goals control the application of the macro-operators which transform the text base into macropropositions representing the gist of the text. The reader's schema always controls text comprehension since the schema dictates which micro-propositions are relevant to the gist of the text.

#### **3.2.3.6 The Stanovich Model**

According to Stanovich (1980), the earlier bottom-up reading models had a tendency to depict the information flow in a series of discrete stages, with each stage transferring the input and then passing the recoded information on to the next higher stage for additional transformation and recoding. Top-down models, on the other hand, conceptualise the reading process as one in which stages which are higher up and at the end of the information processing sequence interact with stages which occur earlier in the sequence. Stanovich (1980) therefore proposed an 'interactive-compensatory' model, a key concept of which is that a process at any level can compensate for deficiencies at any other level.



“Interactive models of reading appear to provide a more accurate conceptualization of reading performance than do strictly top-down or bottom-up models. When combined with an assumption of compensatory processing (that a deficit in any particular process will result in a greater reliance on other knowledge sources, regardless of their level in the processing hierarchy), interactive models provide a better account of the existing data on the use of orthographic structure and sentence context by good and poor readers”. (p 32)

### 3.2.3.7 The Just and Carpenter Model

Based on eye-movement research with college-age readers, Just and Carpenter and their co-workers developed a model of reading comprehension arising from an extended series of studies (Just & Carpenter, 1976, 1978, 1980; Carpenter & Just, 1977; Just, Carpenter, & Woolley, 1982). A diagrammatic representation of their model is shown in fig 3.4.

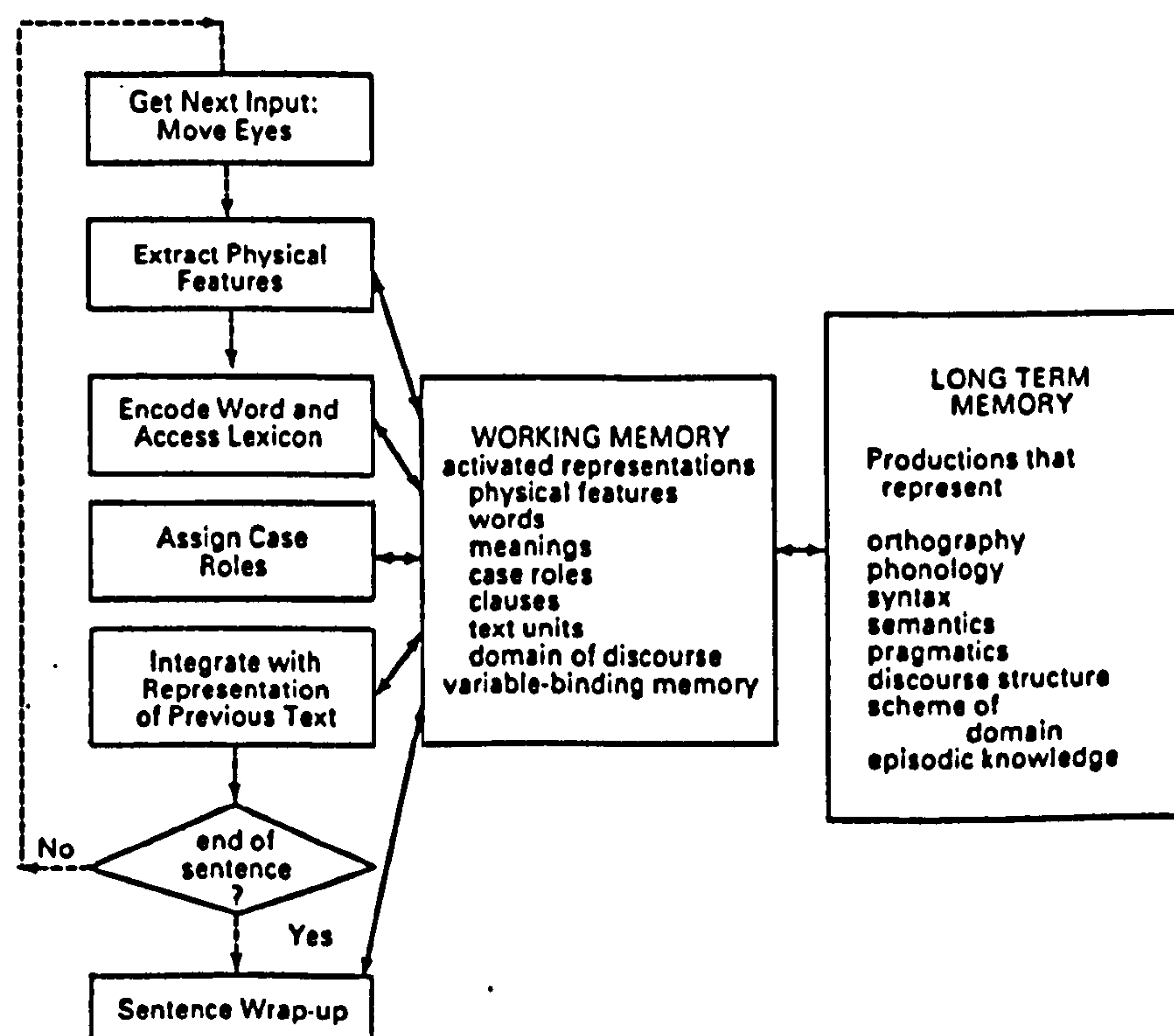


fig 3.4 The Just & Carpenter Model



The model is flexible in that it can account for a large number of different types of reading behaviour, and it attempts to describe mechanisms for all stages of reading. It combines top-down and bottom-up processes, with top-down processes being able to influence bottom-up processes.

Many of the issues behind the rationale for the model are considered within the general framework of eye-movement research reviewed in the next section.

The contribution to an understanding of the reading comprehension process of the various models of reading is discussed on page 134.

### **3.2.4 Other issues in comprehension**

The literature in comprehension has included a wide range of fairly specialised approaches to comprehension, some of which could be subsumed under areas already discussed but which are referred to briefly here because of their particular relevance to the study.

#### **3.2.4.1 Generative processes**

Wittrock (1981) has argued that when people read with comprehension they generate meaning for written language. They attend to the text, they create images and verbal transformations to represent its meaning, but, most impressively, they generate meaning as they read by constructing relations between their knowledge, their memories of experiences, and the written sentences, paragraphs and passages. A study by Doctorow, Wittrock, & Marks (1978) indicates that the facilitation of retrieval of relevant information and the enhancement of the generation of meaningful elaborations can increase reading comprehension and recall, and concludes that

“models of learning with comprehension should attend to the retrieval processes and to the generative processes involved in the construction of meaning for text. Although the retrieval of memories of experience and the elaboration of meaning for text have sometimes been viewed as primarily independent cognitive processes, they seem to be



complementary and interdependent parts of the generative processes involved in comprehension.”

(p 334)

The contribution to an understanding of reading comprehension by generative processes is discussed on page 135.

#### **3.2.4.2 Elaboration and comprehension**

Reder (1980), in a review of research in the area of prose comprehension, argues for the importance of elaboration to comprehension and retention. Drawing upon the work of Schank & Abelson (1977) she proposes a hybrid script-elaboration processing model in which the essential difference is an emphasis on the role of elaborative processing. Elaborations tend to be highly idiosyncratic, based on prior experience with related situations. The generation of elaborations is similar to processes used when ‘scripts’ are used to understand a current situation, and more information is added to the memory representation.

“The difference between inferences that represent the omitted main conceptualizations of a script and elaborations is twofold: any omitted script action is likely to be inferred and the default value for the omission (i.e. the inference) is likely to be similar across readers. On the other hand, the number of elaborations generated varies greatly with circumstance and the content of elaborations varies across readers. How much one elaborates depends upon previous experience with the material, inherent interest in the subject matter, understanding of the text, and general tendency to elaborate”.

(p 41)

Reder (1980) argues that elaborations serve a number of functions in a comprehension model, including the finding of connections among sentences, the generating of expectations about subsequent input, the detecting of anomalies, and the aiding of retention.

In an investigation of the role of age difference in the elaboration of inferences from text, Wagner & Rohwer (1981) demonstrated that the addition of



certain contextual elements to prose paragraphs can facilitate the inference performance of pre-adolescents to a point of equivalence with that of late adolescents, although they acknowledge that the added contextual elements may have fostered an appreciation of premise relatedness, a prerequisite for inferential elaboration, rather than directly increasing elaborative propensity itself.

The contribution to an understanding of the reading comprehension process by elaboration is discussed on page 136.

### **3.2.5 The contribution from eye-movement research**

As already noted, the common view of processing is that it proceeds through a sequential series of analyses of the information, either data-driven through the receipt of information at the sense organs, or conceptually-driven through contextual knowledge and expectations, or both. There is considerable evidence that both are necessary and that perceptual analysis is guided by the overall goal of establishing an integrated interpretation of the events of the world, requiring active construction of internal models and all the while seeking information that will allow confirmation or elaboration of the model. Haber and Haber (1981) have pointed out that, independent of his or her knowledge of language, the world, or the general context of the text to be read, the reader has available for processing a considerable amount of knowledge from visual features alone. By visual features is meant the distinctive features of single letters, word shape, and printing conventions, all of which can provide substantial information about content further ahead. Jackson and McClelland (1981) argue that, despite claims that reading proficiency is almost totally dependent on general language-comprehension skills, their investigations have shown that a basic visual processing skill influences reading ability. Working with college students they demonstrated a visual processing advantage which influences reading ability independently of general language-comprehension processes and appears to be due to visual encoding that accesses representations in memory for visual patterns or symbols. It is against this background that the research in eye-movement and comprehension is examined.



Tinker (1965) mentions that the study of eye movements in reading began about 1879, but that research activity became vigorous only after 1900. He puts the matter in context, thus:

“The traditional belief, one that is still held by many of the uninformed, is that a person reads as his eyes sweep uninterruptedly and smoothly along a line of print. Actually, in reading a line the eyes make several stops, each a *fixation pause*. The move from and fixation to the next is a quick jerk called a *saccadic movement*. Such movements are so fast that while they are in process no clear vision is possible. Fixation pauses are the periods of clear vision and it is during the pauses that perception occurs . . . . . During the reading of a line of print, the eyes sometimes move backwards . . . . . and make fixations to get a clearer view of material or to reread it. These backward movements are called *regressions*. When one line is fixated, the eyes make a long *return sweep* to the beginning of the next line”. (p 53/54)

Rayner (1981) notes that the abstraction of information from a text during the fixational pauses of the eye is one of the most well-established facts about reading, and that fixational pauses average approximately 200 – 250 msec. Each saccade, on average, covers about 7 or 8 character positions. However, as has been pointed out (Rayner, 1978; Rayner & McConkie, 1976), these values represent averages and there is a considerable amount of variability in each of the measures. As Rayner (1981) notes:

“for normal reading rates of 200 – 500 words per minute, the range of saccade lengths within and between subjects is from 1 to over 20 characters and the range of fixations is from 100 to over 500 msec. The frequency of regressions between readers ranges from 0 – 40%”. (p 146)

It has also been noted (Rayner, 1979) that the location of the eye fixation is determined by visual characteristics of the text or the cognitive processing state of the reader, and (McConkie, Hogaboam, Wolverton, Zola, & Lucas, 1979) that the length of time the eye remains in any location is related to the cognitive processing state of the reader and the difficulty of the material being fixated. Wanat (1976) suggests that, while there is general agreement



among reading researchers that language plays a central role in the reader's information processing, the extent to which language guides the eye in reading needs to be systematically investigated: in particular, does the reader selectively allocate his visual attention in extracting meaning from written language?, and, if so, are areas of relatively greater or lesser visual attention predictable from the linguistic structure of the material being used? After reviewing related research and conducting appropriate investigations, he concludes that there is ample evidence of selectivity in visual processing and that grammatical structure is an important factor in the reader's information extraction. Using a wide-angle reflection eye camera to record reader eye-fixation patterning of 12 mature readers, he identified that:

"The reader selectively allocates his visual attention to different sentence areas. A sentence type which is less structurally predictable requires more visual attention . . . . Differences in the kinds of linguistic cues . . . to the same underlying sentence relations affect the reader's allocation of visual attention. Differences in the immediate constituent analysis of sentences affect forward scanning, while differences in the structural predictability of items within a given immediate constituent framework affect regressive scanning."

(p 133)

In an attempt to develop a general approach to the use of eye movement data for studying language processing, McConkie, Hogaboam, Wolverton, Zola, and Lucas (1979) examined the problems of perceptual span, data summary, and eye-mind lag, judging that these could contribute to an understanding of the perceptual and language processes that take place during reading. They argue that eye movement records directly indicate where the eye was centred for a given person on a given fixation but that this does not necessarily indicate what region of text was seen during that fixation nor on which fixation or fixations a given word is being encountered. Similarly, although eye movement records may seem to be a useful source of information regarding the relative amount of processing time required at different points of the text, it would not be so, if it is not possible to reliably identify the fixation on which the word of interest was encountered. Also, there is a further problem of knowing when the effects of the processing of that word will be reflected in the eye movement pattern.



There is a necessity to know how long following visual perception of a word the mental operation of interest is actually carried out.

McConkie and his colleagues concluded that: during reading the eyes are directed to a specific location; the reading of text occurs only during fixations; there is no point during the fixation at which the visual system is insensitive to the textual stimuli and that the acquisition of visual information occurs throughout the fixation as needed to support language processing; there is a particular fixation on which a letter, letter group, or word can be said to be perceived; during a fixation the subject is acquiring visual information from a relatively narrow region of text, the size of which may vary from fixation to fixation, but which lies asymmetrically to the right of the centre of vision and which may be indicated by the locations of the present and next fixation; and, finally, there is, at present, practically no evidence concerning the amount of delay before higher-level processing takes place.

This is in marked contrast to Tinker (1965) who said that:

“Eye movement patterns indicate and reflect the nature of the central processes of perception and assimilation during the reading. That is, they provide information as to why the reading is slow or fast and give clues as to which parts of the reading material (a word, phrase, concept) are easy or difficult to comprehend.” (p 81)

In a similar vein, Carpenter and Just (1977) claim that there is a highly systematic relationship between eye fixations and underlying comprehension processes and that, for example, regressive eye fixations are indicative of the reader's interpretation of the paragraph. They explain that theories of eye fixations usually attribute the control of fixations during reading to one or more of three systems: oculomotor processes, visual processes, or semantic processes.

“An oculomotor model posits that eye fixations are controlled by a motor system that is guided by only the most rudimentary information from the text . . . . A visual model posits that fixations are influenced by the processing of visual (non-semantic) properties of the text . . . . A semantic model posits that fixations are influenced by



ongoing semantic processes. Some combination of these three processes may account for reading behaviour in any given situation." (p 111)

Carpenter and Just (1977) dismiss the oculomotor control model but highlight the fact that some visual characteristics of the text influence the pattern of fixations, thus accepting, in part, the contribution of the visual control model. For example, they note that visual cues, such as the beginning of a line of print, can have a large effect on eye fixations, and that text with lines that begin at irregular places, such as poetry, can produce more regressive fixations than regularly spaced text. Similar arguments can be found in Tinker (1965) where he notes, particularly in the case of formulae (surely a visual cue), that regressions occur.

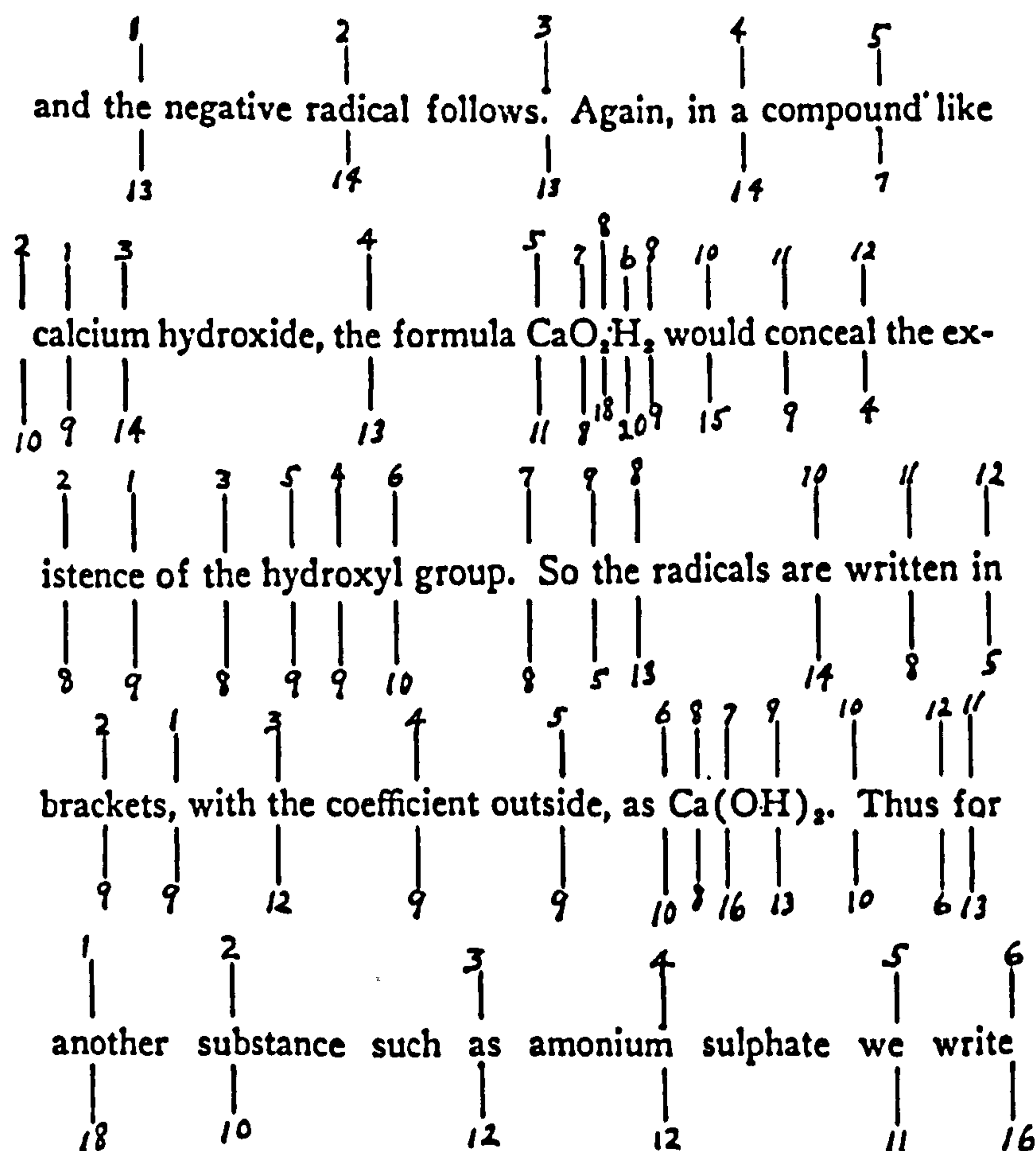


fig 3.5 Location of pauses in reading chemistry by an adult subject. Vertical lines show the location of pauses. The numerals at the top of the vertical lines show the sequence of pauses; those at the bottom indicate duration of the pauses in 50ths of a second.

Carpenter and Daneman (1981) argue that the sequence of regressive fixations reflects the process of detecting and correcting a prior misrepresentation. With regard to the semantic control model, Carpenter and Just (1977)



acknowledge that unfamiliar words receive disproportionately many fixations and that the evidence supports some degree of semantic control of fixations. However, they point out that semantic processes might play an even larger role in determining regressive fixations, and suggest that fixation behaviour can be used to uncover the underlying comprehension processes.

In later attempts to uncover this underlying comprehension process (Just & Carpenter, 1980; Carpenter & Just, 1981) Carpenter and Just argue that readers make longer pauses at points of increased processing that correspond to encoding infrequent words, integrating information from more important clauses, and making inferences at the ends of sentences. The link between eye fixation data and the theory proposed rests on two assumptions. The first — an immediacy assumption — is that a reader tries to understand each content word of a text as he or she encounters it, even at the expense of making guesses that sometimes turn out to be wrong. The second — the eye-mind assumption — is that the eye remains fixated on a word as long as the word is being processed. The first assumption would imply that there is no appreciable lag between what is being fixated and what is being processed. As Just and Carpenter (1980) say:

“A reader can take in information at a pace that matches the internal comprehension processes. By examining where a reader pauses, it is possible to learn about comprehension processes themselves”.

(p 329)

Within their framework, these pauses, which amount to an aggregation of consecutive fixations into units called ‘gazes’, reflect the time to execute comprehension processes, but this point of view is not universally accepted. Nevertheless, Carpenter and Just continue to argue strongly, with only minor modification for their thesis (Carpenter & Just, 1983). They argue that the time a reader spends on a word reflects processes initiated by that word and that several kinds of comprehension processes are involved, including encoding the word, accessing it, and performing syntactic, semantic, and discourse level processes. They reiterate their findings that the currently fixated word influences the time spent on that word, either by increasing the fixation duration or by influencing where the next fixation is made, and that interpretive processes of all levels occur as soon as they are enabled. However, they do acknowledge that, although lower level



processes are usually enabled as soon as the word is encoded, the point at which higher level integrative processes are enabled is unpredictable.

Hogaboam and McConkie (1981) argue that mean gaze durations cannot be directly interpreted as a measure of processing time as there is good reason to believe that the underlying assumptions are wrong, and that processing time profiles could be constructed from eye movement records if more were known about specific relationships between cognitive processes and eye guidance, but they point out that the predicting of processing time profiles requires consideration of how a large number of variables interact in a real-time situation. Any real-time theory of reading must provide testable predictions which go beyond assertions that particular variables are involved in determining processing time. The Carpenter & Just view has also been challenged by Slowiaczek (1983) who points out that one of the problems of the Carpenter and Just approach is that the eyes do not fixate every word in a regular pattern, that words are often skipped and that some words are fixated only after a regressive eye movement. McConkie (1983), on the basis of his research, is led to the inevitable conclusion that processing of the information available during a fixation is not completed by the end of that fixation and that the onset of the next fixation is not triggered by a completion of processing of information obtained on the present fixation. He is willing to acknowledge, however, that the period of time spent fixating a word is not the actual time spent processing it, though there is a relationship between these times.

Rayner (1983) argues that there is clear evidence that the characteristics of the word being fixated influences the fixation duration and that certain syntactic and semantic processes related to that word are still occurring after the eyes have left that particular word and have moved on to a new location. Wolverton and Zola (1983) have concluded that higher order processes continue after removal of the text and they lag behind the actual extraction of the visual information due to transmission delays and finite processing times.

Shebilske and Reid (1979) have presented a more global measure of reading eye movements in the belief that a strict movement-to-movement link between language processes and eye movements is not required for eye



movements to be a useful tool for analysing comprehension processes during reading. They were able to demonstrate that measures of reading rate per sentence supported the idea that reading eye movements are influenced by comprehension processes that link sentential conceptual units together to form higher-order conceptual units (macro-propositions).

Regardless of which view is more correct, it has to be conceded that increased duration of fixation does, at least, provide the potential for increased processing and if it is possible to structure the text, either semantically or visually, so that perceptual and cognitive processing can be enhanced, the nature of such structuring needs to be pursued. Loftus (1983) has noted that although the gist of the scene can be acquired fairly rapidly (within the first 100 msec), the requirement that a large amount of peripheral processing be possible makes it impossible for the gist of information in a block of text to be revealed during the first or even during the first few fixations on the text, and that this therefore has implications for the structure of text in heading arrangements and the judicious placement of information within the first few sentences of the text.

Most writers acknowledge that a reader's purpose or goals in reading will affect strategy, and eye-movement research supports this contention. Rothkopf & Billington (1979) tried to determine, *inter alia*, the influence of learning goals on rates of search for goal-relevant information, and what eye-movement activities are associated with inspection time changes produced by learning goals. They concluded that subjects read background material at a relatively rapid rate but that, after reading two thirds of the goal-relevant sentence, they detect goal relevant information and switch to an inspection style that involves more lines rescanned, more fixations, and longer fixations. Rothkopf (1980), noting that when a sentence is goal-relevant, the density of fixations is increased, and the durations of fixations are lengthened, comments:

"It would be but a small leap of the imagination, though one still consistent with the current *Zeitgeist*, to translate density of fixation into the likelihood of appropriate internal representation of text components, and to equate the small increases in the average duration of fixations with greater depth of processing".

(p 55)



When readers have to perceive importance of text elements for themselves, Shebilske and Fisher (1983a) hypothesised that good readers allocate additional time and resources to those processes that integrate units into a conceptual representation, and analysis of their research not only supported this but revealed that good readers slow down for important ideas by increasing their average fixation duration and by increasing their regressions.

### **3.2.6 Levels/Depth of processing**

As noted earlier, Craik & Lockhart (1972) proposed that events are analysed to different levels or depths by hierarchically organised cognitive structures, such that preliminary, shallow analyses are concerned with physical aspects of the stimulus, whereas subsequent, deeper analyses are concerned with meaning and associative relationships. Craik (1977) subsequently elaborated upon this by commenting that the depth to which an event is processed depends on such factors as the meaningfulness of the stimulus, the attention devoted to its analysis, and the nature of the task being performed, citing the example of proofreading as a case where superficial analysis will suffice and comprehension as an instance where deeper analysis is necessary.

The concept of “levels of processing” as discussed by a number of writers (Ruddell, 1976, Kintsch, 1979) has already been referred to, and it is clear that each tends to put individual and characteristic interpretations on the concept. Craik (1979) has acknowledged that the particular version of the levels-of-processing view of memory advanced by Craik and Lockhart (1972) has evolved and changed in many respects. Nevertheless, he argues that the metaphor of ‘depth’ is still a useful one to express the idea that analysis of an event takes place gradually, and that the qualitatively different internal forms of representation of the stimulus can be ordered from those concerned with sensory, ‘surface’ qualities to those concerned with the abstract, symbolic properties of the event.

Although Anderson and Reder (1979) have argued that the variation in memory with depth of processing is a result of the number of elaborations subjects produce while studying the material and that it is not the depth of processing *per se* that is important but the prior experience of making elab-



orations about various types of information and the practice at interpreting the previously stored elaborations, there have been other reports which support the levels-of-processing approach such as that of Schwartz (1980) which indicated that adult recall reflects the level of semantic analysis when attention to different levels of analysis is forced.

However, it has been the lateral movement from levels of processing in text to depth of processing in learners in general which may, in the end, shed greater light on the strategies necessary for a deep level of comprehension when a reader interacts with a text.

Marton and Saljo (1976a), concerned more with 'what' students learn rather than 'how much' they learn, observed that students adopt four basically different ways of comprehending, which they referred to as 'levels of outcome', and which they claim are concrete examples of qualitative differences in learning. Having identified qualitative differences in the outcome of learning, they hypothesised that there would be corresponding differences in the 'processes of learning' and did, in fact, identify two different 'levels of processing' which they called 'deep-level' and 'surface-level' processing.

"In the case of *surface-level processing* the student directs his attention towards learning the text itself (*the sign*), i.e. he has a 'reproductive' conception of learning which means that he is more or less forced to keep a rote-learning strategy. In the case of *deep-level processing*, on the other hand, the student is directed towards the intentional content of the learning material (*what is signified*), i.e. he is directed towards comprehending what the author wants to say about, for instance, a certain scientific problem or principle."

(p7)

In another investigation Marton and Saljo (1976b) provided further evidence of qualitative differences in learning and also demonstrated that alternative levels of processing and levels of outcome could be induced through the demand characteristics imposed on students by the nature of the questions interspersed with learning. Students appear to adopt an approach determined by their expectations of what is required of them.



Following up this established link between intention, process, and outcome, Entwistle and Ramsden (1983) report an investigation similar in intent to that of Marton and Saljo (1976a, 1976b) but utilising a questionnaire variant for the gathering of data rather than oral examination. They noted that the distinction between 'deep' and 'surface' came through clearly, but they also noted a distinct group of students who look for meaning but who do not interact with the text, relating facts to conclusion, and they chose to label such students as 'deep passive'. Saljo (1975) has also identified a third category which he described as 'technified deep approach' where the student looked for meaning without interacting with the detail of the argument.

Biggs (1976) uses the terms 'reproductive' and 'transformational' to describe the learning strategies employed by university students. The significant feature of the reproductive strategy is that the learning is directed towards giving back the presented material intact, whereas the transformational strategy is characterised by the student consciously relating new material to known material and, in general, a more active and reflective attitude on the part of the learner. Svensson (1984), noting that the aim underlying a learning-task involving an academic task is not the learning of facts but, rather, the learning of an organised whole in which certain facts are embedded, observed four qualitatively different categories of learning outcome which he claims are based on four qualitatively different ways of organising the content of text when reading and remembering it. He identified within these four styles, two ways of interacting with text which he referred to as the 'holistic' and 'atomistic' approaches, the main feature of the distinction between the two being the recognition and utilisation of the principle of organisation. Svensson (1984) points out that holistic and atomistic approaches are not seen as characteristics of individuals, but as individuals' way of relating to specific materials and it was for this reason that he preferred the concept of 'approach' to the concept of 'process'.

As Marton and Saljo (1984) note, the distinction between holistic and atomistic approaches is a distinction in cognitive approach.

"In the holistic approach during reading, students showed indications of a general direction towards understanding the text as a whole — a search for the author's intention, relating the content to a larger



context and delimiting the main parts of the text. The indications of an atomistic approach were: focussing on specific comparisons in the text, focussing on the sequence of the text, but not the main parts, memorizing details and, in contrast, clear evidence of a lack of an orientation towards the message as a whole''. (p 43)

The research data from Marton and Saljo and from Svensson indicates a deep/surface dichotomy which emphasises referential aspects of students' experiences (their search for meaning or not) and a holistic/atomistic dichotomy concerned with organisational aspects (the ways in which students organise the informational content of the article they are reading) respectively.

Different kinds of learners have also been identified by Pask (1976a; 1976b) and categorised as either 'operation' learners or 'comprehension' learners. He also identified two distinct learning strategies — 'holists' and 'serialists' — where the 'holist' assimilates information from many areas and the 'serialist' moves on to another area only when he is completely certain about the one he is currently studying. Holists apparently get involved in thinking about broad relations and form hypotheses about generalisations whereas serialists think about narrower relations and more specific hypotheses. Entwistle and Ramsden (1983) argue from their findings that there is an inevitable connection between a deep approach (as defined by Marton & Saljo) and comprehension learning (as defined by Pask). Saljo (1981) notes that Pask points to various observations concerning how serialists and holists learn which are quite in line with the more general distinction between a memorising and a more organised strategy, but Laurillard (1979) points out that terminological problems abound because none of the terms used, such as 'strategy', 'style', or 'process' has been rigorously defined.

She notes that Pask makes the distinction between 'style' and 'strategy' and reasons that 'strategy' is related to 'style' in the sense that it is a manifestation of style under particular conditions. Further, she draws attention to the fact that Marton & Saljo have equated 'process' and 'strategy', with the process being defined in terms of the student's focus of attention, and



'levels of processing' then being defined in terms of the differences in focus. She distinguishes between the two types of description in terms of the content of the students' thinking, reasoning that both 'style' and 'strategy', for Pask, refer to the way the student thinks about the subject matter itself, the way he relates one topic to another, whereas for Marton & Saljo, 'levels of processing' considers how the student approaches the subject matter, what he is looking for, and where his attention is focused. Laurillard argues, then, that 'process of learning' includes at least two aspects — 'executive style' (as in Pask's 'style' and 'strategy', referring to the way the student thinks about the subject matter) and 'strategic approach' (as in Marton and Saljo's 'processing', referring to the way the student approaches the task). She argues that, if 'executive style' and 'strategic approach' do define different aspects of the learning process, then they should be mutually compatible, and possibly even interactive. Her investigations concluded that students cannot be characterised in terms of a dichotomised description of learning because they are responsive to the environment and their approach to learning is determined by their interpretation of that environment. This is really quite consistent with earlier observations regarding the nature of the interaction between student and learning materials, and is an issue which will be returned to at a later stage.

Arising from the original Marton investigation there have been several attempts to replicate his findings or to extend the methodology to identification of individual differences (Biggs, 1978, 1979; Watkins & Hattie, 1981; Watkins, 1982, 1983a, 1983b; Schmeck & Grove, 1979; Schmeck & Phillips, 1982; Diekhoff, Brown & Dansereau, 1982) and there appears to be strong support for the hypothesis that depth of processing is related to the quality of the learning outcomes, although it has been pointed out by Gibbs, Morgan and Taylor (1980) that the distinction between what Marton calls deep and surface levels of processing refers to a variation within what cognitive psychologists regard as the semantic, or deep level, domain of processing.

The contribution to an understanding of the reading comprehension process by eye-movement research is discussed on page 137.



### 3.2.7 Imagery

Earlier in this section it was recorded that Kintsch (1982) claimed that all current work on text that he was aware of uses propositional representations. However, he followed that remark by indicating that it should not imply that imagery is not important in text processing. Singer (1982a) has noted that current modes of text representation are verbal and that another mode is imagery. He suggests the need to determine the relationship between those two modes of representation and to identify whether they undergo developmental changes in their relationships.

Fleming (1977) raises questions as to what is meant by image but he considers as more important,

“how fundamental and instrumental is the picture  
in your mind to your cognitive processes? . . . .  
What are the effects of imagery on memory? Can  
relatively abstract concepts and thoughts involve  
imagery? (p 43)

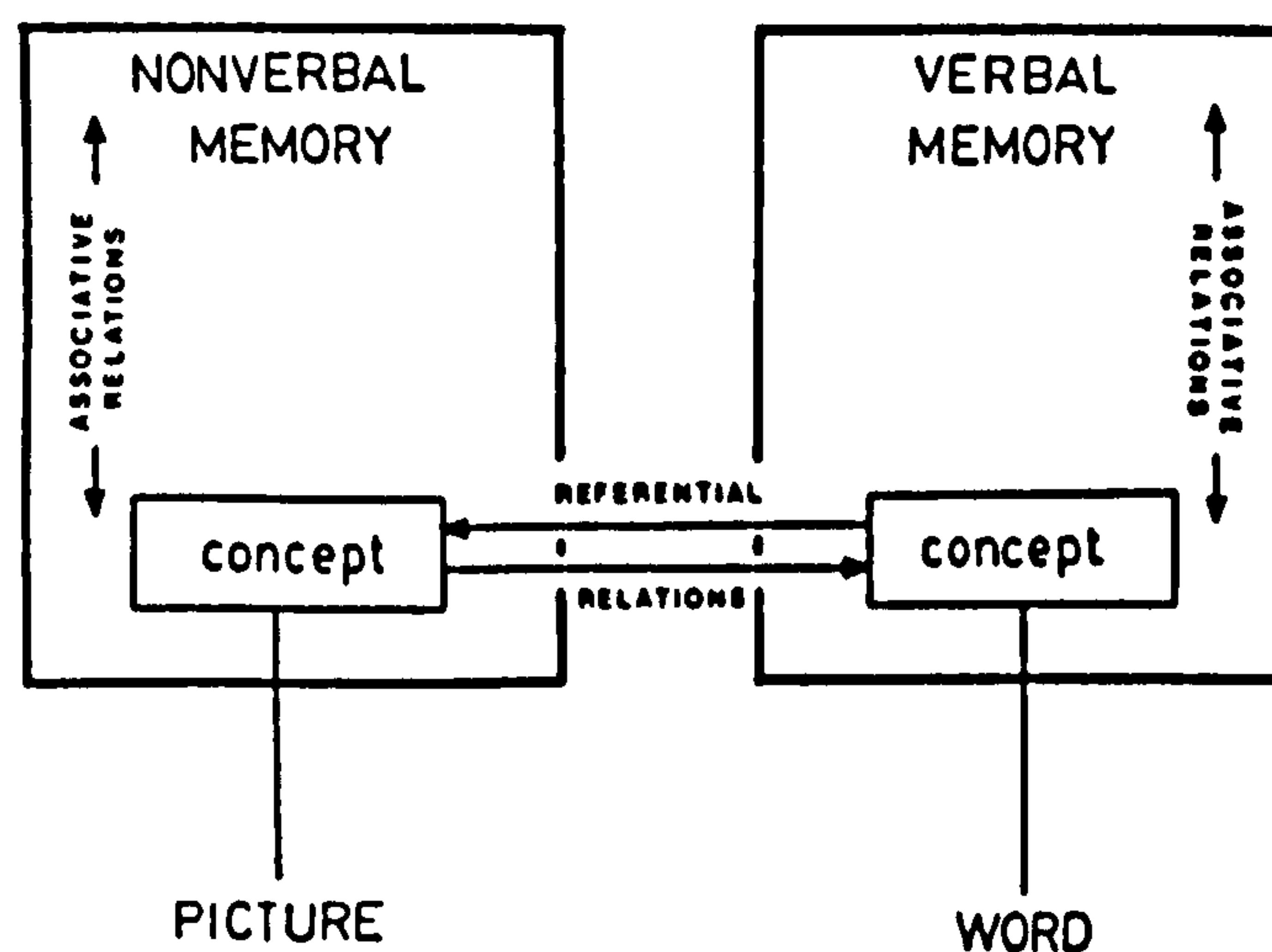
He sees ‘image’ as a phenomenon of memory, as a recalled image, reconstructed with varying fidelity from past experience.

Earlier analysis in this chapter was concerned with propositional representation in memory but, as already noted, there is the possibility that information can be stored in memory as an imaginal representation. Spoehr and Lehmkuhle (1982) say that the existence of imagery as qualitatively different from propositional memory is intuitively evident, but they acknowledge that not all psychologists would agree with this and that alternatives to imagery theory have been proposed.

A major contribution to imagery theory has arisen from the work of Paivio (1971) who postulated that there are distinctive modes of representation for different types of information. The basic premise of Paivio’s theory is that representational memory is comprised of distinguishable codes associated with different classes of information. This ‘dual code’ theory emphasises two coding systems: verbal representations which correspond to words, and imaginal representations which correspond to non-verbal elements of experience. The main assumption in the theory, and reiterated by Paivio (1983), is that cognition consists largely of the activity of two partly interconnected



but functionally independent and distinct symbolic systems. The dual code approach is contrasted with common coding models by te Linde (1983). Common code approaches assume that pictures and words access semantic information in a single conceptual system that is neither word-like nor picture-like, whereas the dual code approach postulates that language and knowledge of the world are represented in functionally distinct verbal and non-verbal memory systems which are independently accessed by their relevant stimuli. The imagery system is activated more directly by perceptual objects or pictures than by linguistic units and structures, with the converse being true for the verbal system.



**fig 3.6** Schematic representation of the dual coding model showing picture and word access to the nonverbal and verbal symbolic systems.

According to J. Clark (1983), Paivio argued that meaning or comprehension is determined by the total reactions of an individual to an external event and that these reactions can be classified as one of three types: representational, referential, or associative, and referred to as 'levels of meaning'. The first level, termed a representational reaction, involves a representation that maintains a perceptual correspondence with the actual event. Thus, a familiar word elicits activity in a specific imaginal representation. In both cases, activation is based on a pattern recognition process and could be considered a direct and relatively unmediated reaction. Referential and associative reactions are, however, not directly elicited; they are mediated by the representational reaction. Initial activation of the verbal or imaginal representation results in second order activation of other representations which are connected to the stimulus less directly.



Referential meaning involves a subsequent reaction in which mediated activity is initiated in a representation of a different type than the initial representation reaction. A verbal representation, once activated, can stimulate related imaginal representations, and an imaginal representation stimulates verbal representations.

Associative meaning relates to the activation of representations of the same type as the original representation reaction. The activation of a verbal representation arouses other verbal representations and the activation of an imaginal representation arouses other imaginal representations. These effects depend on associative connections determined by the prior experience of the individual.

Paivio referred to these different dimensions as levels of meaning because the ultimate significance or meaning of the external event is the composite of these representational, referential, and associative reactions (J. Clark, 1983) Paivio (1983) sums up this aspect of dual coding thus:

“The representational level refers to the relations between perceptual stimuli and their corresponding representations in the two symbolic systems. The referential level refers to relations between imaginal and verbal representations. The associative level refers to relations between units within each system”.

(p 309)

The last statement differs from his original idea and is a change toward descriptive consistency, since his earlier ideas referred to the associative level as involving elaborative associations both within and between systems. He is now of the view that it is more appropriate to restrict the conception to relations between representational units within each system and to describe more complex elaborative processing as a combination of referential and associative reactions.

Kosslyn (1981) has argued that visual mental images are transitory data structures that occur in an analogue spatial medium, and that these surface representations are generated from more abstract deep representations in long-term memory which, once formed, can be operated upon in various ways. In his judgement, a cognitive account of imagery is a theory about the functional capacities of the brain that are invoked during imagery. This



concern with the function of imagery is echoed by Lockhart (1982) who has argued that the proper starting point for a discussion on imagery should be questions about its function rather than its nature.

In elaboration of this view of imagery, Kosslyn (1983) claims that the pictorialness of images lies in the way they are interpreted within the mind, such that images are interpreted as if they were actual displays by means of operations similar to those a computer central processing unit uses to interpret data as displays in a matrix (although he points out that the brain-computer analogy has limitations). He states, further, that

“The mind evidently stores information in media, and properties of the medium affect how we can store and use information. In particular . . . we can infer that images are displayed in a functional spatial medium. Although it is not a literal screen, this medium nevertheless is capable of depicting visual information within certain limits of resolution, size, and shape”.

(p71)

The Kosslyn theory of imagery has, however, been challenged. In a critique of research which used the notion of a *mental image* as a theoretical construct to describe one form of memory representation, Pylyshyn (1973) argued that there were abstract mental structures to which there was not conscious access but which were essentially *conceptual* and *propositional* rather than sensory or pictorial in nature. He claimed that the picture metaphor was seriously misleading. In a later review of the debate between *analogue* and *propositional* approaches, Pylyshyn (1981) argued that functions such as mental scanning and mental rotation transformations needed to be explained by reference to computational cognitive processes whose behaviour is governed by goals, beliefs, and tacit knowledge rather than by properties of analogue mechanisms.

Research related to imagery and text has tended to be concerned with concrete and abstract sentences (Marschark & Paivio, 1977; Irwin & Witte, 1980; Irwin, 1979; Hannafin, 1983), with individual differences in learners (Pierce, 1980; Delaney, 1978; Carrier, Joseph, Krey, & La Croix, 1983; Katz, 1983) or with instructions to readers to adopt an imagery strategy in reading (Tirre, Manelis, & Leicht, 1979; Kulhavy & Swenson, 1975; Rasco,



Tennyson, & Boutwell, 1975). By and large the evidence shows that imagery can assist recall of concrete prose and that field independent learners can make greater use of imagery. However, there are other areas of research which are relevant to this study, such as investigations regarding visual memory for place on the page (Zechmeister, McKillip, Pasko, & Bessalec, 1975) because it has to be recognised that the text itself, by virtue of its typographical features, has a visual form which can be of advantage in memory and comprehension, and this is a matter which will be returned to in a later section.

Kosslyn (1980) has noted that many of the arguments against imagery have consisted of attacks on the idea that visual images are stored in memory much as a snapshot is stored in a photograph album, a metaphor which he considers as misleading. In the face of criticism of imagery, he points out that

- (a) imagery is not an inherently flawed concept, despite the primitive 'picture metaphor' conception of imagery often widely believed;
- (b) imagery is not necessarily only a special aspect of a more general propositional representation system, despite claims to that effect (Pylyshin, 1973); and
- (c) explicit theories are needed to permit the evaluation of the relative efficiency of the various imagery and propositional theories.

In developing a theory of imagery, Kosslyn (1980) proposed that images have two major components — the 'surface representation' which is a quasi-pictorial entity in active memory that is accompanied by the experience of 'having an image', and the 'deep representation' that is the information in long-term memory from which the surface image is derived. To Kosslyn,

"Imagery is a way of representing information that may be especially perspicuous for performing some tasks. Not all thought processes involve imagery, nor is imagery in a privileged position as a form of internal representation. The information represented in an image is defined only vis-a-vis the interpretive procedures that can be satisfied when applied to an image . . . . In addition to representing information about objects



in the world in a static form, images also allow one to transform information, to mimic dynamic aspects of our environment . . . . Thus, imagery is an aid to thinking about the consequences of given actions''.

(p 456)

The contribution of imagery to an understanding of the reading comprehension process is discussed on page 138.



## **3 Principles in comprehension**

### **– a discussion of the issues in chapter 3**

#### **3.1 Introduction**

The point made by Kintsch and Vipond (1979) that psychologists no longer seem to care about readability whereas educators do, raises two serious issues. The first is that psychologists may be failing to see the relevance of application of their research to educational activity, and the second is that educators may be failing to see the indefensibility of current practice in the light of advances in research findings. Goetz (1984) has observed that the traditional separation of basic research, applied research, and educational practice — coupled with traditions within each of these strands of enquiry — have led to the failure to provide students with effective study methods, but suggests that recent developments may indicate that things may be changing. In support of this, he argues that: in basic research there is an increasing emphasis on studying how people learn from complex verbal stimuli such as text and how knowledge is acquired and represented; in applied research, investigators have begun to carefully enquire what students *do* when they underline or take notes; and, efforts are currently underway to bring together basic research, applied research and educational practice.

Comprehension as measured within the frameworks of 'legibility' and 'readability' is clearly inadequate for the purposes of the design of instructional text, and the insight on the process of comprehension available through recent developments in information-processing psychology are, therefore, of considerable relevance.

#### **3.2 The contribution of psycholinguistics**

Although psycholinguistics has been identified as being within mainstream information-processing psychology (Lachman & Lachman, 1979) it is more useful to consider its contribution to reading comprehension separately from



that of cognitive psychology because it is concerned with a narrower range of factors.

The first important aspect of psycholinguistics research must be the recognition that comprehension is not concerned with exact recall but, rather, with transformations, inferences, and integrations, because this is what is required in learning from text. The second important aspect is the idea of levels of comprehension (Perfetti, 1977) and, in particular, the highest level where there is a demand for "thinking" or at least some construction of ideas, because this is even more in keeping with what is required in learning from text. The detailed mechanism of the various processes involved, be they related to synthesised codes or semantic representations, is less important than the broader perspective that reading comprehension concerns mental manipulation beyond the level of recall of information.

The ideas of Kintsch (1979) that a deeper processing than that usually associated with semantic processing is involved and that reading comprehension is a constructive process involving not just the text but the reader's prior knowledge of the topic are fundamental to an understanding of reading comprehension in the real world. His concept of 'text representation' as propositions is consistent with the widely held view of the propositional representation of knowledge in which, as E. Gagne (1985) has pointed out, the proposition corresponds roughly to an idea and

"Words, phrases, and sentences represent  
ways of communicating ideas, whereas  
propositions represent the ideas themselves". (p 39)

The concept of 'gist' as proposed by Kintsch (1979) and based upon the idea of 'macrostructure' is obviously consistent with the above thinking as is his notion of a network of propositions which has been elaborated by Hayes-Roth and Thorndyke (1979).

Thus, from the contribution of psycholinguistics to an understanding of the reading comprehension process can be derived the following principle:

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"If the comprehension of text is concerned  
with the construction of ideas, then the  
text needs to be designed so that ideas are  
emphasised".

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### **3.3 The contribution of cognitive psychology**

The concept of propositional representation is an integral part of a cognitive view of psychology and the work of Kintsch is fairly fundamental to the concept. The important issue, however, is the recognition of the extent to which the reader is involved in the development of the propositional representation (Kintsch, 1982) such that, although the initial text representation is fairly close to the surface structure of the text, the interaction between the reader and the text results in 'meaning' being generated which is dependent upon both the reader's background and goals so that, in effect, not only could different readers produce different meaning, but the same reader could, conceivably, produce different meanings on different occasions, depending upon his/her goals or intentions at the time.

The implications for this line of reasoning are extensive. For example, Saljo (1984) has related the surface or deep approach to learning (Marton & Saljo, 1976a) with the intention the reader has in approaching an instructional text, and the possible effects of pre-instructional strategies such as advance organizers and learning objectives (discussed in chapter 5) need to be considered in this context.

The notion of coherence (Pace, 1982) arising from the use of connective propositions to relate ideas across separate sentences is of interest, but as Frederiksen (1977) has pointed out, there is still a need for the development of a more integrated account of coherence in discourse and the describing of how the cognitive system discovers coherence in discourse, before there will be an account which relates textual to propositional coherence.

Meyer's work (1975, 1977a, 1977b), in identifying the content structure or organisation of information in a passage as the most powerful variable related to recall, clearly goes beyond the issue of coherence. In a more recent discussion of her work (Meyer, 1984) she concludes that the dimensions of emphasis and types of organisational structures in text interact with reader expertise and reader strategy and that this interaction affects the mechanisms of cognitive processing that form a representation of the text in the reader's mind. Different cognitive representations can thus be stimulated by the use of different structures and emphasis plans in text, a conclusion which has important implications for the designer of instructional text.



Although Meyer's concern is with semantic and syntactic contributions to emphasis and organisation, the fact that there is an interaction between these and reader expertise and strategies, and the evidence that different cognitive representations can be stimulated by the use of different structures and emphasis plans, suggests that the principle involved might be applicable to other text-based features more directly related to typography and layout, and this is an issue which will be discussed in chapter 5.

From the work discussed here on propositional representation, the following general principle can be derived:

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"If the ideas in discourse are emphasised and indicated in the organisation of the text, the reader is likely to form representations and networks of representations in keeping with the organisational plan".

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The proposal by Kintsch and van Dijk (1978) that the semantic structure of a discourse is characterised at two levels (the microstructure and the macrostructure) concerned with the structure of individual propositions and their relations and the more global structure of discourse as a whole, together with their assertion that the role of schema is to determine which micropropositions or generalisations of micropropositions are relevant and, thus, which parts of the text will form its gist, are interesting because they highlight the interactive nature of reading. The possibility of different schemata being set up by different readers, depending upon their goals in reading, raises issues of the feasibility of linking reader purpose and strategy to reading outcome, and there is certainly evidence that training students in strategies for identifying the main idea of passages and related metacognitive strategies improves students' ability to identify the main idea of expository passages (Stevens, 1985). However, the point made by Anderson (1980) that the knowledge a person already possesses has a potent influence on what he or she will learn and remember from exposure to discourse, and that the meaning of a text thus arises in an interaction between the characteristics of the message and the reader's existing knowledge and analysis of content, is particularly important. As Schallert (1982) has emphasised, meaning is neither in the text nor in the schemata, it is formed as a result of the



dynamic interaction between existing abstract knowledge structures and the clues available from the message.

Despite the criticism which exists of schema-theories, there appears to be widespread acceptance of the view that schemata enable the making of inferences, are arranged heterarchically in different types of knowledge structure, and are the basis of a constructive process of text comprehension (Jonassen, 1985a). A notable proponent of schema-theory has recently proposed the notion of 'strong' and 'weak' schemata (Anderson, 1984a) where the strong version of a schema is exemplified in a scientific theory and would include general principles that relate form and function, motive and action, and cause and effect. Strong schemas assume idealised worlds, whereas weak schemas include generalisations that are limited in scope, entail low standards for internal consistency, and provide an uncertain basis for *a priori* reasoning and are, thus, able to give the best account of the knowledge that most people have about ordinary matters.

The schema-theoretic view of comprehension is an important foundation for the development of text-based ways of activating relevant schema and making the organisation of text more obvious. It can also provide a theoretical framework for pre-instructional strategies and generative activities which have, previously, been based on less defensible assumptions, and these implications will be discussed at a later stage. In the meantime, the contribution of cognitive psychology can be summarised as:

"The meaning that a learner assigns to a text results from the activation of the network of specific associations and relations that an individual has encoded into memory. These knowledge structures also determine the nature of the interpretive, elaborative, transformational, and inferential processes that an individual can activate when trying to understand material. Learning is a process of constructing and reconstructing mental representations of events or ideas".

(Jonassen, 1985a, p 19)

From this consideration of the schema-theoretic view of reading comprehension, the following principle can be derived.



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“If reading comprehension is an interactive process between text-based ideas and reader-based schemata, then the greater the correspondence between the text and the prior knowledge of the reader, the more efficient will be the comprehension”.

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### **3.4 The contribution from models of reading**

Although it is recognised that the various models of reading do little to explain the comprehension process (Kamil, 1978; Gough & Cosky, 1977) the fact that they attempt to address what happens in the reading process is of interest since it may have relevance for either the design of print or for the strategy that the reader needs to adopt.

The Gough model (Gough, 1976) and the La Berge & Samuels model (La Berge & Samuels, 1974) are of interest in that they are both ‘bottom-up’ models which acknowledge an initial visual input prior to semantic interpretation. The initial visual stimulus, which may be related to physical characteristics of the text, readability and style, could influence the nature of the schemata being activated and, hence, the nature of the ensuing comprehension and is, thus, an important consideration for the design of print. Samuels and Kamil (1984) have observed, moreover, that the emergence of the Gough and La Berge & Samuels models provide convincing evidence that the information processing approach to studying mental processes had impact on the reading field.

The independent-process model proposed by Calfee and Spector (1981), with its involvement of two independent processes — microanalysis and macroanalysis — could be difficult to sustain within the framework of comprehension already discussed, but the interactive-compensatory model of Stanovich (1980), according to Samuels and Kamil (1984), makes a unique contribution to reading models because it explains, from a theoretical viewpoint, the apparent anomaly that under certain conditions poor readers exhibit greater sensitivity to contextual constraints than do good readers. Good readers are less sensitive to contextual effects because their knowledge sources for these lower-level processes are seldom weak.



Samuels and Kamil (1984) have analysed the reviewed models and have noted that those of Gough, La Berge & Samuels, Stanovich, and Rumelhart concentrate on word-recognition processes either in a linear way or in an interactive way, whereas those of Kintsch & van Dijk and Just & Carpenter concentrate on comprehension, almost to the exclusion of letter-level processes.

Each of the models reviewed has contributed to an understanding of particular aspects of the reading process and, although only two have been concerned primarily with the comprehension process, there are two important observations in each of them. However, none is a comprehensive model of the reading process and it would be inappropriate at this stage to try to derive a general principle which could be of assistance to the designer of instructional text.

### **3.5 The contribution from other issues in comprehension**

The description of the cognitive processes which result in meaningful learning as 'generative' is understandable since, as Wittrock (1981) has indicated, when people read with comprehension they generate meaning for written language. Jonassen (1985a) has drawn attention to the fact that the generative model of learning asserts that learners, when faced with a stimulus such as text, construct and assign meaning to that information based upon prior learning. Reading comprehension, within the generative model of learning with understanding (Wittrock, 1974), is facilitated when, during encoding, learners use their memories of events and experiences to construct meanings for text. As Doctorow, Wittrock & Marks (1978) state,

"The words, sentences, and paragraphs in a given context are the retrieval cues that stimulate semantic processing of information stored in memory. From the semantic processing of abstract and concrete memories, readers generate meanings for the text. The actively constructed individualized meanings represent each learner's comprehension of the text".

(p 109)



What is referred to here is a purely cognitive transformation and is consistent with the schema-theoretic model discussed earlier. What is often interpreted as generative activity (e.g. Jonassen, 1985a) is not only cognitive transformation, but a mental elaboration and a physical demonstration of that elaboration. Thus, although such processes can be predicted as facilitative of comprehension on the basis of the generative model, they are not, in themselves, part of the generative model. They are, in effect, extensions beyond the basic generative model and can help to provide a theoretical framework for, for example, adjunct aids. For the purpose of this discussion, the application of such processes will be considered in the context of mathe-magenic behaviour at a later stage, and discussion here will be confined to the immediate cognitive processing.

The notion that meaningful learning is a generative process is beyond dispute: whether the reader can be prompted to adopt an approach to the reading of instructional text such that generative processing can be encouraged is another matter. It really depends more on the learner than on the text.

The same is true with respect to the notion of elaboration (Reder 1980). No doubt the generation of elaborations can contribute to the comprehension process, but an ability to generate elaborations is really part of a reading strategy rather than a function of the text or of readers in general.

Perhaps the summary by Black (1985) of the processes that act on the memory structures constructed when reading expository text is appropriate at this point in the discussion.

“Comprehension processes perform three kinds of functions: They use cues from the text to access the knowledge needed to understand the text, they manage both the text and knowledge information in limited working memory while processing the text, and they construct the memory representation of the text that becomes part of long-term memory”.

(p 263)



A general principle which could be derived from the foregoing discussion of the nature of reading comprehension could be:

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“If the design of text takes into consideration the process of comprehension involved in reading to learn with respect to text-based and reader-based variables, comprehension will be optimised”.

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### **3.6 The contribution from eye-movement research**

The claim by Rayner (1979) that the location of the eye fixation is determined by visual characteristics of the text or the cognitive processing state of the reader and the argument by McConkie et al (1979) that the length of time the eye remains in any location is related to the cognitive processing state of the reader and the difficulty of the material being fixated, together raise issues of interest to the discussion on comprehension and to the design of text in general. Location and duration could both be related to comprehension in that location could reflect structure, particularly identifying headings, key words and phrases, etc., and duration could be indicative of processing time.

The Carpenter and Just view that there is a direct link between the duration of fixation and the comprehension process (Just & Carpenter, 1980; Carpenter & Just, 1981), based as it is on the ‘immediacy’ and ‘eye-mind’ assumptions, has not found support among other workers and has been criticised, in particular, by McConkie and his colleagues (Hogaboam & McConkie, 1981), but also, as has been noted, by Slowiaczek (1983), Rayner (1983) and Wolverton and Zola (1983). Nevertheless, the evidence from Shebilske and Fisher (1983a, 1983b) and Rothkopf (1980) lends some support to the Just and Carpenter view without suggesting a strict processing during fixation. As noted earlier, increased fixation at least allows the possibility of increased processing and the fact that difficult material requires increased fixation and regressions, presumably because of the nature of the processing involved, certainly points to there being a relationship between fixation and processing.



The recognition that there is a relationship between the period of fixation and the period of processing is important, because even if the times are not exactly the same, it is highly unlikely that they are inversely proportional. Chances are that there is a proportional relationship and, if this is the case, it would be interesting to determine the fixation pattern and duration with respect to headings within a typographically cued text and to compare this with the acquisition of the gist or structure of the text.

The discussion thus far is probably of more relevance for those design aspects of print which arise from an understanding of the reading comprehension process, but the work of Shebilske and Fisher (1983b) is more relevant to an understanding of the reading comprehension process *per se*. From eye-movement research they noted that readers adjusted their reading by slowing down for sentences that had to be integrated with three or more other sentences to form a macroproposition and concluded that eye movements are influenced by purpose for reading. They further concluded that comprehension processes influence eye movements when they map surface units on to micropropositions and when they map micropropositions on to macropropositions.

From the discussion relating to eye-movement research, the following general principle can be derived:

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“If the structure and content of text are made clear semantically, syntactically, and typographically, the reader will devote cognitive processing time selectively to these issues”.

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### **3.7 The contribution from imagery research**

The comments by Kintsch (1982) and Singer (1982a) give recognition to imagery as a mode of representation distinct from a verbal mode, but the real problem seems to be in balancing the ‘dual code’ theory of Paivio (1971) with the ‘common code’ theory of te Linde (1983) and the non-propositional theory of Kosslyn (1980), and extracting from this



appropriate principles for reading comprehension and, possibly, text design based upon that understanding of comprehension.

Fleming (1983a) concludes that visual imagery is a very versatile mental process (or group of processes) implicated in diverse ways in a wide range of human thought from preserving identities and association in memory tasks to generating novel entities and relations in creative and problem-solving tasks. Kosslyn (1980) argues that if an understanding of how people represent and use information can be reached, optimal ways can be devised of presenting information, and that it may turn out that the way in which a person should be taught certain information depends on the uses to which it will later be put. Kosslyn (1983) claims that two steps in the imaging process are always used — *generating* an image and *inspecting* it — and that the type of image generated and the way it is interpreted depend on what it will be used for.

It seems reasonable to conclude, therefore, that the imagery contribution to an understanding of comprehension is, again, not so much in the comprehension process *per se*, nor in the application of that process in the design of print, but in the likely application of the knowledge concerned. Thus, it could be domain or content specific.

A general principle which can be derived from the discussion of imagery is as follows:

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“If the content of the text is related to spatial, creative, or problem-solving applications, the eliciting of imagery processes in its comprehension will be helpful”.

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### **3.8 The contribution of levels/depth processing**

Although the concept of ‘levels of processing’ was originally related to memory ( Craik & Lockhart, 1972), it has been the lateral movement from levels of processing to depth of processing in learners in general which is of



most concern to the desired deep level of comprehension when a reader interacts with text. The work of Marton and Saljo (1976a, 1976b) is of particular relevance to the discussion and this, together with work by associated researchers in the UK and Australia, constitutes the major emphasis of this section.

It has been pointed out by Saljo (1984) that

“it must not be assumed that reading done in different contexts constitutes one and the same cognitive activity; that it can be reduced to a single, basic model of information processing characteristics of individuals irrespective of their intentions and the situations which they encounter”

(p 72)

When reading to learn, students are involved in complex cognitive activities, developing ways of conceptualising the world that are frequently abstract and unrelated to every day experiences (Saljo, 1984).

The foundation of the Saljo approach to learning from print lies in a distinction between learning as the acquisition of discrete packages of information, and as a change in the student's conceptions of himself and the world around him (Entwistle, 1984). The approach also builds on a distinction between knowledge which can be characterised as quantitative and reproductive and knowledge which can be characterised as qualitative and meaningful (Dahlgren, 1984). In this approach, learning can be defined as a change in conception, often depending on understanding material which does not have an internal structure that can be grasped and in which case the process of learning has to try to find this structure in as deep a sense as possible (Dahlgren, 1984).

Marton and Saljo (1984) argue that the observable difference in the outcome of learning between individuals is indicative of differences in the process of learning between individuals. They refer to the qualitative differences in outcome of learning as 'levels of outcome' and the qualitative differences in the process of learning as 'levels of processing' because there is a similarity to Craik & Lockhart's (1972) 'levels of processing' concept. Marton and Saljo



(1984) have concluded that there is a very close relationship between process and outcome, a finding that has been confirmed by Watkins (1983b) and by Van Rossum and Schenk (1984).

While the above theoretical framework is fully informed by modern cognitive psychology (McKeachie, 1984), it is less oriented towards the human information processing school of thought and is, really, a phenomenological approach with considerable ecological validity which helps to explain why the learning outcome can vary so widely irrespective of the nature of the text (its readability, style, or structure) or the nature of the learner (his world knowledge, existing schemata, or imagery ability). A significant component of a deep approach is that the reader engages in a more active dialogue with the text, which is a concept qualitatively different from the insights gained from cognitive psychology which identified only the interactive nature of reading to learn.

The problem remains, however, of how to facilitate the adoption of a deep approach to reading and learning. Ballstaedt and Mandl (1985) have shown that depth of processing can be influenced by task orientation such as summarisation or critical evaluation, and Biggs and Rihn (1984) have shown that, while students do have predilection for a deep or surface approach, appropriate intervention can induce a deep approach in surface processors.

Perhaps the most useful general principle which can be derived from this area of research would be:

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“If a text is to be read for understanding,  
then the reader must approach the text  
with that goal in mind”.

---

### **3.9 Conclusion**

As noted in earlier chapters, the concept of ‘understanding’ associated with the research perspective on legibility and readability was hopelessly inadequate for the purposes of the design of text. It is important that it be recognised that the purpose of this study is to identify text design prin-



principles which are relevant to meaningful learning of the 'deep' nature discussed earlier in this section, and not of that conception of comprehension which is restricted to the recall of factual information, and in which, as Cunningham, Cunningham, and Arthur (1981) have pointed out, it is assumed that meaning lies on a page and must somehow be lifted from the page into the mind of the reader.

The various threads of research reviewed in this chapter, and their inter-relatedness in contributing to an understanding of comprehension, can be represented diagrammatically as follows:

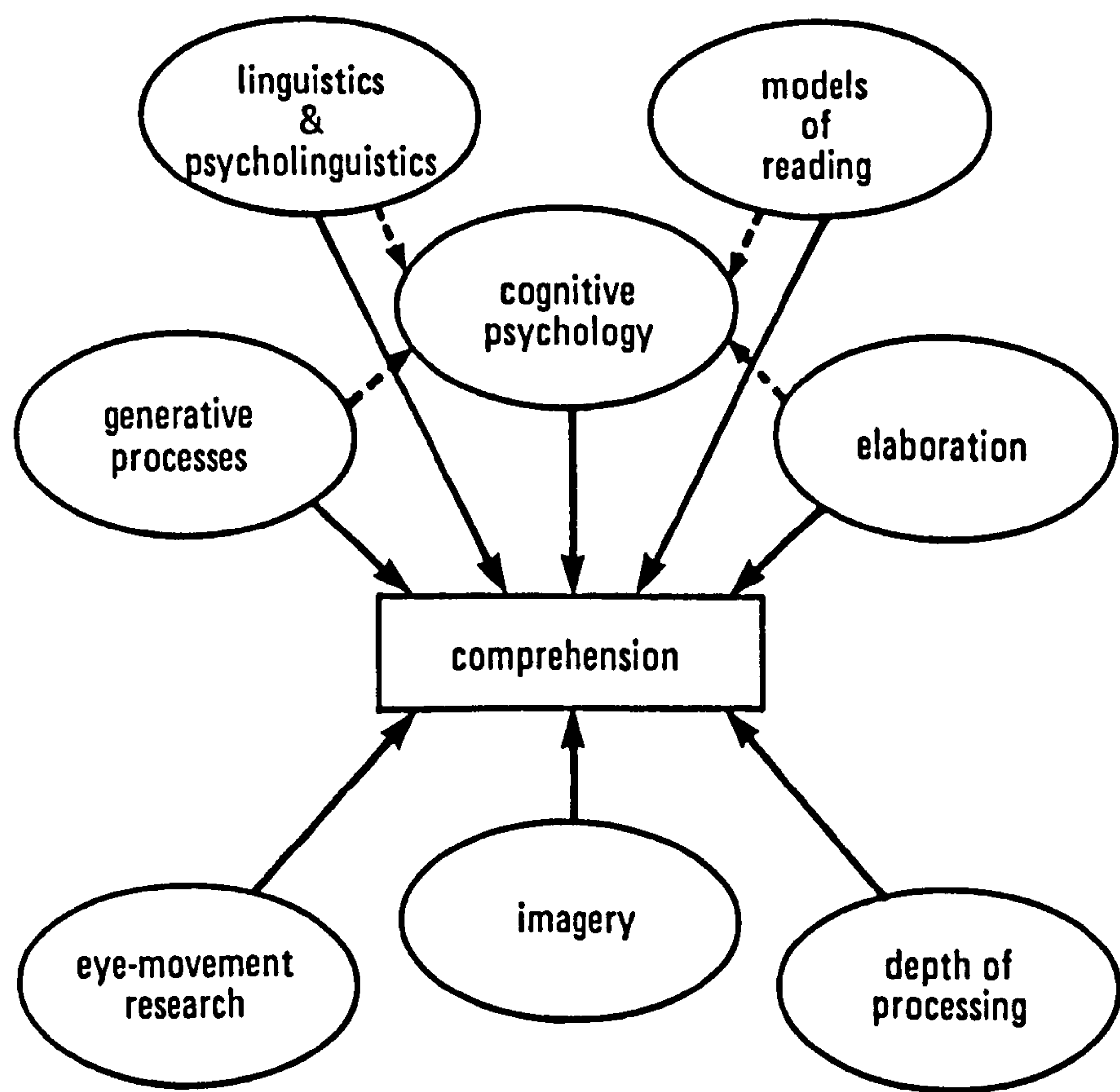


fig 3.7

The inter-relationships of the various areas led to the derivation of principles in groups as follows.

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psycholinguistics & cognitive psychology	“If the comprehension of text is concerned with the construction of ideas, then the text needs to be designed so that ideas are emphasised”.
	“If the ideas in discourse are emphasised and indicated in the organisation of the text, the reader is likely to form representations and



networks of representations in keeping with the organisational plan".

"If reading comprehension is an interactive process between text-based ideas and reader-based schemata then the greater the correspondence between the text and the prior knowledge of the reader, the more efficient will be the comprehension".

"If the design of text takes into consideration the process of comprehension involved in reading to learn with respect to text-based and reader-based variables, comprehension will be optimised"

eye-movement research	"If the structure and content of text are made clear semantically, syntactically, and typographically, the reader will devote cognitive processing time selectively to these issues".
imagery	"If the content of the text is related to spatial, creative, or problem-solving applications, the eliciting of imagery processes in its comprehension will be helpful".
depth of processing	"If a text is to be read for understanding, then the reader must approach the text with that goal in mind".

Most of the research reviewed has concluded that the way text is comprehended and remembered is a function of both the structure of the text and the knowledge utilised by the individual (Voss & Bisanz, 1985). There is, of course, as has been noted frequently in this discussion, an interaction between these two aspects of text comprehension. Reading comprehension has been subject to two variables — text variables and reader variables — and the contributory factors to these variables have been identified (Meyer, 1981), although the interactions between text and reader variables have not been so explicitly stated. The work of Marton and Saljo (1984) could, perhaps, be included within the area of 'reader variable', but it is not so much a function of the reader as a function of the reader's approach to



learning. Thus it can be concluded that reading comprehension is influenced by variables in the text, variables in the reader, and variables arising out of the interaction between the reader and the text. It is interesting to note that Goodman (1984) goes beyond the idea of reading as interactive process and regards it, rather, as transactive, since the reader constructs a text during reading through transactions with the published text, in the course of which the reader's schemata are transformed. The conclusion of Spiro and Myers (1984) that individual differences in reading performance can arise from factors in bottom-up (or text-based) processing, top-down (or knowledge-based processing), the interaction of top-down and bottom-up processing, and the metacognitive control processes that manage the entire system, is also worthy of note.

The relationship of the text-based and reader-based variables in the interactive process of reading comprehension can be represented in the illustration below (fig 3.8).

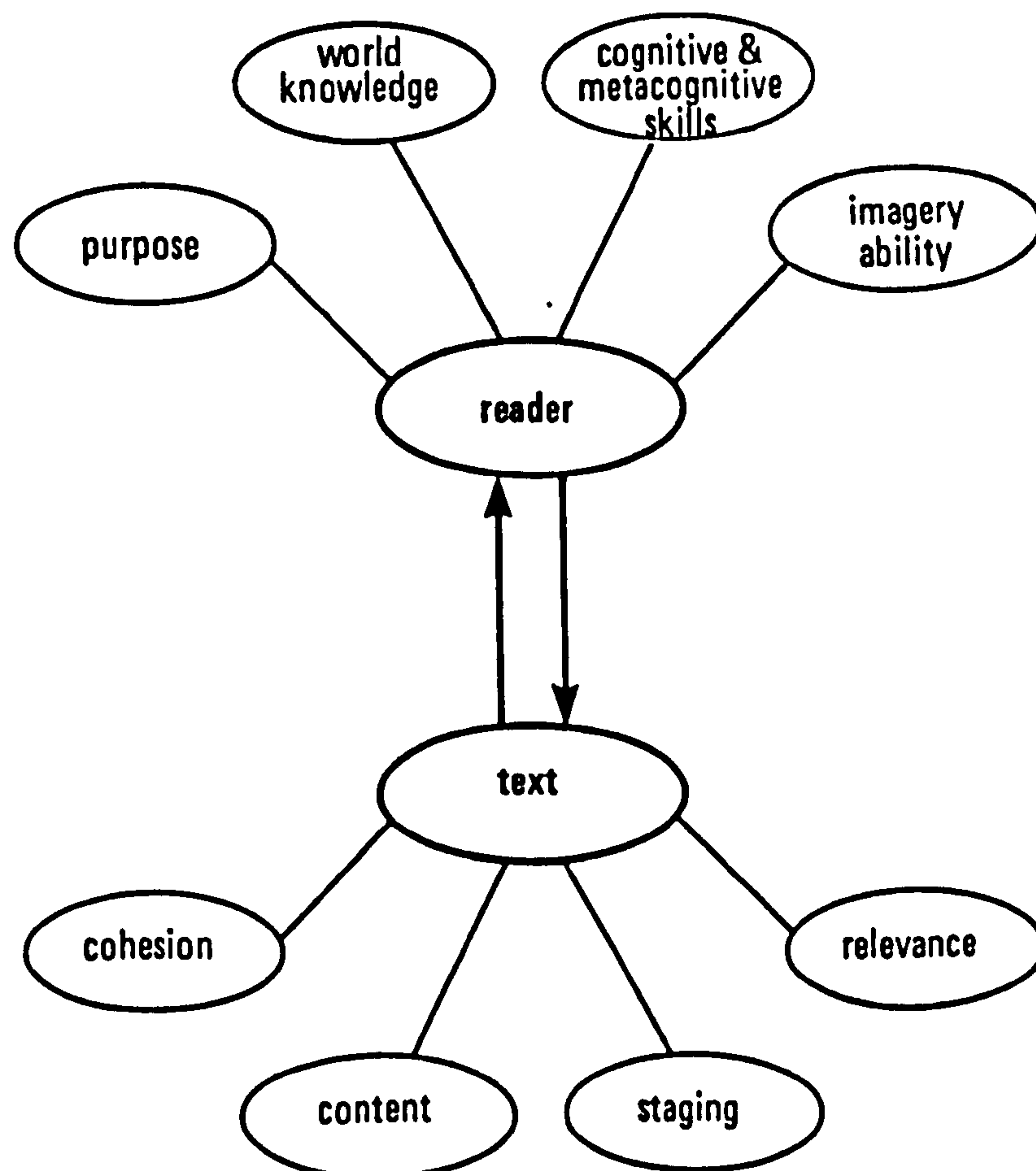


fig 3.8



Reading comprehension is, thus, a very complex issue. Nevertheless, without comprehension there can hardly be meaningful learning, yet meaningful learning is what educational practice is all about. It is the implications for educational practice, or at least that part of educational practice as typified by the design of text, arising from the derivation of principles in relation to the reading comprehension process which need to be considered at this point, and, in general, they come under two categories.

The first implication is in relation to the nature of the text itself and requires that the idea units in the text be emphasised, either semantically, syntactically, or typographically. Although typographical issues may be taken into consideration within an instructional design framework in much the same way as would media characteristics and the grammar of media, it is probably true to say that the grammatical construction of a message is not normally an issue addressed within the instructional design process. It is not uncommon, certainly within instructional design courses, to highlight the ways in which the grammar of the media can be utilised to convey meaning and highlight ideas, yet it is probably just taken for granted that the student of instructional design or instructional materials development knows how to handle written language. From the research reviewed here, there is no doubt that the construction of written material requires a linguistic skill of considerable proportion if meaningful learning is intended to take place.

The second implication is in relation to the guidance given to the reader and requires that encouragement be given to adopt a learning goal and, where appropriate, to utilise imagery ability. Present practice in text design does not normally take into consideration instruction or guidance to the reader in how to approach the material. To some extent this may be included within pre-instructional strategies, and will be discussed in that context in chapter 5. Nevertheless, there remains an identified opportunity for improving the design of text by including directions to the reader in relation to approach to be adopted.

An understanding of the reading comprehension process also has implications for the topics of legibility and readability and the principles derived in relation to these aspects, and further discussion of this will be undertaken in chapter 6.

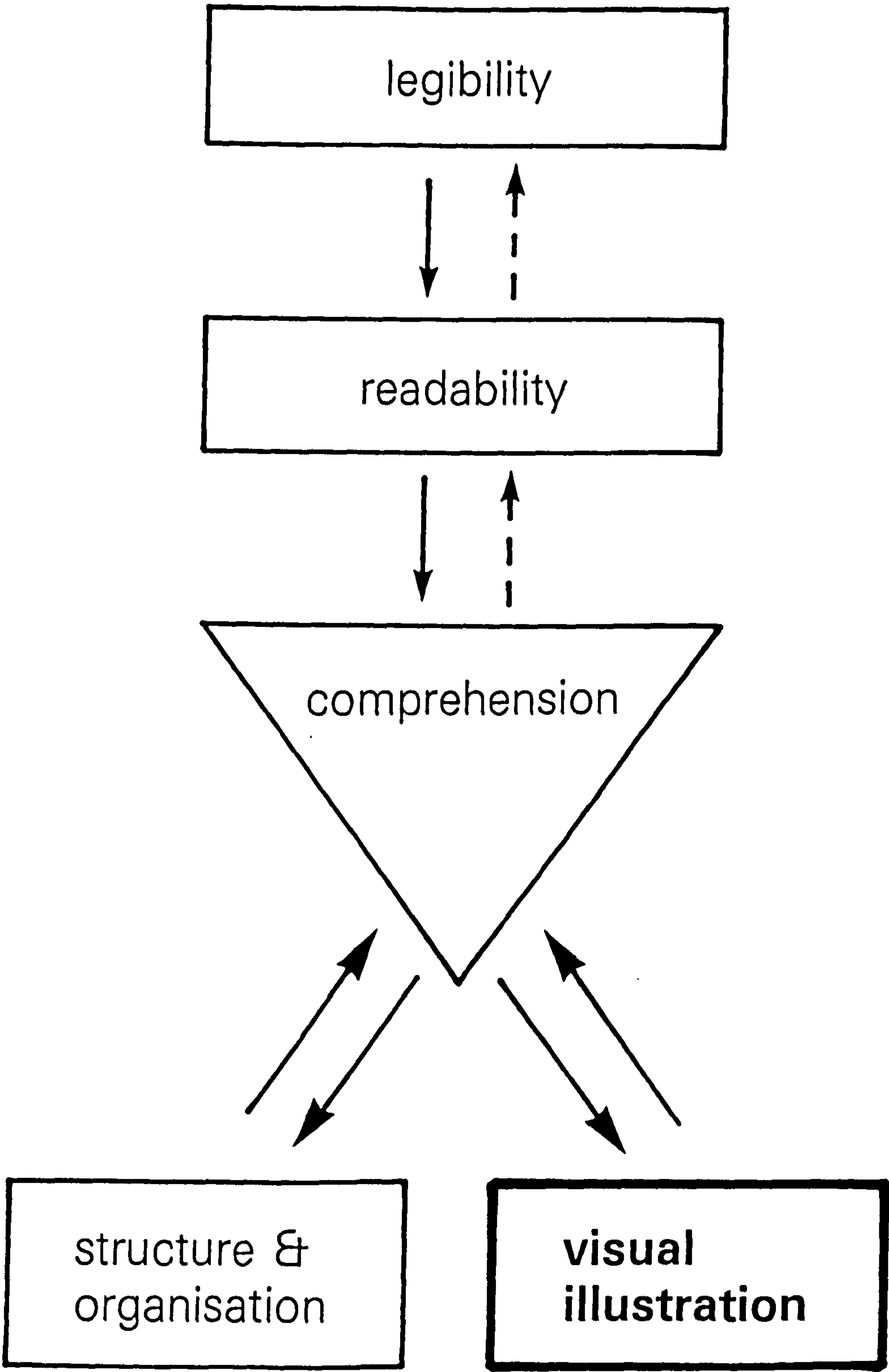


Having established the nature of the reading comprehension process, it is appropriate now to consider how other aspects of the design of text, such as visual illustration and the structure & organisation of text can contribute to the facilitating of comprehension and these areas are pursued in the following two chapters.



<b>4</b>	<b>Comprehension through visual illustration</b>
<b>4.1</b>	<b>Introduction</b>
<b>4.2</b>	<b>Perception and visual information processing</b>
4.2.1	The Gestalt approach
4.2.2	The information processing approach
4.2.3	Direct perception
4.2.4	Other theories of perception
●	Neisser's perceptual cycle
●	generative theory
●	coding theory
●	transformational theory of perceptual structure
<b>4.3</b>	<b>Perception of visual illustrations and pictures</b>
4.3.1	The nature of images
4.3.2	Perception of complex visuals
4.3.2.1	eye-movement research
4.3.2.2	global/local processing
<b>4.4</b>	<b>Visuals in learning</b>
4.4.1	General issues
4.4.2	Classification of illustrations
4.4.3	Diagrams, graphs, charts
<b>4.5</b>	<b>Illustrations in text</b>
4.5.1	The research in relation to illustrations in text
4.5.2	The functions of illustrations in text
4.5.3	Illustrations without text
	<b>Discussion of the issues in chapter 4</b>







#### 4. Chapter orientation

Although imagery has been considered as contributing to the reading comprehension process, it obviously is of particular relevance to non-verbal images. Is “one picture worth a thousand words”? The purpose of this chapter is to identify the contribution which visual illustration can make to the reading comprehension process; to ascertain what kind of pictures can replace words; and to determine possible interactions between words and pictures which contribute to learning.

While imagery may be a useful common link between comprehension and visual illustrations, it does not provide a sufficient theoretical framework for the development of principles relating visual illustrations to comprehension.

Accordingly, the chapter reviews various research perspectives concerning perception and visual information processing to ascertain the contribution each can make to the comprehension process, and reviews research relating, more specifically, to perception of visual illustrations and pictures to clarify, further, the ways in which comprehension can be facilitated. In the discussion of those issues later in the chapter it is recognised that the research evidence available does not lead to the adoption of a single, best, approach and that there is value in each of the approaches. In an integration of the evidence from the various approaches, appropriate principles are derived and implications for practice discussed.

Having ascertained the nature of perception and visual information processing, particularly in relation to illustrations and pictures, the research with regard to visuals in learning and, specifically, illustrations in text, is reviewed in order to identify ways in which visuals can contribute to learning and, in the discussion section, to derive from that relevant principles and indications for good practice.

It is concluded that the design of instructional text must take into consideration the potential interactions between the visual elements of the text and between the reader and the text as a whole as well as with the verbal and visual elements separately, in the process of which comprehension can be facilitated.



## **4 Comprehension through visual illustration**

### **4.1 Introduction**

There does seem to be evidence that imagery processes are involved in the capacity of humans to recognise large numbers of previously encountered pictures (Fleming, 1977), and Madigan (1983) pointed out that although dual-code theory was first developed to account for imagery effects in verbal learning studies, it was extended to explain picture effects because they so naturally fit into the abstract-concrete dimension and thus, like concrete words, can be represented by imaginal as well as by verbal codes. Paivio (1975a) and Paivio and Csapo (1973) have demonstrated that presentation of a pictorial representation of an item and presentation of a verbal representation of the same concept have independent and additive effects on recall, unlike picture-picture or word-word representations.

Hill and Baker (1983) have identified five classes of visual imaging, two of which could be related to visual stimuli of the type associated with illustrations. One involves the active exploration and transformation of elements in a visual field and the other involves imagery metaphors which may be initiated by illustration. However, it is clear that the role of illustration in facilitating meaning and comprehension involves more than imagery. In a discussion of brain functions during learning, Hand (1982) suggests that the reader needs to be directed to visual, non-verbal information which can assist the assimilating of verbal and non-verbal, thereby breaking the word chain pitfall of short-term memory. Information processed into long-term storage is multiply encoded with various aspects of the input stored in multiple locations in the brain due to the experience itself having had multiple aspects. Hand (1982) also points out that, because both hemispheres of the brain share in mental activities, it is inappropriate to state that verbal processing is entirely a left-brain function or that the right hemisphere is solely responsible for processing pictorial information. The hemispheres share functions but not equally. Irrespective of the nature of the function, the brain appears to have tremendous capacity for storing non-verbal information (Hand, 1982) and advantage can be taken of this in the design of text so that the reader is supplied with non-verbal stimuli or encouraged to construct non-verbal stimuli to network with verbal text material.



## 4.2 Perception and visual information processing

It has been noted by McFee (1969) that, in education,

“we diagram, graph, and organize symbols to express relationships . . . . We expose students to more varied visual experiences and learning processes than can be achieved through written and spoken symbols. Non-verbal symbolic communication plays a major role in interpersonal and intergroup communication.” (p 196)

She goes on to assert that design is the grammar of the visual world and the ordering system that makes the visual symbol either more or less readable. However, there is wide recognition as McFee notes that the elements of design — form, line, colour, texture, and the overall interacting impacts they can be made to produce — affect people differently. In attempting to identify the factors involved in individual responses to the visual environment, she proposes a lowest common denominator of visual information handling which can be used by a message designer to mediate between raw data — visual information before it has been organised by the viewer — by doing some of the organising for him.

Doblin (1980) reports that it is estimated that about 85 per cent of all messages are visual and that these can be of two kinds — orthography (writing words according to standard usage) and iconography (representations by pictures or diagrams). He argues, however, that although the vast majority of people are taught the three R's, most people fail to develop half of their ability to communicate, think, and solve problems:

“Iconographic language can be structured and taught but, until it is, the public will remain half illiterate.” (p 89)

This sentiment is echoed by McFee (1969) who regrets that too few teachers or students are educated in how to use visual communication to best advantage, and by Arnheim (1969) who recognised widespread visual illiteracy and argued that systematic training of visual sensitivity is an indispensable part of any educator's preparation for his profession.



Leaving aside the problem of visual illiteracy, there is a need to identify the factors involved in visual literacy. Szlichcinski (1980) notes that whereas the factors determining how effectively text communicates have been studied intensively by psychologists, those affecting the comprehensibility and communicative power of pictorial materials have received relatively little attention.

Arnheim (1969) contends that the cognitive operations called thinking are not the privilege of mental processes above and beyond perception but the essential ingredients of perception itself. By 'cognitive' he means all mental operations involved in the receiving, storing and processing of information (sensory perception, memory, thinking, learning) and he, therefore, extends the meaning of the terms 'cognitive' and 'cognition' to include perception. By the same token, he sees no way of withholding the name of 'thinking' from what goes on in perception, thus he concludes that visual perception is visual thinking.

While McFee (1969) can argue that visual perception is not a direct "image in the mind" of an outside stimulus but rather a cognitive response to a sorting or ordering process from what Gregory (1966) calls the "mosaic of retinal stimulation" which is, in turn, a reaction to the stimulating objects, others such as Gibson & Gibson (1955) would argue that there is such a thing as 'direct perception' by which the flux of stimulation at receptors does yield all the information anyone needs about the environment, and still others would agree with Spoehr and Lehmkuhle (1982) that, within an information processing approach, visual information processing refers to the entire process by which human beings receive visual information and adjust their behaviour on the basis of that information. In addition to these three distinct approaches there are also combinations and variants and attempts to reconcile all three. Clearly, the salient points of each would be helpful prior to discussion of the potential of visual perception and visual information processing for learning.

#### **4.2.1 The Gestalt approach**

The 'lowest common denominator' of visual information handling to which McFee (1969) refers is derived from the work of the Gestalt psychologists in



the 1920's, one of whose principal interests was the question of how individual stimuli are grouped together during perception into wholes or *Gestalts* which possess features of their own that are not obvious from an examination of their individual parts.

One of the principal aims of the Gestalt psychologists in the area of visual perception was to specify the principles by which individual items are combined into larger, organised wholes, and Wertheimer (1958) has translated these from the original German as

- (a) principle of proximity;
- (b) principle of similarity;
- (c) principle of common fate,
- (d) principle of good continuation;
- (e) principle of closure;
- (f) principle of area and
- (g) principle of symmetry.

The principle of *proximity* states that grouping occurs on the basis of small distance or nearness. Thus, in the illustration below (fig 4.1), most people

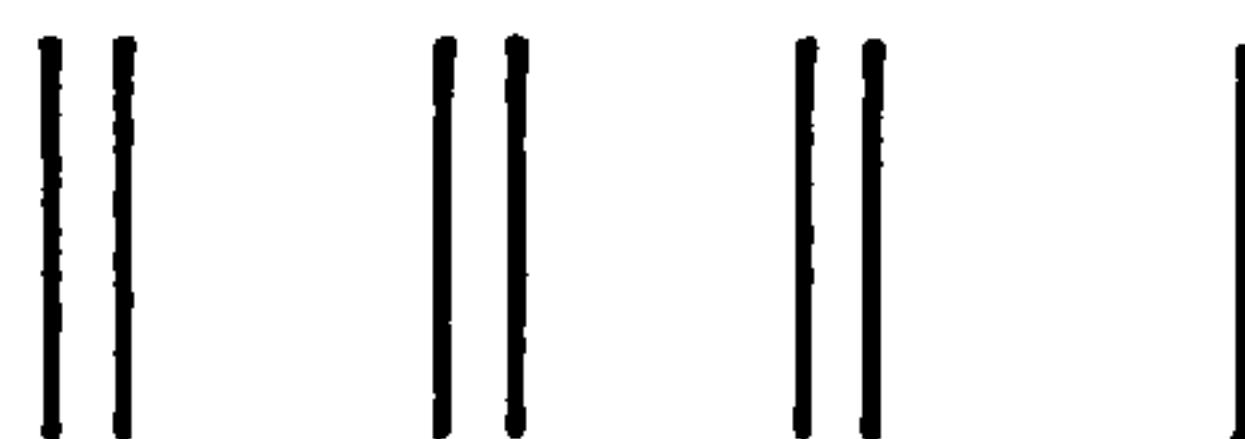


fig 4.1

will see three pairs of lines and an extra one on the right, and it is extremely difficult to see three pairs with one on the left.

The principle of *similarity* states, that, if several stimuli are presented together, there is a tendency to see the form in such a way that the similar items are grouped together. Thus, in the illustration below (fig 4.2) it is

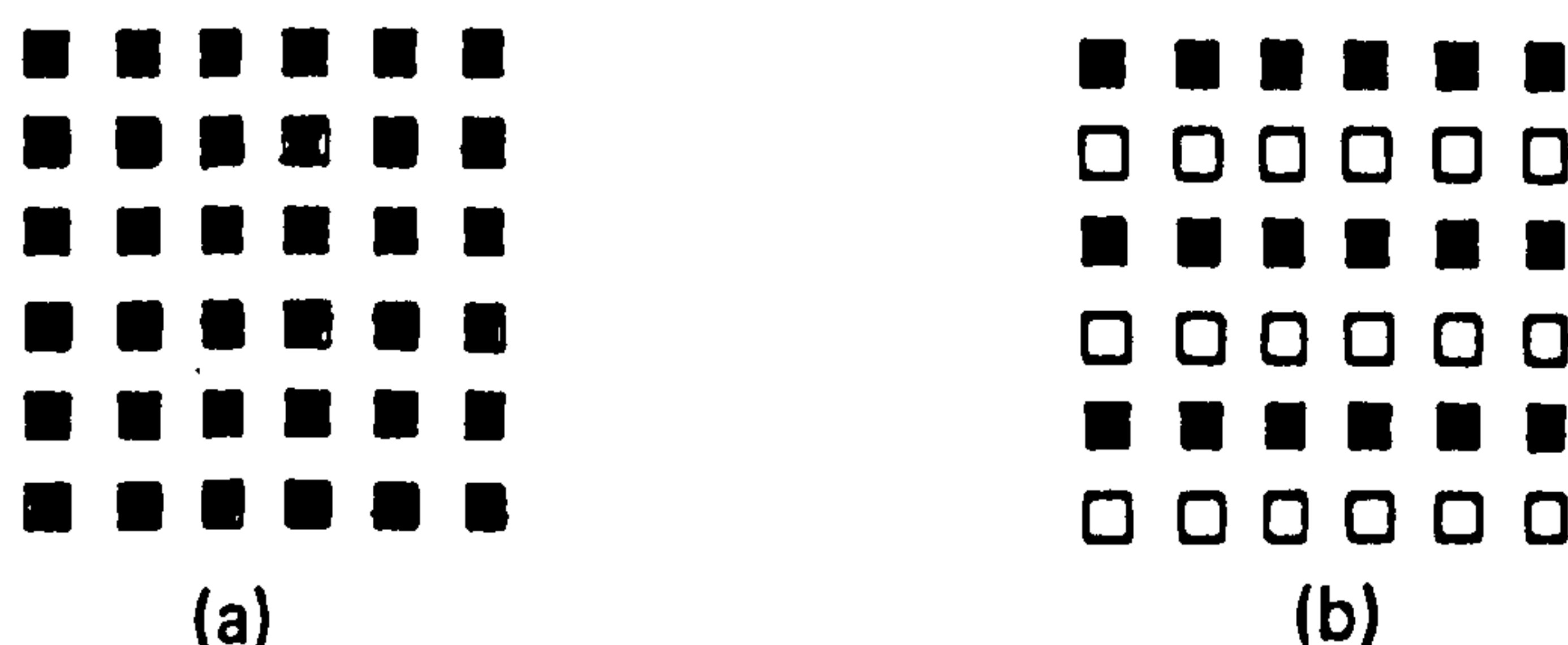


fig 4.2



difficult in (a) to try to group any one horizontal row together because all the options are equal, but relatively easy to group alternate horizontal rows in (b) because of the similarity of shape and size. Similarity of colour is also a powerful grouping possibility.

The principle of *common fate*, which relates to moving images, notes that when elements within the visual field are subjected to a common, uniform transformation over time, the moving elements spontaneously organise into a group.

The principle of *good continuation* states that elements will be organised into wholes that yield few interruptions or changes in continuous lines, and from the many examples given by Wertheimer, this applies equally well with

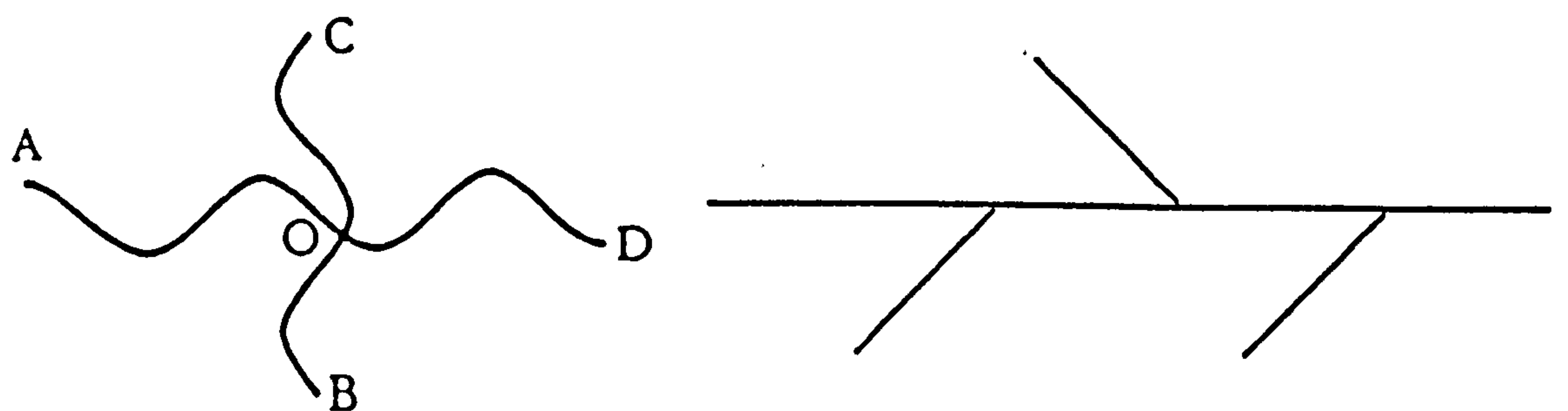


fig 4.3

curved or straight lines. Wertheimer, in explaining good continuation, has stressed the need for an appropriateness of the curve, an 'inner belongingness', a resulting in a 'good whole' or 'good configuration' which exhibits its own definite inner requirements.

The principle of *closure*, related to the principle of continuation, states that the organisation of elements tends to form them into simple, closed figures, independent of their other continuation, similarity, or proximity properties.

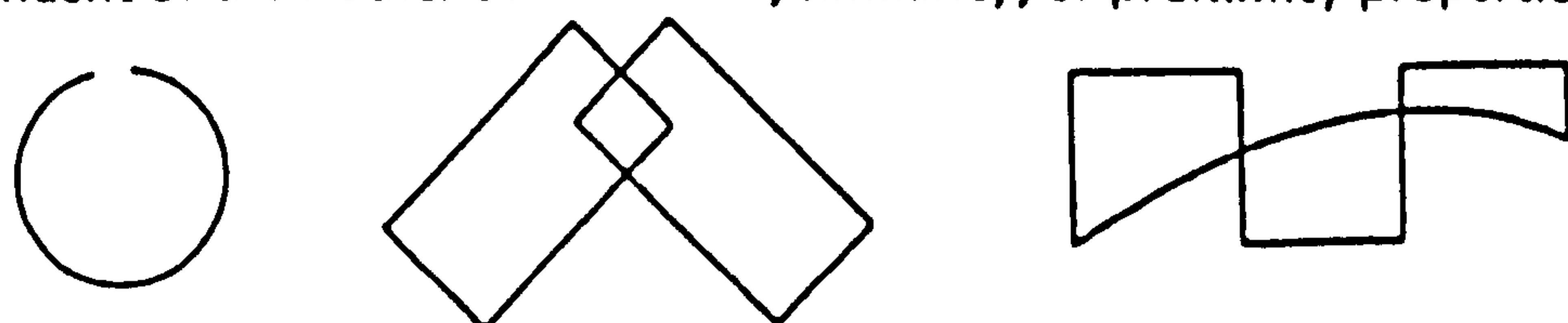


fig 4.4

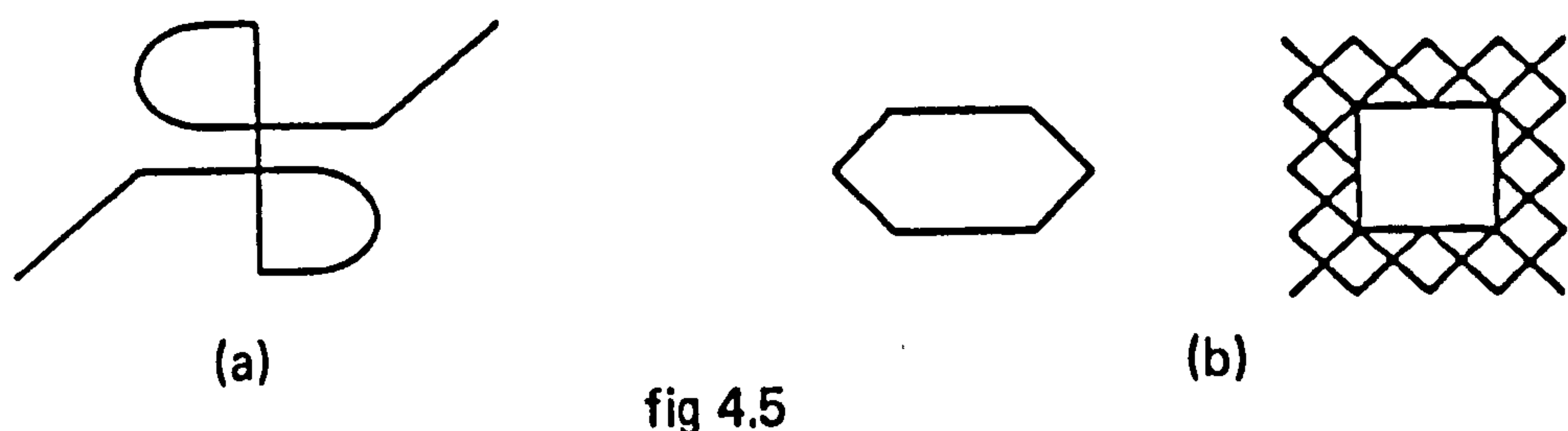
In fig 4.4, the figure on the left tends to be described as a circle even though the small gap technically makes it an unclosed curve; the figure in the centre is described as two overlapping rectangles rather than as a small diamond surrounded by two rectangles out of which a corner has been cut because the overlapping rectangles organisation permits the grouping of the information



into simple closed figures instead of incomplete ones; and in the figure on the right, closure works to counteract good continuation, since good continuation would produce the organisation of a curve and a squared zig-zag line, and the tendency is, rather, to see three closed figures that touch at the corners.

The principle of *area* states that the smaller of two overlapping figures is more likely to be viewed as the figure, and the larger as the ground, a principle which influences the way in which the perceptual system segregates a figure from the background against which it is shown.

The principle of *symmetry* states that the more symmetrical a figure is the more likely it is to be seen as a closed figure thus, like the principle of area, it is a principle of segregation. The examples given by Spoehr and Lehmkuhle (1982) (fig 4.5) illustrate how the Gestalt principles of good continuation and



closure help explain why it is difficult to see many of the numerical digits embedded in (a), or to find the hexagon in the drawing on the right in (b).

The Gestalt principles of organisation are very general descriptions and attempts have been made by a number of researchers to determine more quantitatively how the principles operate. In general these studies (for example: Hochberg & Silverstein, 1956; Beck, 1966; Olson & Attneave, 1970; Hemenway & Palmer, 1978; Prytulak, 1974) have shown that the configuration of individual elements in a stimulus leads to strong organisational effects that affect the interpretation or identification given to that stimulus.

#### 4.2.2 The information processing approach

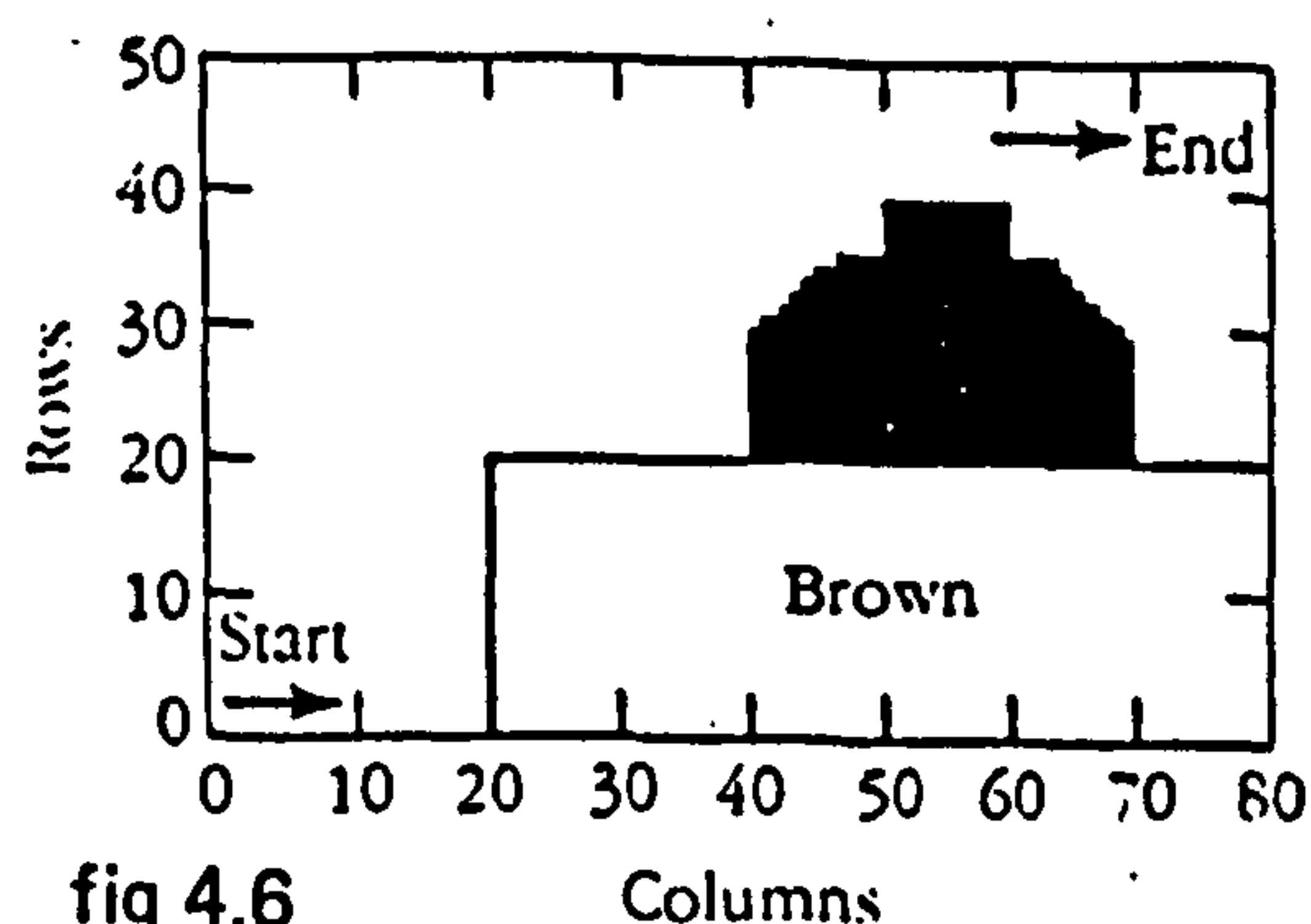
As Haber and Hershenson (1973) have pointed out, the information processing approach to the study of perception did not arise as a reaction



against other viewpoints. Rather, it was a reflection of new conceptualisations and methods applied to the study of perception. Dodwell (1975) notes that the emergence of the information processing movement around 1960 has been a major development in psychology, but suggests that it is, to a large degree, a point of view rather than a fixed set of principles, findings, or research strategies.

A major assumption of the information-processing approach is that perception is not an immediate outcome of stimulation, but is the result of processing over time. The information needs to be interpreted, identified, compared to information in memory, and the purpose of the information-processing approach is to explain the processing of the stimulus information.

Attneave (1954), recognising that the ideas of information theory were, at that time, stimulating many different areas of psychology inquiry, indicated some of the ways in which the concepts clarify understanding of visual perception. He demonstrated that, when perception is considered as an information-handling process, it quickly becomes clear that much of the information received by any higher organism is redundant. If, in the illustration (fig 4.6), it is accepted that there is a black ink bottle on a brown desk, and that the background is uniformly white, it is obvious that the points on



the edges of the objects contain most information about the forms that are present and that information from other parts of the illustration is, in fact, redundant. Attneave (1954) identified two principles from this demonstration; (a) that information is concentrated along contours, and, (b) that information is further concentrated at points where a contour changes direction most rapidly. He relates this to the Gestalt approach by arguing that many of the Gestalt principles of perceptual organisation pertain essentially to information distribution: that the 'good gestalt' is a figure with some high degree of internal redundancy; that the grouping laws of 'similar-



ity', 'good continuation', and 'common fate' all refer to conditions which reduce uncertainty; and that 'proximity' can be conceptualised in a similar manner. Spoehr and Lehmkuhle (1982) have restated this as "the Gestalt laws posit that elements that share the same information are grouped together perceptually". They similarly restate Hochberg and McAlister's (1953) concept of simplicity as the defining characteristic of good figures by saying that "good figures are those that have both the fewest points of high information content and the most redundancy", and conclude that the most perceptually simple interpretation of a line drawing is that in which there are fewest individual line segments and angles.

Attneave (1954) suggests that the abstraction of simple homogeneities from a visual field does not appear to be different, in its formal aspects, from the induction of a highly general scientific law from a mass of experimental data, and raises the question, "where does perception leave off and inductive reasoning begin?", because perception seems to involve a set of processes whereby information is 'predigested' before it ever reaches awareness. Spoehr and Lehmkuhle (1982) believe that the information processing system must do something to the input it receives in order for an appropriate response to be generated. They suggest that:

- (a) the system has to *transform* information from one form to another;
- (b) the system has to *reduce* information to prevent overload;
- (c) the system may have to *elaborate* on information on the basis of information stored in memory;
- (d) the system has to be able to *store* information in memory and
- (e) the system has to be able to *retrieve* information from memory.

The important features of information-processing are that the sequential ordering of stages implies that the output from one stage serves as the input for the next stage; the processing operations may occur in a serial sequence, in a parallel fashion, or both; the time necessary for serial processing is the sum of the times needed for each stage; and the accuracy of the overall task depends on the accuracy of each of the component steps.



## **The visual input**

The early belief that only four or five items could be perceived from a series of visual presentations was refuted by Sperling (1960) who demonstrated that a visual representation of a brief visual display is still available to a subject after the display has been turned off, and that the post-exposural visual representation consists of an accurate but rapidly fading visual memory of the display. He referred to this memory as a 'visual information store'. Atkinson and Shiffrin (1968) used the term 'sensory buffer', but the most popular, and perhaps most helpful term is that used by Neisser (1967) viz. 'iconic memory'. Coltheart (1972), in reviewing the work by Sperling (1960, 1963) together with the contributions of von Wright (1968, 1970), concludes that the spatial locations of items must be represented in iconic memory, otherwise subjects could not, as demonstrated, selectively process items in iconic memory according to their particular spatial location. He further notes that the evidence suggests that the subject cannot selectively process items in iconic memory according to whether they are letters or digits because it is not possible to tell whether it is a letter or digit until it is processed, or, as Spoehr and Lehmkuhle (1982) have pointed out, the information in the iconic store is precategorical. The basic experiments on selection in iconic memory elucidate for Coltheart (1972) two features of this form of memory. First, it decays rapidly, and secondly, physical properties of the display are represented in iconic memory, but knowledge of higher-order features of items can only be attained after the items are transferred to a different form of memory.

Barber and Legge (1976) summarise this first part of visual information processing as follows:

"A visual stimulus is represented initially in a short-lived visual information store, whence it is lost unless information is transferred to a later, less ephemeral store where it may be preserved by a process of rehearsal, one possibility being that it is then represented as an auditory code."

(p 75)

They emphasise that the importance of the statement lies not so much in whether it is correct but in the kind of assumptions about perception that it entails and its general conceptual atmosphere. Information is, thus, seen as



being 'processed'; perception consists of a series of 'processes' or 'stages'; and perception makes use of concepts like 'store' and 'code'.

An alternative view of the process involved was put forward by Posner (1969) who proposed that when a letter is presented, it can be represented in memory in two ways — in a visual code and in a name code. When a second letter is presented, visual and name codes of this letter are also produced. The visual codes of the two letters are then compared and, if they match, the two letters must have the same name and so the response 'same' is initiated. If the two visual codes do not match, however, neither the 'same' nor the 'different' response is justified. The name codes are also compared, a process which takes longer than the comparison of visual codes. However, the visual code of a letter decays over time whereas the name code does not. According to Coltheart (1972), Posner's visual code of a display and Sperling's iconic memory of a display appear to be separate and different forms of visual memory, and he proposed that the simplest way of conceptualising the process was to assume that the construction of visual and name codes occurs with either the visual display or its subsequent iconic memory as data and he cites his own work (Merikle, Coltheart & Lowe, 1971; Merikle & Coltheart, 1972) in support (fig 4.7).

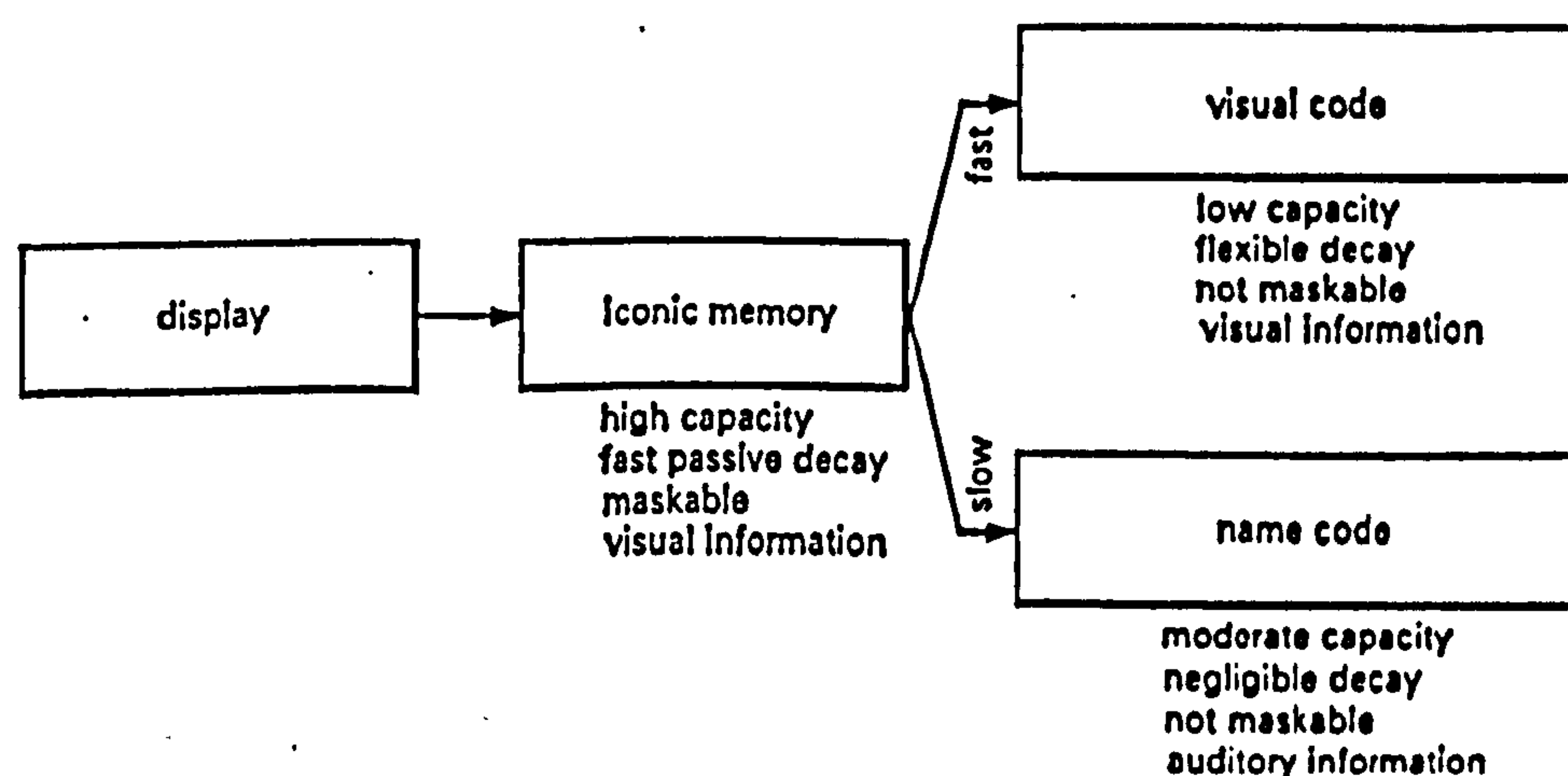


fig 4.7 Coltheart's hypothetical organization of memory sub-systems involved in visual information-processing

Dodwell (1975) comments on this model and that of Sperling (1967), noting that they make use of the concept of different codes, or modes of representations at different processing stages for symbolic materials, and Haber and Hershenson (1973), noting that the construction of a visual image representation occurs soon after the onset of visual stimulation,



comment that many perceptual theorists identify such a process — the conscious awareness of the experience of perceiving — as occurring after the original iconic storage.

### **Processing into memory**

Haber and Hershenson (1973) note that there is a substantial amount of evidence that the short-term memory representation is in the form of an acoustic code, and Neisser (1967) appears to assume that verbal coding is involved. There has been considerable interest in whether information is processed sequentially or in parallel and, although Sperling's (1963) work seemed to suggest a serial processing, later work (Eriksen & Spencer, 1969; Shiffrin & Gardner, 1972; Shiffrin, McKay & Shaffer, 1976) seems to provide quite convincing evidence that iconic processing occurs in parallel, although it is often difficult to distinguish parallel and serial processes. Among the parallel processing models of how the iconic store is encoded, have been the Limited Capacity Model (Rumelhart, 1970), the Independent Channels Confusion Model (Gardner, 1973), and the Interactive Channels Model (Estes, 1972). Spoehr and Lehmkuhle (1982) note that while each of these models assumes that recognition of multielement stimuli takes place through feature extraction, they differ in their estimates of the capacity of the feature extraction process; they differ in their assumption about whether letters can be processed independently; and they propose different explanations of the decision process. Nevertheless, despite the different assumptions about how processing occurs, all may be able to account for the same experimental findings.

All of the discussion, thus far, with regard to the information-processing approach has concerned the processing of linguistic information from the iconic storage into short-term memory. The extension of the information-processing approach to the construction of an organised visual representation of other visual images will be discussed later. Suffice, at this stage, to note the summary of perception as information processing by Haber and Hershenson (1973):

“Information-processing is characterized by its focus on how the information of the luminence discontinuities contained in the retinal projection are transformed into different forms or codes, visual codes, auditorily represented linguistic



codes, and semantic codes . . . . This way of thinking makes it clear that several stages or processes are involved, and that in no sense can perceptual processing be considered immediate or instantaneous.” (p 174)

#### **4.2.3 Direct perception**

The idea of ‘direct perception’ comes, initially, from the work of Gibson (1950) but, because the Gibsonian theories have evolved substantially since then, most of the discussion here will be based upon later, more comprehensive, developments of the concept. Gibson (1979) states that direct perception is the activity of getting information from the ambient array of light: it is a process of information pickup that involves the exploratory activity of looking around, getting around, and looking at things. This radical view of perception is part of a radical view of psychology in general which came to be known as the ecological approach. As Shaw and Bransford (1977) comment:

The ecological approach, unlike information-processing theories, denies . . . that nature, in any sense, communicates messages to us in a kind of sensory shorthand which, to be comprehended, must be translated by a phalanx of cognitive homunculi into a more readable long-hand for perusal by whom no one can say. Rather, it seems more parsimonious to assume that evolution has rendered such busy work unnecessary by designing perceptual systems, naturally selected over eons of practical use, to extract meaning directly from the structured energy propagations without benefit of any other stage of epistemic mediation.” (p 10)

Gibson (1966) defines perception as the pickup of information over time — a sufficient amount of time, that is, for extracting the significant information available to correctly judge the nature of ecologically relevant phenomena, and the point to be emphasised, as Shaw and Bransford (1977) point out, is that cognitive judgements are parasitic on perceptual experiences; they are logically posterior to perception rather than either anterior to it or



part of it. The theory of information pickup differs radically from the traditional theories of perception as Gibson (1979) indicates:

“First, it involves a new notion of perception, not just a new theory of the process. Second, it involves a new assumption about what there is to be perceived. Third, it involves a new conception of the information for perception, with two kinds always available, one about the environment, and another about the self. Fourth, it requires the new assumption of perceptual systems with overlapping functions . . . . Finally, fifth, optical information pickup entails an activity of the system not heretofore imagined by any visual scientist, the concurrent registering of both persistence and change in the flow of structured stimulation.” (p 239)

In Gibson’s view, perceiving is a psychosomatic act, not of the mind or of the body but of a living observer. The act of picking up information is a continuous act, an activity that is ceaseless and unbroken, and the continuous act of perceiving involves the coperceiving of the self. ‘Information’ refers to specification of the observer’s environment, not to specification of the observer’s receptors or sense organs.

“Words and pictures convey information, carry it, or transmit it, but the information in the sea of energy around each of us, luminous or mechanical or chemical energy, is not conveyed. It is simply there” (p 242)

He argues that the assumption that information can be transmitted and the assumption that it can be stored are appropriate for the theory of communication, but not for the theory of perception.

Neisser (1976) notes that Gibson’s view of the observer perceiving simply by picking up information with no need to process it, has striking advantages over traditional views because the organism is not thought of as buffeted about by stimuli, but rather as attuned to properties of its environment that are objectively present, accurately specified, and veridically perceived. Nevertheless, he considers that the theory is unsatisfactory, particularly as it says nothing about what is in the perceiver’s head. On the other hand, Mace (1977), in discussing Gibson’s strategy for perceiving adopts as the title of his paper ‘Ask not what’s inside your head, but what your head’s inside



of', and goes on to argue that a direct theory of perception is both logically consistent and empirically sound.

The notion of the perceiver being 'attuned' is also referred to by Shaw and Bransford (1977):

“For the ecological theorist, evolution plays an indispensable role in perception by designing the perceptual systems of individuals to be especially attuned to the most significant dimensions (not specific contents!) of information required for adaptive functioning within the ecological niche provided their species by nature. Perception, however, is no less direct for having been genetically preattuned, for what is perceptually experienced *is* solely the information presented to the senses by the world. All that genetic preattunement accomplishes is greater facility for the perceptual systems differentiating the information made available by the environment so as to extract perceptual invariants that embody the ecologically significant properties of the perceiver's world.”

(p 16)

They state that perception is the act of apprehending the properties of the message conveyed rather than the properties of the medium by which they are conveyed. The perceptual act is nothing more or less than apprehension of the configurational properties of the event — the network of adjacent and successive relationships in which the individual components of the event mutually participate. Thus, perception is the act of experiencing that mutual participation rather than the memory of their successiveness.

#### **4.2.4 Other theories of perception**

A number of researchers and theorists have reviewed the mainstream theories of perception, frequently trying to reconcile between them and, equally frequently, adding another dimension and, thus, another theory to the existing repertoire.



## Neisser's perceptual cycle

After considering the contribution of information processing theories and Gibson's ecological theory, Neisser (1976) concludes that perception is a constructive process and that the cognitive structures crucial for vision are the anticipatory schemata that prepare the perceiver to accept certain kinds of information rather than others and thus control the activity of looking. Nevertheless, there is substantial recognition of some of Gibson's ideas:

"At each moment the perceiver is constructing anticipations of certain kinds of information, that enable him to accept it as it becomes available. Often he must actively explore the optic array to make it available, by moving his eyes or his head or his body. These explorations are directed by the anticipatory schemata, which are plans for perceptual action as well as readiness for particular kinds of optical structure. The outcome of the explorations — the information picked up — modifies the original schema. Thus modified, it directs further exploration and becomes ready for more information."

(p 20)

Fig 4.8 illustrates Neisser's perceptual cycle but it should be noted that the

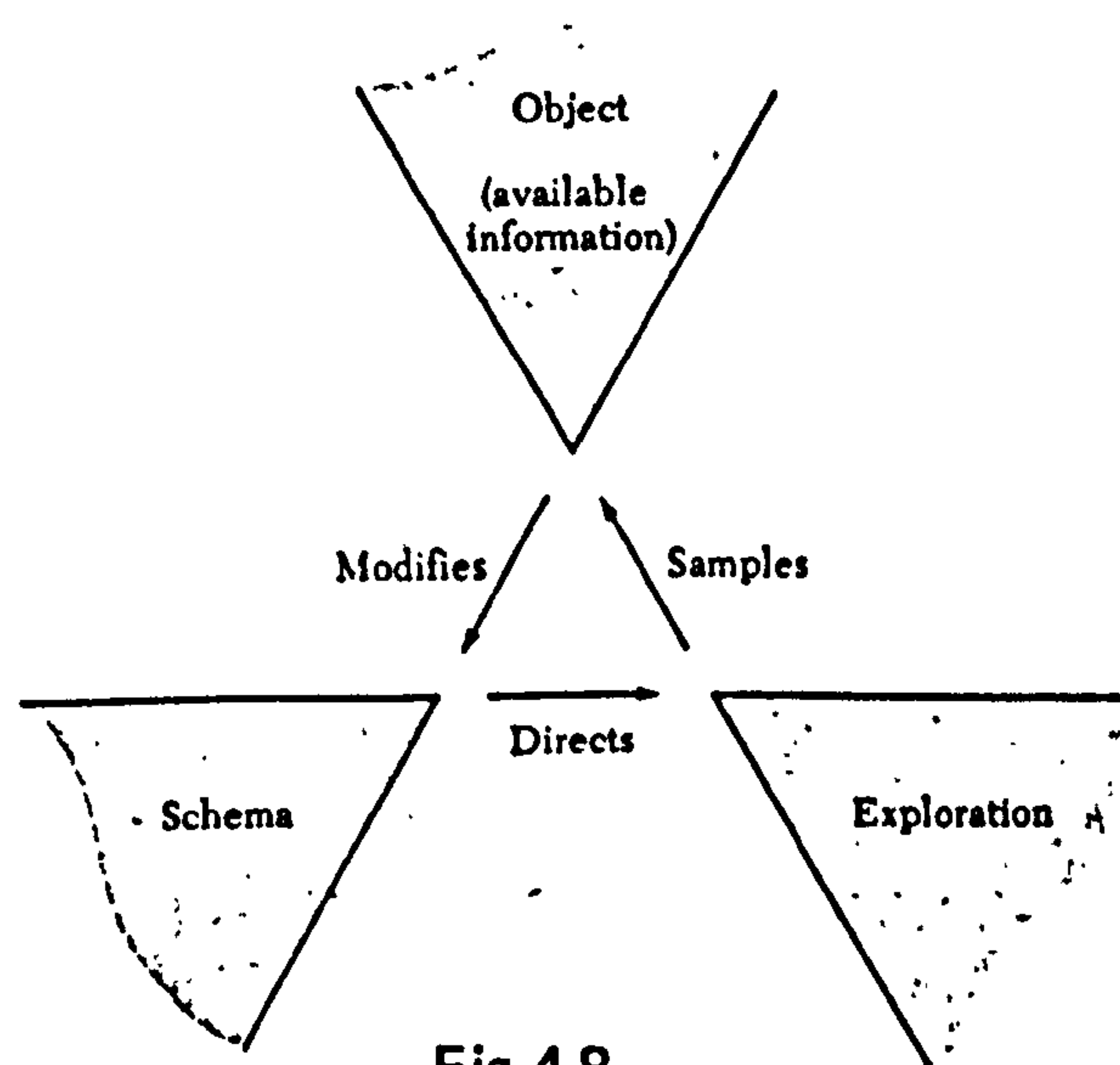


Fig 4.8

triangle labelled 'schema' is highly structured, subserving a continuously interactive process. Although the schema plays a critical role in every perceptual act, it is not a 'percept'. The schema is just one phase of an ongoing activity which relates the perceiver to his environment, and the term 'perception' applies properly to the entire cycle not to any detached part of it.



In proposing his account of perception as outlined above, Neisser (1976) comments that it is not intended as a radical alternative to the classical theories but as a way of rendering them coherent with one another and with everyday reality. He recognises that the Gibsonian approach is right in claiming that the optic array provides accurate information about the environment; that those who treat perception as information processing are also right as complex mechanisms in the brain are involved in accepting this information; and that those who have described perception as the testing and confirming of hypotheses are also right. Each view focuses on a single aspect of what is normally a continuous and cyclic activity.

Neisser (1976) acknowledges that his account of perception is similar to that developed independently by Hochberg. Certainly, Hochberg (1981) adopts elements of Gestalt and Gibsonian theories, emphasises the importance of mental structures, and rules out only the probabilistic problem-solving approach to perception.

### **Generative theory**

Hagen (1980) identifies three areas of dispute among perceptionists — the nature of the stimulus, the nature of perceptual activity, and the nature of the percept — and categorises three distinct schools:

- “(a) the Constructivists, who argue that perception consists of adding meaning by correlation or association to a constantly varying and essentially unstructured visual stimulus in a process of probabilistic inference;
- (b) the Gestaltists, who likewise argue that perception consists of adding meaning to the unstructured stimulus, but by brain or mental organization in a process of deterministic inference, and
- (c) the Gibsonians, who argue that perception consists of picking up meaningful structure in the light, also in a process of deterministic inference.”

(p 4)

She argues that it is on the issue of the nature of perceptual inference that the major perceptual theorists differ, and that this difference pervades their descriptions of the perceptual stimulus, the nature of perceptual activity and the perceptual product, as well as their empirical approach to the problems



of perception, noting, in passing, that a position on these central issues of perceptual theory is more a matter of religious conversion or graduate school attended than it is one of intellectual argument or the marshalling of empirical evidence.

After reviewing the salient features of each approach, examining their theories of representation, and conducting a critique of each theory of representation, Hagen (1980) concludes that each of the theories suffers because it defines the domain of discourse too narrowly, because it denies the validity of the perceptual phenomena which are the meat of the competition's endeavours at explanation, and argues that what is required is a theory that acknowledges the empirical phenomena which have served as domains of research enterprise for all the perceptual theories so far described, and which resolves the apparent opposition among them by subsumption of each into a more descriptively adequate general theory of perception. Such a comprehensive theory should, she believes, conceive of visual perception as consisting of three inter-related components:

“first, the ability to pick up the formless and timeless *invariants* which specify the permanent properties of objects and events; second, the ability to attend to and indeed generate the momentary perspective appearances of objects and events which specify the *variant* properties; and, third, an awareness of the rule or *generator* of these invariant and variant aspects operating as a conjunction of the permanent properties of the object and the geometrical transformations it can undergo.”

(p 28)

In the Generative theory, the construct of the generative concept, *mutatis mutandis*, unites the apparently unrelated variant and invariant components of perceptual experience and incorporates the facts of constant change into the explanation of detected nonchange. The Generative theory, emphasising as it does the projectively rule-generated commonality of both structural invariants and momentary variants in the light coming to the eye, anchoring both in natural perspective, lays the foundation, according to Hagen (1980), for a descriptively adequate theory of representation, and provides for a determinate percept given by the deductive laws of ecological geometry being, in this sense, similar to both the Gestaltists and Gibsonians despite its other differences.



## **Coding theory**

The Theory of Coding comes from Leeuwenberg (1971, 1978) and is concerned with the enumeration of the parts of a stimulus so that all lines, angles, and other features are mentioned in a way that permits reconstruction of all the essential characteristics of the display. A given figure can give rise to many interpretations, each interpretation can be given several codes depending on starting place, and a given code can be simplified in many different ways using logical operators in many ways. As Restle (1982) has pointed out, Coding Theory does not immediately reveal the process that goes on in perception, and is not a theory of reaction time, fine sensory discrimination, or even quantitative ratings. Rather, it asks what will be seen, given a certain physical display, in the sense of the interpretation given after due deliberation and inspection of the display. This means that the subjects are given free reign to describe their experiences, as in phenomenological studies and, for this reason, Coding Theory, as Restle notes, may serve to analyse experiments and observations that belong to Gestalt tradition. In fact, he argues that the Gestalt laws become clearer when rephrased from the point of view of Coding Theory, and that Coding Theory sees these laws as applications of certain effective ways of making a code more economical, equating thus, the principle of simplicity as used in Coding Theory with the Law of Pragnanz in Gestalt Theory.

Restle (1982) argues that several of the information-processing models of perception have close theoretical affinities to the Coding Theory, although he acknowledges that information-processing theories tend to be concerned with the process by which perceptions are constructed whereas Coding Theory is more concerned with the end result. He concludes that Gestalt theory and information-processing theories are not really opposed theories, but are complementary approaches to the question of perception. Coding Theory is seen as an instrument for the theoretical interconnection of the two theories.

## **Transformational theory of perceptual structure**

Palmer (1982), acknowledging that the nature of perceptual organisation has been closely associated with the notions of symmetry and transformation, attempts to bring together the Gestalt approach and the information-



processing approach through a coding theory approach to develop a transformational theory of perceptual structure in which the basic assumption is that perceptual analysis is carried out in parallel by a multiplicity of 'local spatial analysers' with finite resolution capabilities and a particular sort of transformational structure. His theory is claimed to be applicable to a diverse set of perceptual problems and phenomena and he suggests a number of specific areas of applicability. For example, the critical aspect of the theory is the overall systemic structure it hypothesises for the visual system, and many perceptual phenomena, such as figural goodness, can be accounted for simply on this systemic basis. However, perhaps its most interesting applicability is in the suggested way in which Gestalt, Gibsonian, and information-processing theories can be integrated.

Although the basic approach is within the information-processing tradition, the theory itself is not typical. It supports and extends the Gestalt contention that 'good figures', emergent properties, and laws of organisation are critical aspects of perception, and it supports the general idea that the structure of the whole system may be far more important than the nature of its component parts. From the Gibsonian point of view, the theory suggests ways in which complex patterns of stimulation might be analysed computationally, and it stresses the importance of transformations in perception and the invariances to which these transformations give rise.

The way in which an understanding of perception contributes to the comprehension process, and the implications which this has for the design of print are discussed on page 221.

### **4.3 Perception of visual illustrations and pictures**

A considerable part of the research in the development of theories of perception has been carried out on alphanumeric or geometric images, but theories of perception need to be applied in the context of the kind of visual illustrations and pictures that are encountered in everyday instructional text, and the purpose of this section is to review the research likely to be relevant to the design of instructional text.



### 4.3.1 The nature of images

In instructional text it is common to encounter a variety of visual images from line drawings to full colour photographs. Arnheim (1969) has identified images capable of serving as pictures, as symbols, or as signs: Doblin (1980) discusses three variations of visual information — 'idiogrammatic', 'diagrammatic', and 'isogrammatic' — and suggests that they are at three levels of abstraction; and Wileman (1980) argues for three major ways of representing objects within a concrete-abstract continuum — as pictorial symbols, graphic symbols, and verbal symbols.

Arnheim (1969) states that the terms 'picture', 'symbol' and 'sign' describe three functions fulfilled by images and elaborates by arguing that

- (a) an image serves as a *sign* to the extent to which it stands for a particular content without reflecting its characteristics visually (e.g. numerals and letters);
- (b) images are *pictures* to the extent to which they portray things located at a lower level of abstractness than they are themselves (where abstractness is a means by which the picture interprets what it portrays); and
- (c) an image acts as a *symbol* to the extent to which it portrays things which are at a higher level of abstractness than is the symbol itself.

The degree of abstraction is an important variable to be considered. As Arnheim (1969) notes, pictures and symbols depict experience by means of images in two complementary ways: in a picture, the abstraction level of the image is higher than that of the experience it represents, and in a symbol the opposite is the case. He notes, also, that every pictorial analogue performs the task of reasoning by fusing sensory appearance and generic concepts into one unified cognitive statement, and presents as a summing up of the functions of pictorial analogues the diagram below (fig 4.9). He argues that for

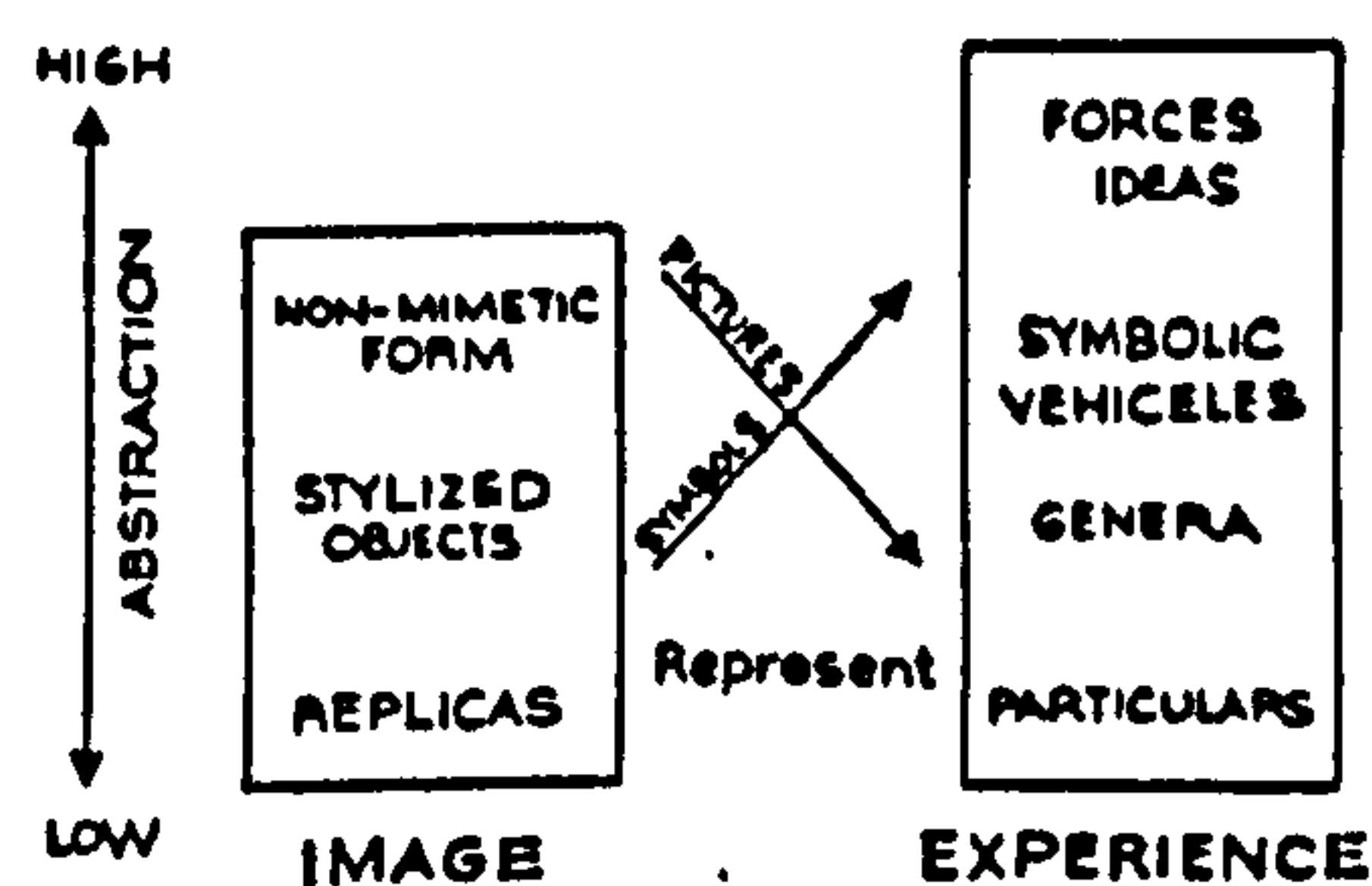


fig 4.9



the Image Scale, even if the image is entirely abstract (non-mimetic), it needs to reflect some of the complexity of form by which realistic images depict the wealth of human experience. Inversely, a realistic portrayal, in order to be readable, generic, and expressive, must fit its presentation of objects to the pure forms more directly embodied in abstract art. Arnheim (1969) points out that, for the Experience Scale,

“this condition demands that, while focusing upon the ultimate forces inherent in existence, the mind views them as creating the richness of empirical manifestation; and vice versa, the teeming multiplicity of particular phenomena must be seen as organized by underlying general principles”.

Doblin (1980) recognised three types of information content — nominal (names or terms given for identification or classification), noumenal (conceived by reason, but not knowable through the senses), and phenomenal (known through experience rather than thought or intuition) — and he matrixed these with the three types of message form referred to earlier (verbal, numerical, visual) to produce nine kinds of information:

	VERBAL	NUMERICAL	VISUAL
NOMINAL	lexic	numeric	ideogrammatic
NOUMENAL	logic	mathematic	diagrammatic
PHENOMENAL	prosaic	arithmetic	isogrammatic

*verbal nominal information*, called *lexic*, is words (the definition of which appear in lexicons).

*verbal noumenal information*, called *logic*, is words used for definition, classification, and reasoning.



*verbal phenomenal information*, called *prosaic*, is words used to describe reality as in reports or descriptions of persons, objects, or events.

*numerical nominal information*, called *numeric*, is numbers used for identification (license plates, telephone numbers, football players, route markings, and so on). Such numbers are not used for calculation.

*numerical noumenal information*, called *mathematic*, is numbers and symbols used for complex calculations.

*numerical phenomenal information*, called *arithmetic*, is the "real world" encoded into numbers by instrumentation. These numbers are used to subtract, multiply, or divide for ordinary purposes.

*visual nominal information*, called *ideogrammatic*, is visual "words" that convey a single meaning. Included are trademarks, ideographs (Chinese characters are one form), roadway signs, flags, and so on.

*visual noumenal information*, called *diagrammatic*, includes charts and graphs used for visualizing processes that are otherwise difficult to comprehend.

*visual phenomenal information*, called *isogrammatic*, is visual representation of reality. Isogrammatic techniques include drawing, drafting, model making, sketching, photography, portraiture, illustration, and so forth.

(p 91)

The column of visual information messages is intended to be conceived of as three levels of abstraction, where phenomenal messages are the most realistic, noumenal messages (images of processes, not objects) are more abstract than phenomenal messages, and nominal messages are the most abstract because of their 'all-or-nothing' character (e.g. failure to know that a red disc on a white rectangular field means 'Japan' is a total loss of information). Doblin (1980) has subdivided these visual levels so that isograms are divided into four — models (the most realistic type of visual message), photographs, drawings and drafting — and there is, thus, a total of six practical levels with charts & graphs and marks completing the series. He



then proposes that these six levels of visual abstraction can be removed from the matrix and rearranged to give even emphasis to the six types of visual messages, ranging from the very realistic to the very abstract.

Wileman (1980), restricting the representation of objects to the three major ways already noted, argues that

- (i) *pictorial symbols* are produced as either 3-D models, relief sculpture, photographs, illustrations or drawings in an attempt to reconstruct the object or things as a highly realistic/concrete symbol;
- (ii) *graphic symbols* can be constructed as image-related graphics best characterised as silhouettes or profiles of the object, concept-related graphics conveying the essence of the object as a stylised version of the real thing, and arbitrary graphics which are typically abstract geometric symbols visually unrelated to the object; and
- (iii) *verbal symbols* are single words or whole sentences which define or describe an object.

The three major symbol groupings help to cluster the range of ways in which objects are represented visually and the range is, as he notes, best described as running from concrete to abstract representations (fig 4.10).

Ways to represent objects  
 Fig 4.10

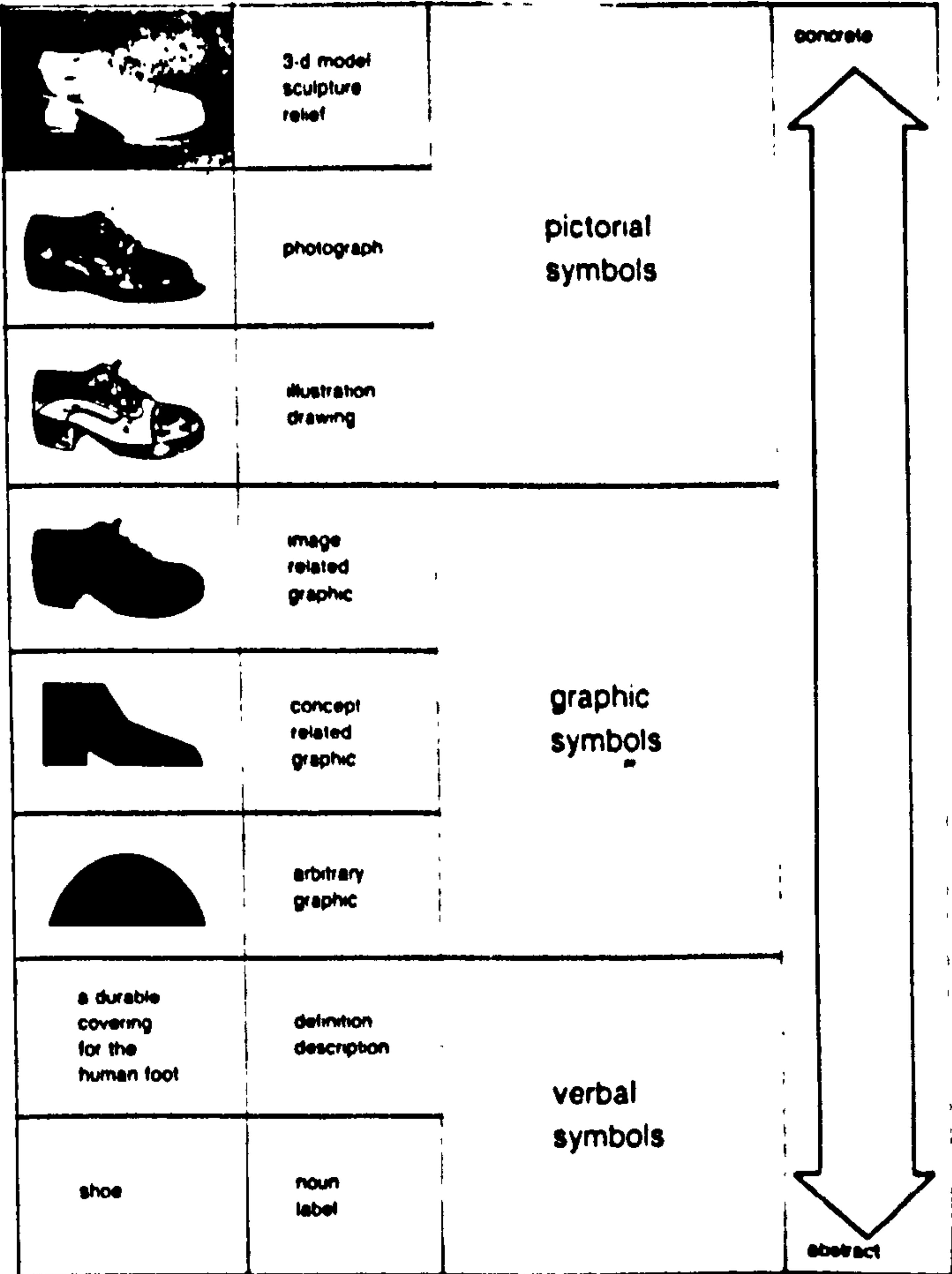


Figure 2 Ways to represent objects



The concept of a realism-abstract continuum was also proposed by Dwyer (1978) and this will be returned to at a later stage.

Szlichcinski (1979, 1980) has argued that the syntax of pictorial instructions can be considered at the level of the formation of individual pictorial elements depicting objects or abstract symbols, at the level of the assembly of these elements into scenes, at the level of the combination of elements into scenes, at the level of the combination of elements and scenes into a complete instruction to perform a single action, or at the level of combining instructional units to describe a sequence of operations. Irrespective of the purpose as outlined by Szlichcinski, it is clear that, apart from the realism/abstract dimension of illustration, there is also a complexity dimension, and it is necessary to identify how viewers cope with the perception of complex visuals.

#### **4.3.2 Perception of complex visuals**

By 'complex visuals' is meant diagrams, photographs or other kind of image with a considerable amount of information which needs to be processed. A number of different research areas have contributed relevant findings and these are considered in turn.

##### **4.3.2.1 Eye movement research**

Yarbus (1967) conducted a large number of experiments from which he was able to generalise that

- (a) a very large proportion of eye fixations are made on areas that are highly informative;
- (b) fixations are not necessarily drawn to either the brightest or darkest parts of a picture,
- (c) fixations are not necessarily drawn to the regions with greatest detail; and
- (d) scanning patterns are affected by the subject's purpose in looking at the picture.



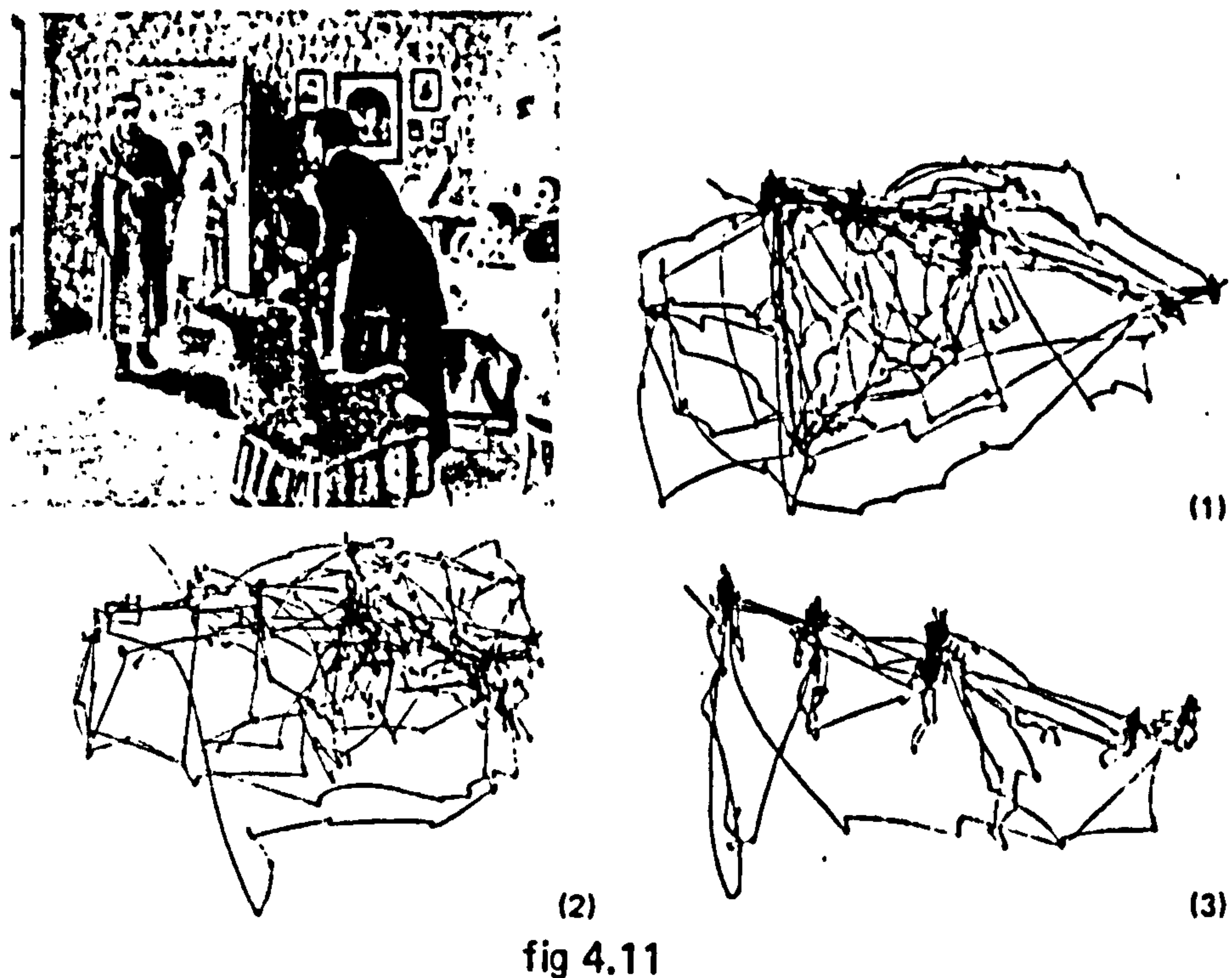


fig 4.11

Fig 4.11 shows the scanning pattern over 3 minutes for one subject when (1) free examination of the pictures was allowed, (2) the subject was asked to estimate the material circumstances of the family in the picture, and (3) the subject was asked to give the ages of the people in the picture. Fig 4.12 shows the scanning during free examination of the first three consecutive 5 second segments of the scan together with, on the right, each point of fixation covered with a black circle, the size of which corresponds to the size of the central fovea of the subject's eye.

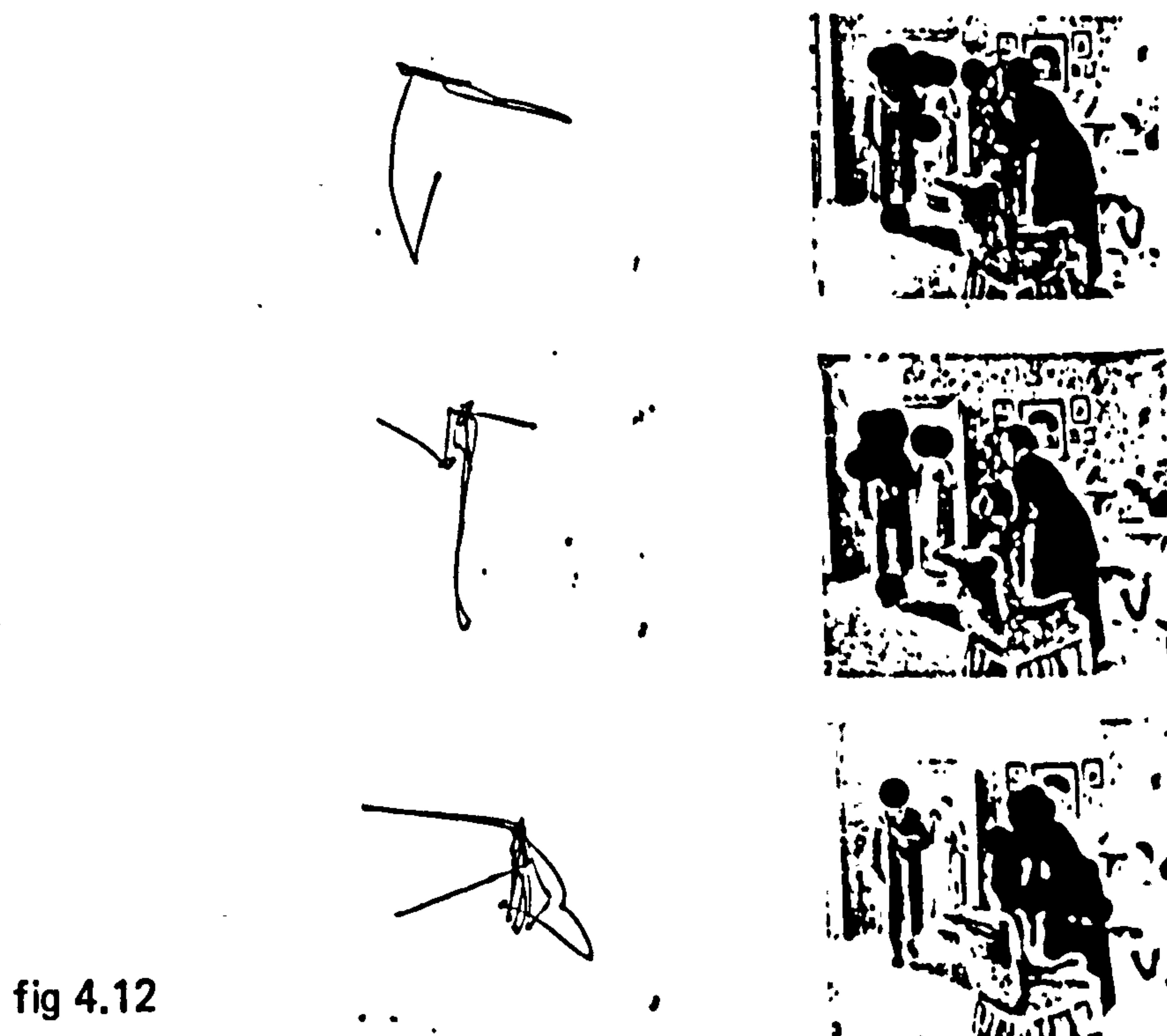


fig 4.12



It is clear from the illustration that the viewer tends to return frequently to the most informative parts of the most informative areas or objects in the picture. Details receive relatively few fixations unless they are also informative. In fact, as Spoehr and Lehmkuhle (1982) have noted, comparison of scanning patterns for pictures drawn in silhouette and regular photographs or paintings shows that the fixation patterns for both are very similar.

The variation of scanning pattern with purpose is of particular interest. It has already been noted that purpose in reading affects scanning pattern, so it should not be surprising that there is a similar effect with pictures, but it does raise questions regarding the extent to which cognitive effort is required, although Spoehr and Lehmkuhle (1982) report that research evidence indicates that cognitive control of scanning patterns may be an automatic process and that eye movements reflect what the brain is thinking about. This contrasts with the observations of Arnheim (1969) who, in commenting upon the fact that perception is purposive and selective and that active selectivity is a basic trait of vision, notes that the observer's attention is searching to find its objective in a perceptual field that has an order of its own.

Treisman and Gelade (1980), in their feature-integration theory, argue that separable features such as colours, orientations, spatial frequencies, brightness levels, and direction of movement are initially registered automatically, and in parallel, but percepts or objects, which are conjunctions of features, are identified only by focusing attention at the point in the visual field where the features are located. Thus, as La Berge (1981) points out, attention serves as the 'glue' that conjoins features into a unitary percept or object. He conjectures that two kinds of attention are operating: attention to the features of form or colour during initial search for these cued features, and attention to integrating the set of features at the location found by the search.

Given that perception is inherently selective, and that the pattern of successive eye fixations is considered an observable indication of selective processing, especially in visual scanning tasks, Cohen (1981) postulates that, with respect to control of eye fixation patterns, a perceiver's intentions, expectations, and strategies of scanning are tempered by the particular task and



stimulus materials with which he/she is confronted. Thus, if searchers are given prior knowledge regarding the relevance of particular stimulus information in a search task, they can selectively allocate attention and/or accompanying eye fixations to specific information which is most critical for task resolution. The searcher is, therefore, a selective processor and integrator of multiple stimulus features and this places, according to Cohen (1981),

“a heavy burden on the perceiver both to appreciate figure-ground separations, invariant relations, or distinctive features in a stimulus array and to integrate these elements in the visual environment with strategies, expectations, or intentions.” (p 273)

In terms of a model of visual searching, she proposes four processes, where

- (a) the first process is that of *parsing* in which the subject must specify where visual information relevant to task solution is located in the display field;
- (b) the second process is that of *comparing* in which the subject goes beyond mere isolation of stimuli and determines which stimuli are the most relevant for task solution;
- (c) the third process consists of *testing* in which the subject goes beyond hypothesising about the relevance of the stimulus and devises and implements a plan of action to verify prior hypotheses; and
- (d) the final process is that of *confirming* in which the subject must decide whether he/she has sufficient information to confirm or disconfirm the hypothesis regarding the match of a peripheral alternative with the standard.

Cohen (1981) concludes that her research enhances an understanding of the relation between available stimulus information and sequences of eye fixations — the link between perception and action.

Visual searching suggests the possibility of perceiving a picture at a macro level with subsequent, more detailed, perusal at a micro level, and, although



the infrequent fixations in uninformative regions reported by Yarbus (1967) suggests that peripheral vision plays an important role in visual exploration, Antes (1974) has demonstrated that a peripheral editing process is operating prior to the first fixation and that a brief scan of the pictures is not necessary to locate informative areas. Informative regions of pictures are fixated immediately and are certainly concentrated in the initial few seconds of viewing and less informative detail receives a greater proportion of the fixations later in viewing. Loftus and Mackworth (1978) demonstrated that subjects tend to look earlier more often and for longer fixation durations at informative objects in pictures, and they suggest that there is a role for cognitive factors in peripheral visual processing.

#### 4.3.2.2 Global/local processing

The evidence from eye-movement research suggests that complex visual processing occurs in a global-to-local fashion. Printzmetal and Banks (1977) demonstrated that, when shown an entire array of objects, an observer first organises the elements into larger patterns, and the observer is first aware of the emergent properties of the organised wholes but not of the characteristics of the component parts. Work by Navon (1977) confirms the global influence of organisation, as his subjects seem to be immediately aware of only the global characteristics of a visual stimulus and not of the individual components. Palmer (1977) suggests that visual form is represented and analysed hierarchically starting with the overall configuration, and the implications for perceptual theory include a need for representing information about the perceptual organisation of elements into structural units and a recognition that the encoding of structural units must be context sensitive.

Antes and Penland (1981), in examining the role of context as a characteristic of pictures in influencing attention, as measured by eye movement patterns, concluded that contextual information in a picture provides rapid access to the picture theme that biases visual exploration in a manner consistent with that theme, and that during the fixational pause, semantic information of the object viewed and objects from the immediately preceding fixation are encoded and decisions regarding the next object of



fixation made on the basis of the semantic information of the surrounding objects. Since the relations among objects contributing to context seem to come within the category of global information, the evidence that global processing precedes local processing supports the notion of the processing of contextual information preceding processing of the details of a scene. The early processing of contextual information can, thus, influence the course of later processing. Biederman's (1981) work supports this view by demonstrating that viewers have rapid access to semantic information in a picture, at least as rapid as their access to information that is not dependent on referential meaning.

The idea of data-driven (bottom-up) processing or conceptually-driven (top-down) processing is cited by Antes and Penland (1981) as suggesting that analysis of information may proceed through a series of stages determined by the current input information, or may be directed by expectations and organisational strategies. They note that, ordinarily, both types of processing occur simultaneously, but that when the operation is conceptually-driven, contextual information influences subsequent processing both through the precedence of global information and by expectation derived from previous inputs. Kinchla and Wolfe (1979), however, in bringing together the notions of global/local and top-down/bottom-up suggest that neither an invariant top-down (gross shapes first followed by lower-order details) nor bottom-up (the opposite) sequence is involved. Rather, there appears to be a sort of "middle-out" sequence where forms at some intermediate level of structure having an optimal size or spatial-frequency spectrum are processed first, with subsequent processing of both higher and lower levels of form.

There is evidence from investigations into picture processing in a single fixation that the overall content and organisation of the entire picture greatly influences the processing (Biederman, 1972). Biederman, Glass and Stacy (1973) have suggested that schema may play an important role in such processing, and Biederman (1981) has suggested that viewers need an overall representation, or schema, that serves to integrate all the separate aspects of the picture. The schema is, thus, a mental structuring of data that embodies necessary real-world constraints on the content and organisation of the picture and contains expectations about what should appear in the picture. Palmer (1975) has demonstrated that visual characteristics of



individual objects and top-down scene organisation influence recognition of objects in a picture, and this, together with other similar investigations, has led Spoehr and Lehmkuhle (1982) to conclude that three main aspects of a picture determine how easily processing proceeds during a single fixation: the theme or overall topic of the picture; the nature of the visual information itself; and the spatial organisation of the objects and parts of the picture.

The global-to-local and top-down processes seem to be inextricably linked through organisation which appears, repeatedly, to be an extremely important feature of perception. Kahneman and Henik (1981) assert that the rules of grouping and organisation are essential to describe the abilities and limitations of selective attention, and Pomerantz and Kubovy (1981) have noted that there is, today, far better evidence that perception is organised and that there is a far more optimistic picture of the varieties of organisational phenomena to be explained. Organisation is, clearly, of considerable importance to the processing of visual information just as it is to the processing of verbal information. In fact, the work of Pazdek (1978) and Kolars (1977) suggest that pictures can be integrated into thematic wholes just as linguistic material is integrated, and that viewers process pictures for theme and gist without remembering the exact visual details just as readers do with linguistic material.

The perception of visual illustrations and pictures is of relevance not only to an understanding of comprehension, *per se*, but to the use of visuals in text for the facilitating of comprehension, and this is discussed on page 223.

Just as it was necessary to determine how linguistic material facilitated comprehension in its deepest sense, so it is necessary, now, to identify how visual material, alone and in association with print, contributes to a deeper comprehension.

## **4.4 Visuals in learning**

As Funkhouser (1938) has pointed out, the graphical representation of ideas is one of the earliest and most universal characteristics of human activity,



with the earliest recorded language being the ideographic drawings of cave dwellers, and the writing of the Babylonian, Mayan, and Egyptian civilizations being largely figurative symbols and hieroglyphs. Davis (1983) notes that when, as early as 35,000 BC, primitive man in Lascaux, France and Altamira, Spain was painting pictographs on cave walls, the attempt to communicate was more symbolic than aesthetic. The purpose of this section is to elaborate on the 'symbolic' rather than the aesthetic, and to identify how illustrations, in general, can contribute to learning.

#### **4.4.1 General issues**

Arnheim (1969) comments that visual perception, far from being a mere collector of information about particular qualities, objects, and events, turned out to be concerned with the grasping of generalities, and does, in fact, lay the ground work of concept formation.

"The mind, reaching far beyond the stimuli received by the eyes directly and momentarily, operates with the vast range of imagery available through memory and organizes a total lifetime's experience into a system of visual concepts. The thought mechanisms by which the mind manipulates these concepts operate in direct perception, but also in the interaction between direct perception and stored experience, as well as in the imagination of the artist, the scientist, and indeed any person handling problems 'in his head'." (p 294)

Winn (1982a) distinguishes between visualisation in learning and visualisation in instruction by indicating that visualisation in learning has to do with the role of visualisation in internal cognitive processing whereas visualisation in instruction has to do with embedded and detached instructional strategies that cause information to be processed visually internally. Salomon (1979) emphasises the fact that, in learning, it is internal processes and not external forms that must be considered first.

These comments are in marked contrast to the widely accepted belief that 'one picture is worth a thousand words', a belief which was shared (and probably still is shared) by many in the educational world. Dwyer (1978)



notes that hundreds of articles and research studies have contributed to the popularisation of using visualisation in the instructional process, citing Day & Beach, 1950; Allen, 1960; Wendt & Butts, 1962; Chu & Schramm, 1967; Briggs, 1968; and Levie & Dickie, 1973 as examples. Treichler (1967) quotes data distributed by the Socony-Vacuum Oil Company (fig 4.13) which illustrates the popular importance attributed to the visual medium but,

WE LEARN:	
1%	THROUGH TASTE
1½%	THROUGH TOUCH
3½%	THROUGH SMELL
11%	THROUGH HEARING
83%	THROUGH SIGHT

Learning through the senses.

PEOPLE GENERALLY REMEMBER	
10%	OF WHAT THEY READ
20%	OF WHAT THEY HEAR
30%	OF WHAT THEY SEE
50%	OF WHAT THEY SEE AND HEAR
70%	OF WHAT THEY SAY AS THEY TALK
90%	OF WHAT THEY SAY AS THEY DO A THING!

How we remember.

METHODS OF INSTRUCTION		RECALL 3 HOURS LATER	RECALL 3 DAYS LATER
A	TELLING WHEN USED ALONE	70%	10%
B	SHOWING WHEN USED ALONE	72%	20%
C	WHEN A BLEND OF TELLING AND SHOWING IS USED	85%	65%

Effect of visualization on delayed recall.

fig 4.13

as Dwyer (1978) points out, the naive individual glancing at these percentages might be left with the impression that merely integrating visualisation into a presentation will automatically facilitate increased learning and retention on the part of the students, despite the fact that the research basis for these claims is not known. As Dwyer (1978) notes:



**“As a result of widespread claims emphasizing advantages to be obtained through the use of visual media in the teaching-learning process, educators on all levels have been incorporating visualization in their classes in an attempt to improve the reliability of their oral/printed communication and to facilitate increased information acquisition and retention on the part of the learner. Unfortunately, however, in many instances it appears that the visual media are being employed rather indiscriminately with the expectation that since visualization is being used in the classroom, the quality of instruction is being improved, and the students are automatically acquiring more information.”**

**(p 10)**

Gombrich (1974), alluding to the assertion that the world is entering a historical epoch in which the visual image will take over from the written word, argues that it is all the more important to clarify the potentialities of the visual image in communication, to ask what it can and what it cannot do better than spoken or written language. Dismissing the papal pronouncement of Pope Gregory the Great that “pictures are for the illiterates what letters are for those who can read”, he argues quite strongly that what a picture means to the viewer is strongly dependent on his or her past experience and knowledge. The visual image is, thus, not a mere representation of ‘reality’ but a symbolic system. The issue of past experience is also taken up by Spaulding (1956) who, in identifying the factors which influence the communication potential of pictorial illustrations, concluded that an illustration as such has no educative value, and may even be a detracting influence, if the drawing content has not been presented in terms of the past experience of the intended audience. As Winn (1982a) noted,

**“The knowledge structures (schemata) representing what a learner already knows and feels about something are of far more importance to learning.”**

**(p 6)**

In referring to the pictorial plaque (fig 4.14) which the National Aeronautics and Space Administration (NASA) sent on the Pioneer spacecraft, designed to tell “scientifically educated inhabitants of some other solar system” who had



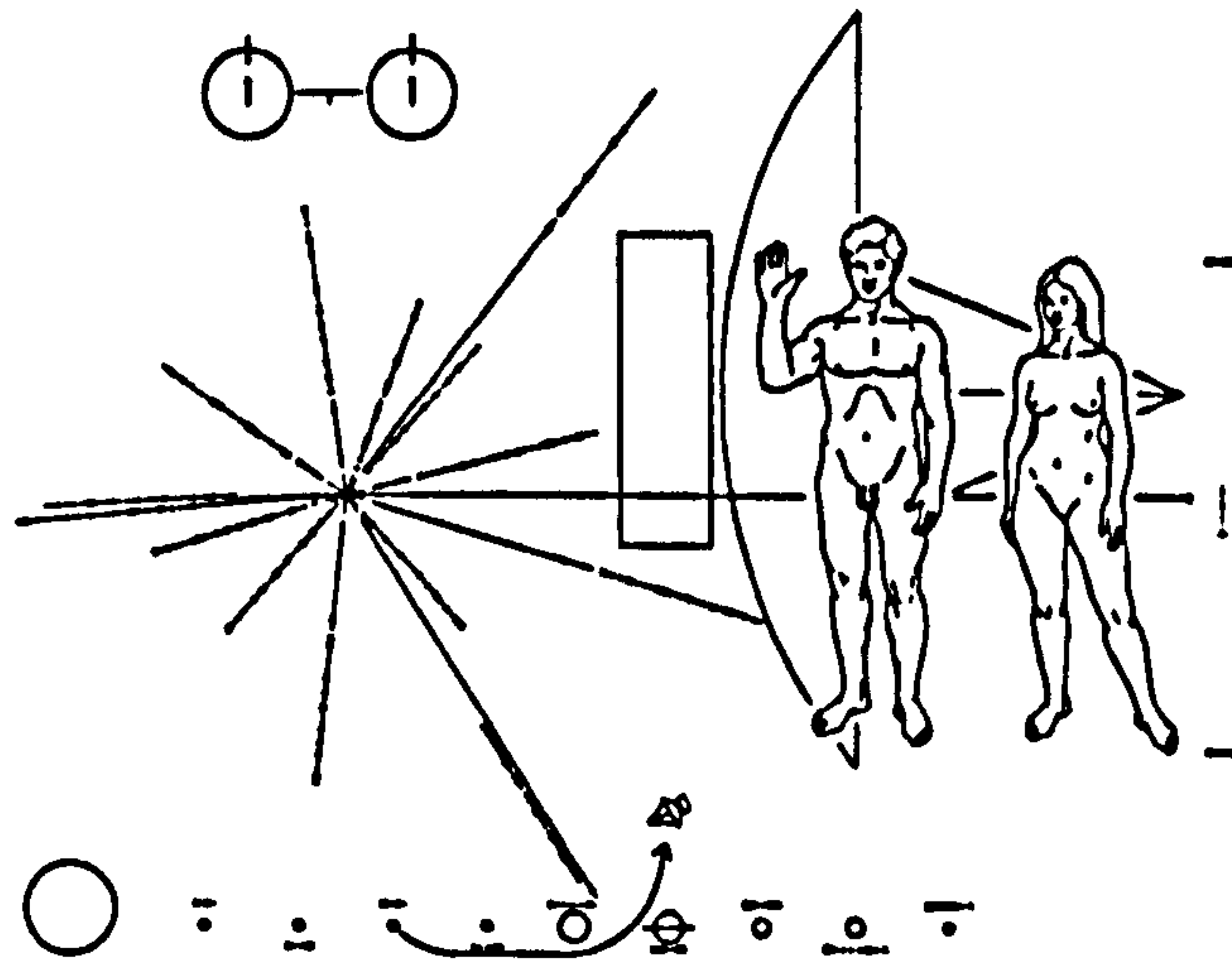


fig 4.14

launched the spacecraft, Gombrich (1974) notes that without prior knowledge of the people of Earth's use of symbols, the inhabitants would not be able to decipher the message. He wryly comments that the trajectory has a directional arrowhead and that "it seems to have escaped the designers that this is a conventional symbol unknown to a race that never had the equivalent of bows and arrows."

Dwyer (1972) cited a number of reasons for using visuals, including the clarifying of information and highlighting of key parts of a presentation. He also identified other functions which are commonly attributed to visuals in explaining their potential value for improving instructional presentations. For example, visualization of content material is said to be able to:

1. Facilitate the accuracy and standardisation of the message being communicated.
2. Bring into the classroom inaccessible processes, events, situations, materials, and phase changes in either space or time.
3. Illustrate, clarify, and reinforce oral and printed communication, quantitative relationships, specific details, abstract concepts, and spatial relationships.
4. Provide concreteness (realistic detail) in the learning situation.
5. Increase student interest, curiosity, and concentration.
6. Present to the learner the opportunity to perceive an object, process, or situation from a variety of vantage points.
7. Provide important instructional feedback.



In a later discussion of the reasons why visualisation is used, Dwyer (1978) lists the undernoted characteristics commonly attributed to visuals in explaining their potential value in improving instructional presentations:

1. Increase learner interest, motivation, curiosity, and concentration;
2. Provide important instructional feedback;
3. Provide remedial instruction;
4. Present to the learner the opportunity to perceive an object, process, or situation from a variety of vantage points;
5. Facilitate the retention of information acquisition;
6. Span linguistic barriers;
7. Foster generalizations of responses to new situations;
8. Stimulate discussion and raise questions;
9. Increase reliability of communication, making learning more precise and complete;
10. Bring into the classroom inaccessible processes, events, situations, materials, and phase changes in either space or time;
11. Provide greater flexibility and variety in the organization of instruction;
12. Illustrate, clarify, and reinforce oral and printed communication — quantitative relationships, specific details, abstract concepts, spatial relationships;
13. Summarize the important points in a lesson;
14. Isolate specific instructional characteristics;
15. Sharpen powers of observation;
16. Guide learners to think more carefully and make conclusions;
17. Present relationships, locations of parts, etc.;
18. Facilitate discrimination and identification of relevant cues;
19. Overcome time and distance;
20. Introduce, organize, and present new information;
21. Emphasize and reinforce aural and printed instruction;
22. Function to integrate facts, skills, and judgements.

Hoban (1961), commenting on the instructional use of visualisation, stated that



“for approximately forty years, research has produced empirical evidence to support the popular truism that children, adolescents, and adults do learn from motion pictures, still pictures, and other forms of pictorial representation.” (p 2)

However, as Dwyer (1978) notes, although it has been established that visual aids specifically designed to explain, clarify, and reinforce the important concepts in an instructional presentation do facilitate student learning, this fact cannot be generalised liberally and interpreted to imply that merely visualising instruction will automatically improve student achievement. To demonstrate what he means by effective use of visualisation, Dwyer (1978) uses two illustrations (fig 4.15) the first symbolising ineffective use and the other effective use (V indicates visual being used and I<sub>0</sub>, I<sub>1</sub>, etc indicates

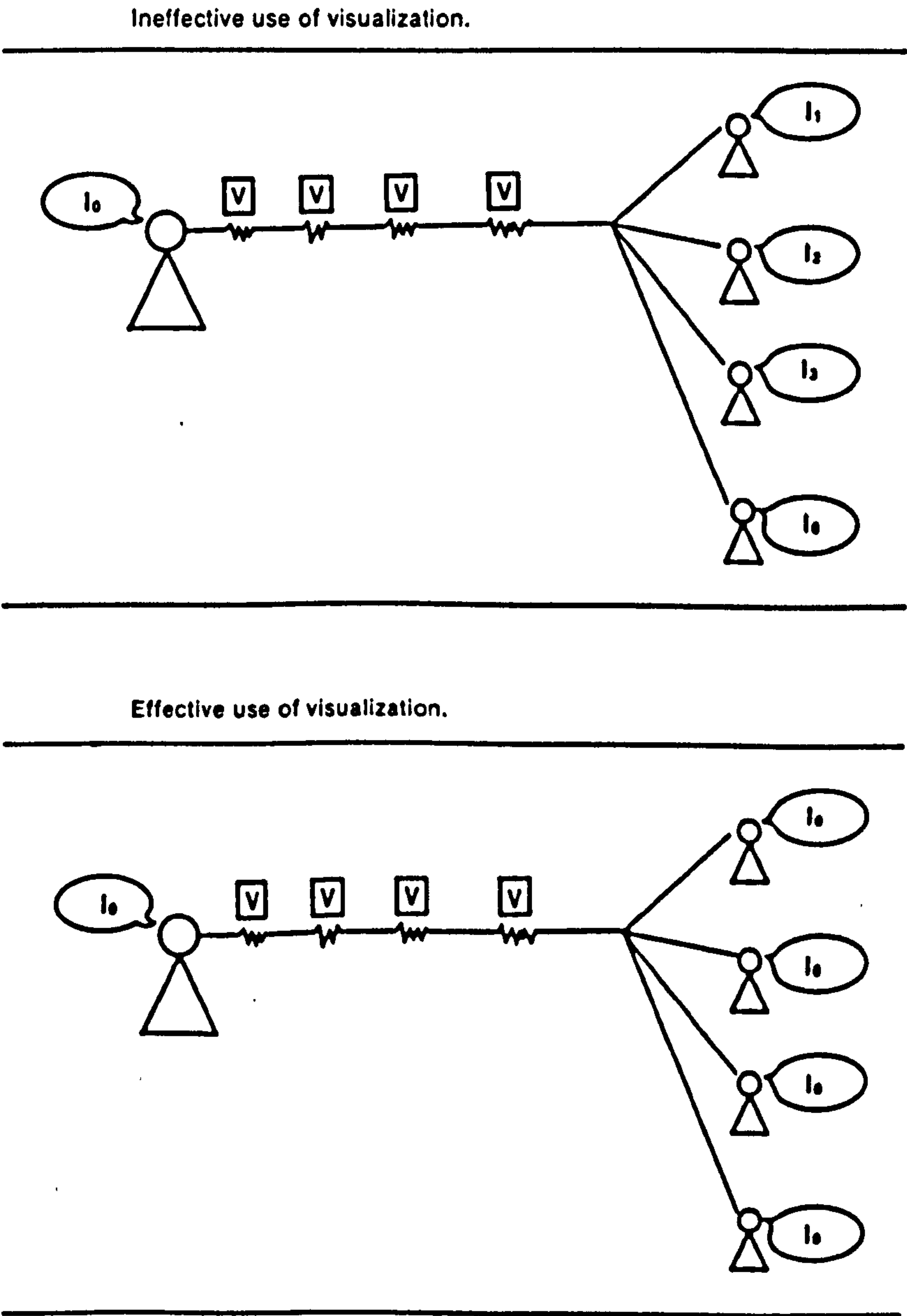


fig 4.15



messages) but it is doubtful whether the illustrations chosen are, themselves, effective use of visualisation as the distinguishing features of each illustration are not, in fact, iconic.

Arnheim (1969) argues that instructional visuals will be aids to learning only if they meet the requirements of visual thinking. The unity of perception and conception suggests that intelligent understanding takes place within the realm of the image itself, but only if it is shaped in such a way as to interpret the relevant features visually.

“If the picture fails to state the relevant propositions perceptually, it is useless, incomprehensible, confusing, worse than no image at all. In order to do its job, the sight must conform to the rules of visual perception, which tell how shape and color determine what is seen.”

(p 309)

#### **4.4.2 Classification of illustrations**

According to Kennedy (1974) iconic displays are used to intrigue students (the motivative function) to serve as memory aids (the mnemonic function) and to arouse evocative or helpful associations (a generative function). However, this does not take into consideration the nature of the iconic display which is capable of achieving these functions, whether it is high or low in abstraction (Arnheim, 1969) or whether it is ideogrammatic, diagrammatic, or isogrammatic (Doblin, 1980) as noted earlier.

An early attempt to classify and analyse instructional illustrations in relation to the learning which they could facilitate was carried out by Fleming (1967), who operationally defined ‘illustration’ in terms of three elements:

1. *Pictorial elements*. Those configurations of line, dot, or area and any combination of these three that resembled events or objects (persons, places, and/or things) either as perceived or as generally conceived. Included were the following borderline cases: number lines, geometric figures, structural chemical formulae, curves, graphs, and time lines.
2. *Verbal elements*. Those configurations of line, dot, or area and any combination of these three that



resembled alphabetical or numerical symbols. Included were punctuation marks and scientific notation systems, so long as they were arbitrary, i.e., did not resemble objects or events.

3. *Design elements*. Those configurations of line, dot, or area and any combination of these three that did not meet the definition of either pictorial or verbal elements. Examples were lines around or between areas, arrow, and colored or textured areas under pictorial or verbal elements. (p 247)

Out of the many physical attributes of illustrations he chose eleven as being reasonably definable and of possible relevance to learner behaviour, viz: (1) area, (2) framing, (3) shape, (4) position, (5) elements, (6) chroma, (7) achroma, (8) encoding style, (9) encoding medium, (10) information, and (11) unification. He was able to determine that the physical attributes of illustrations could be classified on these eleven scales by relatively naive judges, with results adequately reliable for many purposes. He concluded that very few guidelines are available to the instructional designer for the adequate description of pictorial stimuli, and fewer still for the prediction of the behavioural consequences of the addition or deletion of pictorial components for an instructional system.

In a later review, Fleming (1979) commented upon the remarkable breakthrough which had occurred during the previous ten years in the study of pictures both within educational contexts and outside them, but notes that, compared to verbal research, the study of pictures has been less extensive, and that part of the reason for this is that existing taxonomies of picture attributes are few and inadequate.

The taxonomy of Mandler and Johnson (1976) identified four types of information (other than motion and inter-relationships) in complex pictures:

1. *Inventory information*, which specifies what objects a picture contains.
2. *Spatial location information*, which specifies where the objects are located. This category includes the relative positions of objects, such as "to the right of," "below," "facing," and so on.



3. *Descriptive information*, which specifies the figurative details of the objects contained in the inventory, that is, what the objects look like.
4. *Spatial composition information*, which specifies areas of filled or empty space and the density of filled spaces. This aspect of pictures is roughly equivalent to the figure-ground relationships involved in distinguishing a single object from its background. (p 530)

Initial investigation suggests that changes in inventory information and spatial location information are more accurately recognised than changes in description and spatial composition. Mandler and Johnson (1976) noted that, within the context of the types of information studied, real-world schemata control some kinds of information more than others. In particular, they aid recognition of meaningful spatial relations among objects and inhibit the processing of the spatial composition of pictures.

Newton (1984), recognising that, in mimetic representation of appearance, the objective classification of pictures according to levels of information content is not easy, proposed a classification of textbook illustrations based on the discrepancy between the number of dimensions possessed by some aspect of the environment and the way in which it is depicted. Accordingly, the mimetic representation of an aspect of the environment was classified by the extent of the dimensional discrepancy between that aspect as it might normally be perceived and its depicted form, as follows:

1. *Fully representational*, in which there is no discrepancy between the dimensions depicted and those of the referent.
2. *One-dimension discrepancy*, in which the dimensions depicted and those of the referent differ by one (e.g. lack of depth cues).
3. *Two-dimension discrepancy*, in which the dimensions depicted and those of the referent differ by two (e.g. a 3-D object such as a plank represented by a line).
4. *Three-dimensional discrepancy*, in which the dimensions depicted and those possessed by the referent differ by three (e.g. where a 3-D object is represented by a point).



Newton (1984) noted also that, as pointed out by Kennedy (1982), as well as mimetic representation of appearances in pictures, there also can be metaphorical representation, and he classified the metaphorical representation of an aspect of the environment as follows:

1. *No metaphor*, in which no use is made of metaphor or simile.
2. *Simple metaphor*, in which one or more metaphorical representations are present in the picture but none carries more than one significant piece of information.
3. *Complex metaphor*, in which at least one metaphorical representation carries more than one metaphorical piece of information.

It is claimed by Newton that the classification system presented above seems to be capable of describing some aspects of the illustration style of textbooks, but he acknowledges that it is not intended to be used to predict with accuracy the 'readability' of a given picture. It is interesting to note that Spaulding (1956), in trying to isolate the factors which influence the communication potential of illustrations, also makes reference to 'readability', and suggests that, just as readability researchers have found a correlational relationship between idea density (number of different ideas per number of running words) and reading difficulty, his studies have shown an inverse relationship between complexity of an illustration and its effectiveness in communicating clearly. He concludes that illustrations that are intended to communicate specific ideas will be most effective if:

- (a) the number of objects that must be seen to correctly interpret the illustration is kept to a minimum;
- (b) the number of separate actions necessary to correctly interpret the basic message of the illustration is kept to a minimum; and
- (c) all objects and inferred actions are realistically portrayed and not open to dual interpretation or secondary inference.

The reference above by Spaulding (1956) to "realistic" portrayal is indicative of the prevalent theoretical orientation of that period from which has since evolved a widely researched classification of visual illustration. As



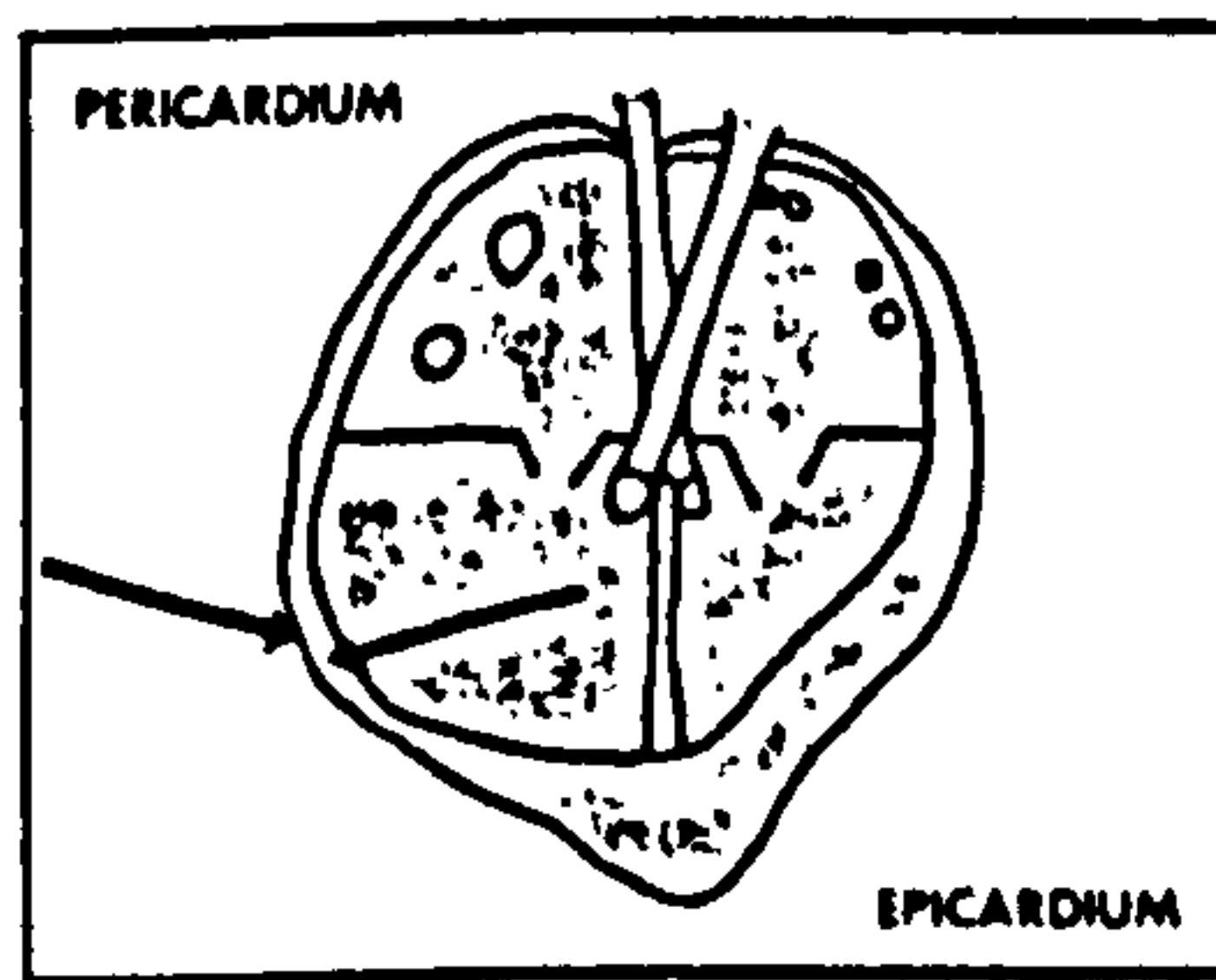
Dwyer (1978) has pointed out, an explanation for the current widespread use of visualisation can be traced back to the 1940's and 1950's when a number of theoretical orientations which he refers to, collectively, as the realism theories were proposed. They include the iconicity theory identified by Morris (1946), Dale's (1946) cone of experience, and the sign similarity orientation developed by Carpenter (1953). The basic concept around which these realism theories have been oriented, according to Finn (1953), is the concrete to abstract dimension of learning in which it was generally concluded that the more realistic or lifelike the stimulus is, the greater the probability it has for facilitating learning.

However, as Dwyer (1978) points out, it seems reasonable to assume that for instructional purposes, visual illustrations varying in the amount of realistic detail they contain are not multipurpose in character. He argues, in fact, that there is a considerable amount of literature available that contends that an increase in the amount of information presented in a visual will not add proportionally to the amount of learning achieved by the student. Travers (1964) has suggested that the emphasis on realism is the worship of a false god; Arnheim (1969) argues that deficient pictures can be found at any level of abstraction and that they fail not because they are not lifelike or devoid of detail but because they are ambiguous and misleading; and Dwyer (1972) concluded that excess of realism may actually interfere with the effectiveness of visual materials.

The need, therefore, was to identify those characteristics within visuals that could facilitate student achievement of specific kinds of learning, the so-called 'relevant cue' position which, as Clark & Angert (1980) point out, has its origins in information theory and the concept of a limited channel capacity in humans for processing sensory stimulation. Dwyer's (1972) programme of evaluation attempted to determine the relative effectiveness of four different types of black and white and coloured illustrations (fig 4.16) in facilitating student achievement of different learning objectives.

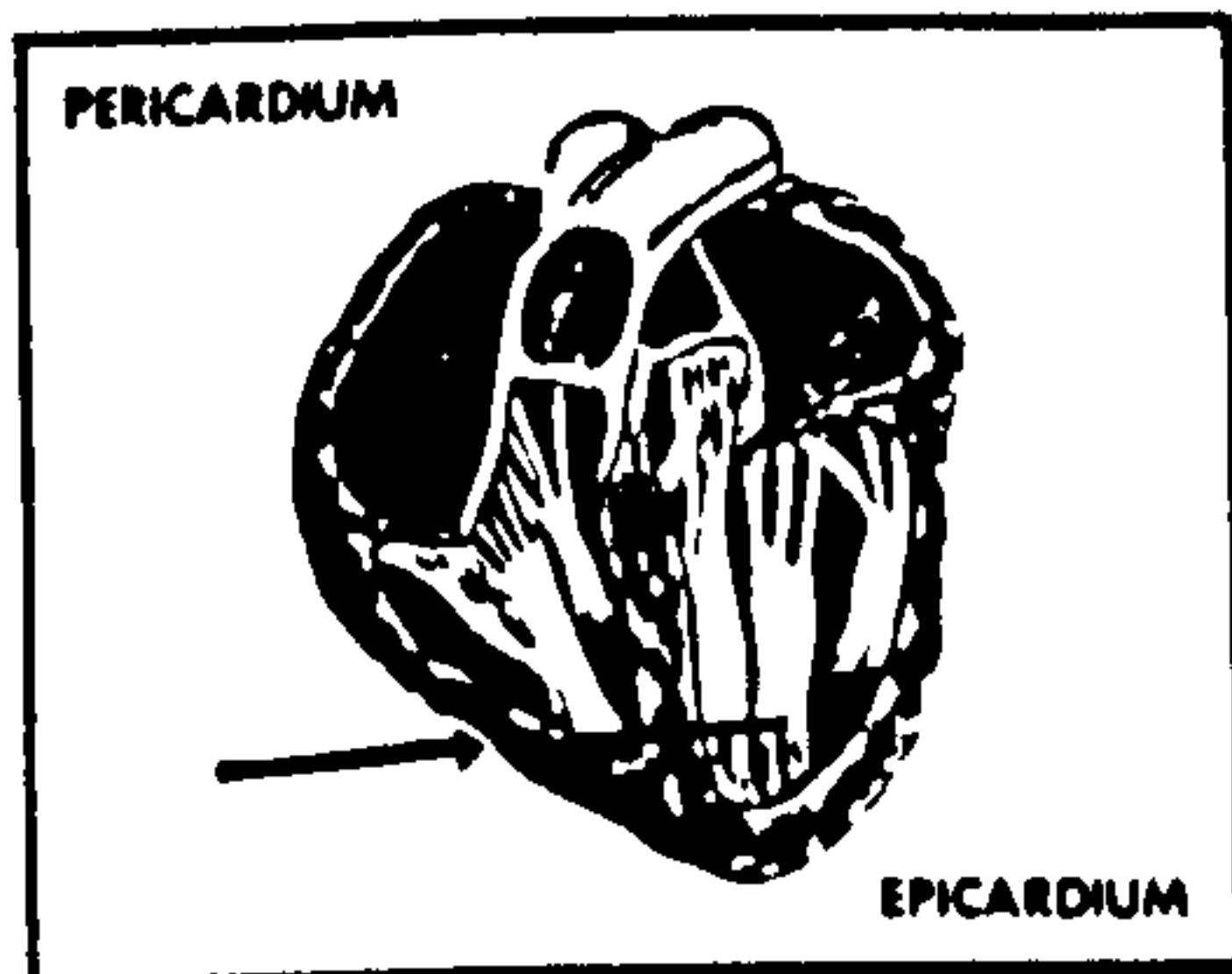
The series of studies based on this continuum carried out by Dwyer and his colleagues and reported by Dwyer (1978) represents the only extended and concerted investigation of pictorial stimulus complexity as it relates to static





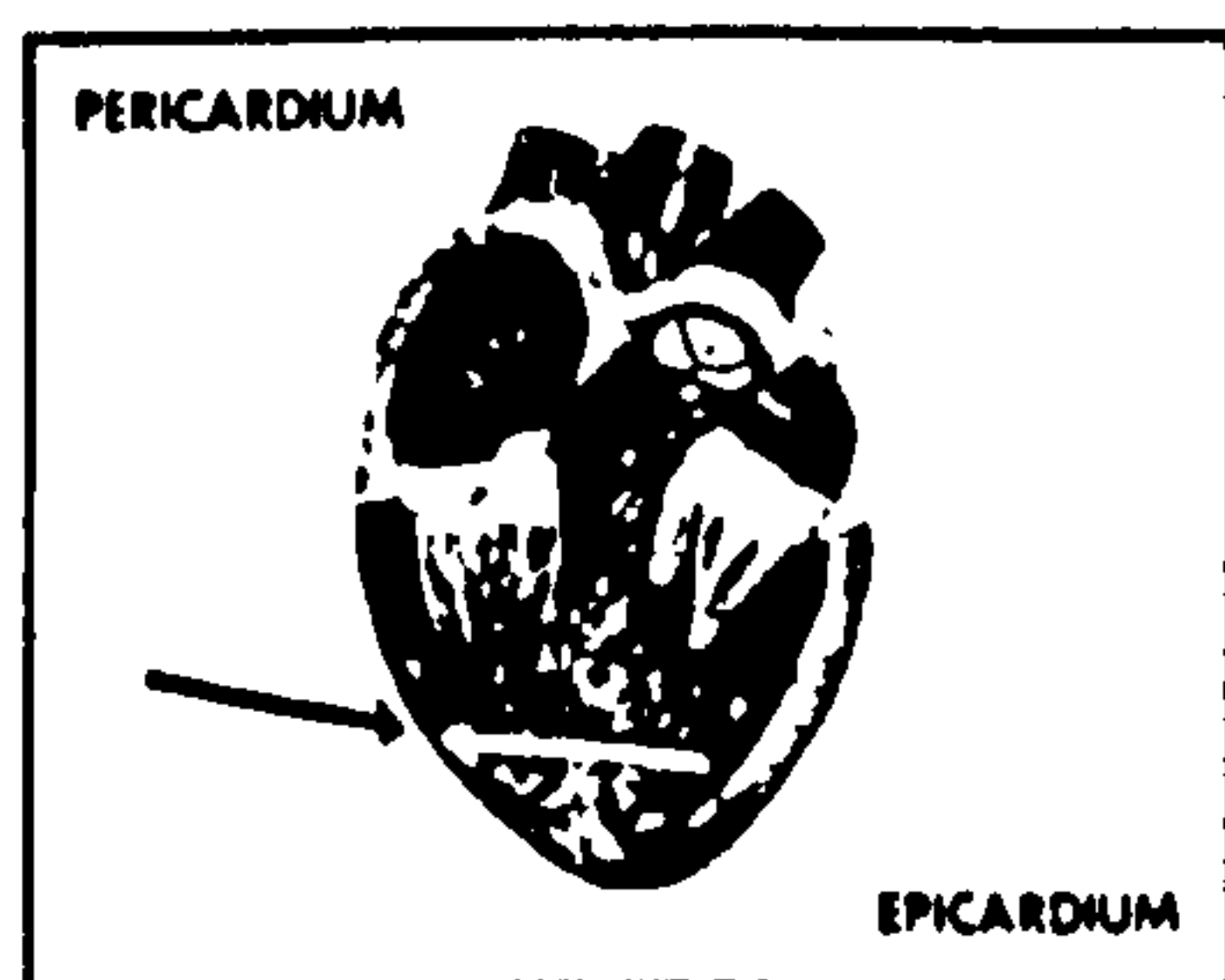
1. simple line drawings (black & white)

2. simple line drawings (colour)



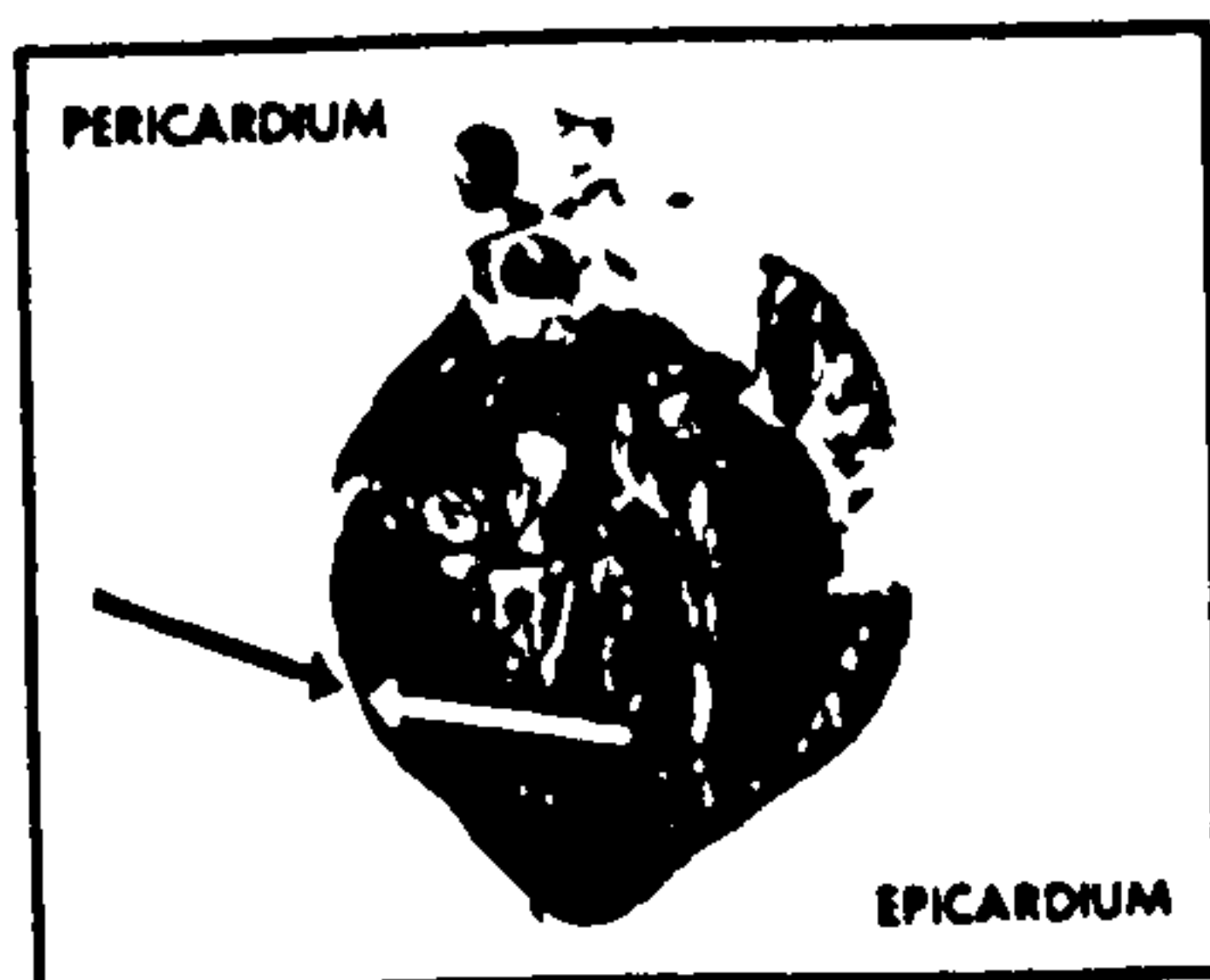
3. detailed, shaded drawings (black & white)

4. detailed, shaded drawings (colour)



5. heart model photographs (black & white)

6. heart model photographs (colour)



7. realistic heart photographs (black & white)

8. realistic heart photographs (colour)

fig 4.16

instructional visuals. Despite the evidence against realism, Joseph (1979) found that the inclusion of realistic visualisation improved instructional effectiveness under general conditions, dependent upon pacing, general ability, and type of instructional objective. It was also reported by Joseph (1980) that although students with a low general knowledge of the subject may find all types of visuals equally effective, students with moderate and high levels of knowledge of the subject may benefit from realistic visualisation, depending on the pacing of the instruction and the type of instructional objective.

As noted by Clark and Angert (1980), the predominant definition of pictorial complexity has been expressed in terms of the physical parameters of the stimulus. Duchastel and Waller (1979) have argued, however, that the



thematic complexity, the learner's subjective impressions, or the illustration's function may be more important considerations than the physical parameters in judging instructional effectiveness, and this will be referred to in a later section.

Perkins (1980), recognising that what is identified as realism in pictures involves a curious mix of the practical and the arbitrary, and that more realistic pictures are closer to the real thing, proposes that, instead of more realism, the following rules may make more sense:

- Rule 1. For more informative pictures, include more information of relevant kinds.
- Rule 2. For more informative pictures, provide simplified highlighted information of relevant kinds.
- Rule 3. For more informative pictures, match the manner of presenting the information to the viewer's habits of information pick-up.

He concludes:

"No doubt pictures will inform better when they eliminate irrelevant information, provide more relevant information, highlight and clarify it, and present it in an accessible way. However, the implications of these rules taken separately often are not clear, nor do we know how to trade them off against one another when they conflict in many practical circumstances . . . . Practical picture making is . . . . a matter of recipe rather than principle, of tradition and invention rather than law or application." (p 272)

The tendency to provide guidelines or rules is quite common in the research relating to the effectiveness of illustrations in learning, particularly in relation to the important sub-grouping of pictures which includes the diagram in its various forms.

#### **4.4.3 Diagrams, graphs, charts**

Graphic devices have been invented by humans, according to Macdonald-Ross (1977a), to help represent, explain, and control the world in which



they live, and, although verbal language is the primary means of communication, it is impossible to do without mathematical and numerical notations, scientific diagrams, tables, and maps. Considering the decorative connotation of graphics as a secondary role, he proposes fairly strong criteria of effectiveness so that, for nomograms and algorithms, the graphic device is effective if, and only if, the user can perform some well-specified operation with its aid, and for scientific diagrams, comprehension, general trends, or relationships are expected to be achieved.

Unfortunately, there is a tendency for 'recipe' approaches in the use of charts (e.g. McGregor, 1982; Szoka, 1982) in which statements are made without any supporting research evidence and guidelines amount to 'do this' 'do not do this'. Nevertheless, there is a considerable amount of research evidence concerning the effectiveness of diagrams, graphs and charts in learning.

Frase (1969a) found diagrams to be superior learning devices to tables, although students preferred tables; Holliday, Brunner, & Donais (1977) investigated the differential cognitive responses to flow diagrams in science — a picture-word diagram and a block-word diagram — and noted that learners with lower verbal performance had more difficulty in learning from the block-word diagram; and Szlichcinski (1979) found that procedural operations could be taught utilising only pictorial diagrams.

Macdonald-Ross (1977b) usefully defines a wide range of charts and graphs and, after extensively reviewing the research on the presentation of quantitative data in texts, concluded (Macdonald-Ross, 1977a) that:

1. The quantity and the logical and visual arrangements of data have an important effect on learning.
2. No form is more effective in all respects than all other forms.
3. Bar charts are generally superior to circle charts and to line graphs.
4. Circles (or squares) of differing sizes should be avoided; if used they should be range-graded (in stepped sizes) and a key provided to show the number represented by each step.



5. Where possible, labels should be placed directly on bars or lines; they should not be indirectly keyed.
  6. For general use, horizontal bar charts were understood better than tables, and tables were understood better than text.
  7. Use text to support charts and tables.
  8. If pie charts are used, avoid fine angular discrimination.
  9. In general, the advice given by expert designers has been vindicated by subsequent empirical tests.
  10. Any graphic format can be executed well, or poorly, for a particular purpose. This is often a more significant variable than the choice of format.
- (p63/64)

Holliday (1973) has highlighted the fact that most science educators value the use of visuals in instruction, partly because they are concerned with the student's ability to identify various kinds of structure-function relationships, and he draws attention to the need to investigate the type of drawing which could be used in conjunction with such objectives. In recognising the role of scientific diagrams in explaining and illustrating, Macdonald-Ross (1977b) suggests a list of purposes which could be used to develop a more sophisticated classification:

*Iconic purpose.* Here the purpose is to show what an object looks like, and to identify and label key parts.

*Data display purpose.* Here the purpose is to display the results of empirical observations.

*Explanatory purpose.* Here the purpose is to show the logical relationships between key ideas.

*Operational purpose.* Here the purpose is to help the reader to perform some well-specified task.

(p 70)

He claims that, in general, scientists are not aware of the role diagrams play in their work, but his claim is difficult to substantiate, because it is in the area of science that some of the most notable work has been done with regard to study of the role of diagrams.



Winn and Holliday (1981) confirm that, although diagrams of all types are frequently used in various forms of instructional materials, the way in which these diagrams are designed is due as much to inspired guess-work as to sound principles of instruction and instructional design and that this is because there has been little empirical research on the effectiveness of various types of diagrams with the result that there are few specific principles for the design, preparation, and use of diagrams that have a basis in scientific research. Accordingly, they set out to identify some of the relationships that exist between the unique properties of diagrams and various aspects of cognitive processes and learning in an attempt to derive principles from these relationships which would direct the design and use of diagrams in the classroom.

The unique properties of diagrams can be considered, according to Winn and Holliday (1981) in four different contexts. The first consists of the special ways in which diagrams convey information. Like pictures they exploit the spatial dimension, but any isomorphism they exhibit with a domain of referents is logically rather than iconically derived. Diagrams therefore give priority to conceptual structure rather than to realism. The second context identified by Winn and Holliday (1981) within which the diagrams can be studied involves the way that they relate to the text in which they may occur, and this will be dealt with in the next section. The third context involves the ability of diagrams to direct attention. Since diagrams may present only the abbreviated equivalent of text (often just 'labels'), they are highly simplified representations of conceptual domains, as a result of which, the designer of diagrams has control over what particular concepts are highlighted, and, since diagrams can incorporate varying details of realism, the designer can use visual cueing devices to focus attention. The fourth context is that of learner ability. Since diagrams can exploit verbal, spatial and sometimes iconic forms of communication in order to instruct, the learner's verbal and spatial aptitude is, presumably, an important consideration.

In a series of eight studies, (Winn, 1980; Winn, 1981; Winn, 1982b; Holliday, 1976a,b; Holliday, Brunner, & Donais, 1977; Holliday, 1981; Holliday & Benson, 1981), Winn and Holliday (1981) examined hypotheses developed within each of these four contexts, which provided information about how learning in general, and cognitive processes in particular, are



related to:

- (a) the way in which diagrams present conceptual domains spatially;
- (b) the interactions between diagrams and the texts within which they are embedded;
- (c) the ways in which diagrams draw attention to important information; and
- (d) the ways in which learners' verbal and spatial ability predict their success in learning from diagrams.

The conclusions from these studies are summarised by Winn and Holliday (1981) as follows:

1. Diagrams help learners learn because they direct attention to important information, replacing critical verbal information with graphic devices such as lines and arrows. They show which concepts "go with" which others, aiding generalization and discrimination, by placing concept labels in the same or different rectangles.
2. Diagrams help low-verbal learners overcome some of their difficulty with language by providing information in a form they can handle more easily.
3. Through the use of normal left-right, top-bottom layout, arrows and other graphic devices, diagrams can teach sequences of events effectively, as well as make it easier to learn classification schemes. The relative effectiveness on sequencing and patterning is to an extent dependent on learners' verbal (general) ability.
4. The addition of study questions to diagrams helps learners by directing their attention to critical information, but must be used with care because they also direct attention away from information that is not questioned.
5. Likewise, prompting can be useful in helping learners. However, overprompting can be dysfunctional as it encourages learners to learn surface information rather than the more important underlying concepts shown in the diagram. (p 22)



In a subsequent paper relating to design principles for diagrams and charts, Winn and Holliday (1982) enunciated nine principles to help instructional designers to create diagrams that can be effective and suitable for the intended students.

*Principle 1* Make sure that the distances among labels in the layout on the page correspond to the “semantic distance” between concepts in the content you are teaching. Also, be careful that layout accurately reflects any sequential relationships among concepts.

*Principle 2* Use arrows and lines to indicate direction and sequence of concepts within processes. Use boxes and other graphic devices to enhance the “distance” effect, and to assist students to generalize and discriminate concepts.

*Principle 3* Whenever possible, arrange the layout so that concept labels are found in positions corresponding to where they would occur in the real world.

*Principle 4* Include small pictures in diagrams to teach concept identification, especially with students of low verbal ability.

*Principle 5* Be sure to arrange any sequences of concepts so that they run left-to-right and top-to-bottom on the page.

*Principle 6* Arrange the layout of diagrams and charts so that the names of superordinate categories of concepts are read first, from left-to-right across the page or top-to-bottom. This is especially important when teaching classification.

*Principle 7* Use study questions to focus students’ attention on important details of diagrams and charts. Take care that the questions cover all of the material to be learned.

*Principle 8* Make sure that study questions used with charts and diagrams do not overprompt students.

*Principle 9* Do not use complex and redundant diagrams and charts with low-ability students. Remember, understanding diagrams requires



certain mental skills. Diagrams are **not** necessarily “easier” forms of instruction.

In deriving these principles and in identifying practical considerations for the design of diagrams, Winn and Holliday (1981,1982) developed a theoretical framework for research which related to models of cognition, information theory, schema theory, and learner attention, which will be returned to in the final chapter of this present study.

In relation to diagrams in the field of science, it is interesting to note that Macdonald-Ross (1979) argues not only for diagrams in scientific learning materials, but diagrams as a means of expressing scientific hypotheses. Taking up a phrase from Pierce (1931-35) that “all valid reasoning is diagrammatic”, he suggests that access to the store of paralogical notions is by means of visual representations and that the scientific diagram is a tool designed by man to help solve certain types of problems which were difficult to represent in any other form, and, more broadly, they are the means whereby the scientist assesses and uses his paralogical apparatus. Macdonald-Ross (1979) sees in this an explanation of the phenomena whereby the invention of a new kind of diagram acts as a catalyst for effective thought in a problem domain with the existence of the diagram making possible certain kinds of mental operations which are inaccessible through language or with other kinds of notations. Certainly this is consistent with the view of Waller (1979a) that a diagram is a tool for analysis, not just an aid to description, and that the construction of a visual argument, no less than a verbal one, poses questions of logic and validity. Classification is central to science and is essentially a graphically organised task — the perception of pattern and structure among apparently chaotic data.

A particular requirement of diagrams in a scientific setting is for the visualisation of rotation of three-dimensional structures. Seddon, Eniaiyaju, and Jusoh (1984) recognised that students have difficulties in visualising the diagrammatic representation of a three-dimensional structure after the structure has been rotated and they identified that the student must understand first the overall depth relationships portrayed by any diagram and, second, how these depth relationships change as a result of the rotation. Several researchers have identified problems with depth perception, par-



ticularly in the context of cross-cultural studies (e.g. Jahoda & McGurk, 1974; Hagen, 1974; Hagen & Jones, 1978; Miller, 1973; Walker, 1979), although the gap between Western and developing countries in this respect has probably been exaggerated, but Evans and Seddon (1978) have suggested that there are many students who cannot respond to depth cues.

Seddon et al (1984) have identified the types of depth cues involved in the rotation of diagrams (fig 4.17) and their investigations confirmed that the

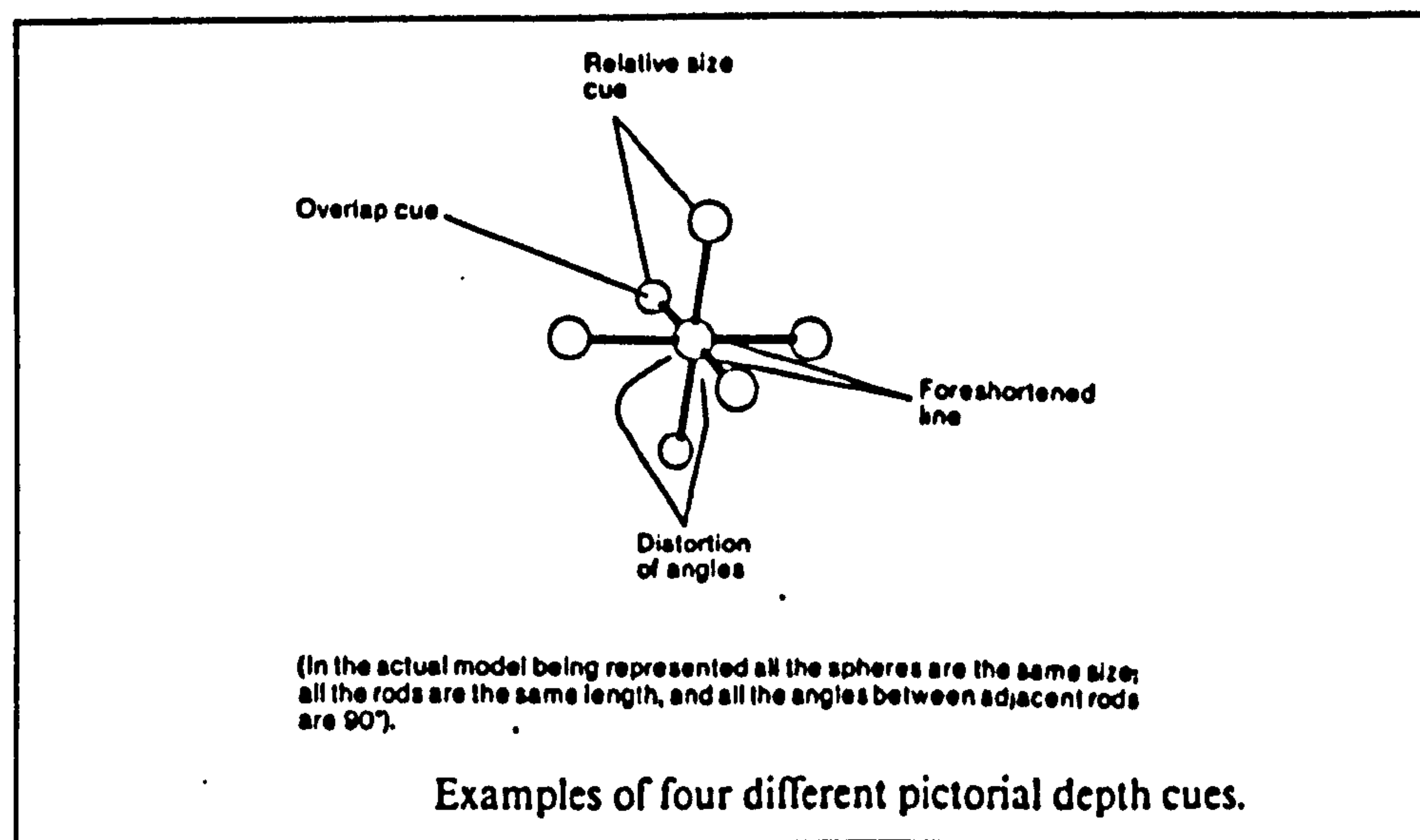


fig 4.17

ability to respond to these cues is an essential prerequisite skill needed to visualise the effects of rotations.

On the issue of movement in illustrations in general, Friedman and Stevenson (1980) acknowledged that movement occurring over time cannot be captured in two-dimensional representations and that the eye cannot be fooled by pictorial movement as might be the case with pictorial depth. Accordingly, they analysed paintings, photographs, caricatures, cartoons, and diagrams produced by different cultures and during different historical periods to identify the types of information artists use for portraying movement in pictures. Once the pictorial indicators for movement had been enumerated, they then tried to determine the effectiveness of such indicators in inducing a correct understanding of pictorial movement. The following indicators for movement were identified:

1. There are indicators depicting a selected single moment of the process of movement as seen from a specific point of view.



2. There are indicators showing an object (living or still) or part of it at selected successive moments.
3. There are indicators suggesting movement by showing side-by-side aspects of the environment that are unlikely to occur together in the environment.
4. There are abstract lines or shapes that have the power to suggest movement. (p 251)

However, they noted that only the first type of indicators have been used frequently in art of different cultures and periods and that a limited body of psychological research suggests that the different pictorial indicators for movement are not equally effective — they are first understood at different ages. Friedman and Stevenson (1980) hypothesised that

“these indicators could be placed on a continuum of information correspondence to the environment. At one extreme of the continuum are the pictorial indicators spontaneously recognized as representative of the environment. At the other extreme of the same continuum are indicators that are arbitrary and must be learned by a process of association.” (p 251)

The use of graphs is a particular application of diagrams which is fairly widespread in instructional materials. Funkhouser (1938) outlines several stages in the historical development of graphical representation — the origin of the coordinate principle, the drawing of curves on the coordinate background, the invention of analytic geometry, the collection of numerical data resulting from observation, and the translation of the numerical statistical data into graphical expression. Segal (1974) states that charts and diagrams (including graphs) represent a synthesis of art and science in which the graphic designer endows them with elegance. Elegance he sees as a measure of the grace and simplicity of the designed product relative to the complexity of its functions. Given two charts, the one conveying the more information is the more elegant, and, conversely, of two charts conveying the same information, the simpler is the more elegant. From an artistic point of view this may be acceptable, but Bertin (1980) is much more rigorous in his criteria, arguing that the value of a diagram, chart, graph, or map is defined by the service it provides.



Bertin (1980) argues that every graph is the transcription of a two-dimensional table of data and that the objective of a graphic transcription is comprehension, i.e., the reduction of a multiplicity of elementary data to the groupings that the set of data generates. Consequently, he argues, a graph must furnish a visual answer to two questions —

- (a) What are the  $x$  and  $y$  components of the table of data? and
- (b) What are the groups of elements in  $x$  and the groups of elements in  $y$  that the data generate?

— and these two questions constitute the basic test of the graph. As he notes, “One does not passively ‘read’ a graph: one queries it.” Bertin (1980) argues that every problem can be posed in terms of a network of relations or in terms of a matrix of relations, but notes that a network can quickly become illegible whereas a visual matrix can permit movement from the part to the whole and from the whole to the part while accommodating a significant number of data. The graph, then, has as its aim the use of this property of visual perception to understand the problem better and to make better decisions.

However, there may be some doubt as to whether students can cope with graphs. Roller (1980) judged that, by ninth grade of schooling, readers encounter many graphs in functional and consumer mathematics situations and that from about the sixth grade readers are expected to integrate information contained in graphs with a surrounding text. Although Vernon (1951) observed that a text with graphs is more difficult than a text without graphs, Roller (1980) notes that the testing methods commonly used to assess graph reading abilities of students seldom require the integration of graph and text information. Eggen, Kauchak, and Kirk (1978), however, suggest that textual cues interfere with comprehension of information on graphs. Roller’s (1980) study indicated that all 13 year-olds in her investigation could ‘read’ graphs, but the results favoured isolated presentation of graphs as far as her reading and interpretation test items were concerned, with no differences being found between graphs embedded in text or in isolation with respect to her summarisation test.

It is obvious from the above and from earlier references that it is sometimes difficult to distinguish between the effectiveness of graphical devices in



isolation and in combination with text. Or, to put it differently, there really is a need to consider the research concerned with graphical devices or illustrations and their relationships to text.

## **4.5 Illustrations in text**

When Gropper (1963) explained that a picture is worth a thousand words because, for some purposes, visual materials can do a better job than words or can do a job which words cannot do, he sparked off a considerable controversy with Bourisseau, Davis, and Yamamoto (1965) responding that the conclusion that pictures are more effective than words in both the presentation of information and the evocation of sensory responses was supported "more by faith than by facts" (p 250). The subsequent for-and-against (Gropper, 1966; Yamamoto, Davis, & Bourisseau, 1966) discussion merely succeeded in contributing to the confusion since neither side had closely defined or limited terms and procedures.

### **4.5.1 The research in relation to illustrations in text**

Schallert (1980) set out to delineate when it is that a picture is worth a thousand words, and, recognising that some researchers have found that pictures facilitate the comprehension and retention of text whereas others have found that pictures either make no difference or actually interfere with reading, she distinguished between situations which could be described as "learning-to-read" and "learning-from-reading". In the first case, pictures are accessory to the words, whereas in the second case, the focus of interest shifts to the sum total of the information being conveyed by an author, whether through words or pictures or through an interaction between the two.

Koenke and Otto (1969) commenting upon the fact that the results of investigations into the effects of pictures on comprehension differed, noted that Miller (1938) and Goodykoontz (1936) concluded that the addition of pictures to reading material did not enhance comprehension, while Halbert (1943) and Strang (1941) found that pictures enhanced comprehension.



They noted, further, that reviews of investigations of the effects of pictures upon comprehension (Spaulding, 1955; Weintrub, 1960, 1966; Koenke, 1968) show that researchers who have been concerned about picture effects have generally measured reading comprehension in a global way rather than specifically in relation to main ideas, sequence, or details. Accordingly, Koenke and Otto (1969) examined the extent to which content relevant pictures contribute to children's comprehension of the main idea inherent in a printed passage, and concluded that, for sixth-grade students, performance was significantly higher for those students who read passages accompanied by pictures than for those who did not see the pictures.

On the other hand, Vernon (1953), in seeking to answer the questions of whether pictures help or hinder the acquisition of knowledge from text and whether they increase interest to any appreciable extent, concluded that versions of text illustrated by pictures are not remembered significantly better than those without pictures, although it did appear that certain major points in the text directly illustrated by pictures were remembered better than those same points unillustrated by pictures, and that the pictures produced, in several cases, a considerable emotional impact such as might affect the attitudes of the subjects to the problem described in the text.

It is not simply that earlier investigations were not concerned with the interaction of text and illustration: a study by Sewell and Moore (1980) examined the effect of the inclusion of cartoon embellishments on printed presentations relating to the use of a college library, and concluded that, if comprehension is the only goal, the printed text without cartoons is just as effective as text with cartoons but, if enjoyment is a factor, cartoons should be considered.

Schallert's (1980) perception of the problem is much more pertinent to this present study. A similar orientation is advocated by Brody (1981) who notes that, for the most part, research has not discriminated between the effect of illustrations on learning from reading and the effect of illustrations on learning to read, with the former having been studied only rarely while the latter has been the subject of considerable research. Levin and Lesgold (1978) reviewed studies of prose learning in which the role of pictures is examined. At the outset, and despite claims by Concannon (1975) and



Samuels (1970) to the contrary, Levin and Lesgold (1978) concluded that there was solid evidence that pictures facilitate prose learning, but they recognised that ground rules were required as a basis for understanding why not all pictures-in-prose manipulations would be expected to produce positive results. The experiments they reviewed showed five important commonalities which became the ground rules:

1. Prose passages are presented orally;
2. The subjects are children;
3. The passages are fictional narratives;
4. The pictures overlap the story content; and
5. Learning is demonstrated by factual recall. (p 233/234)

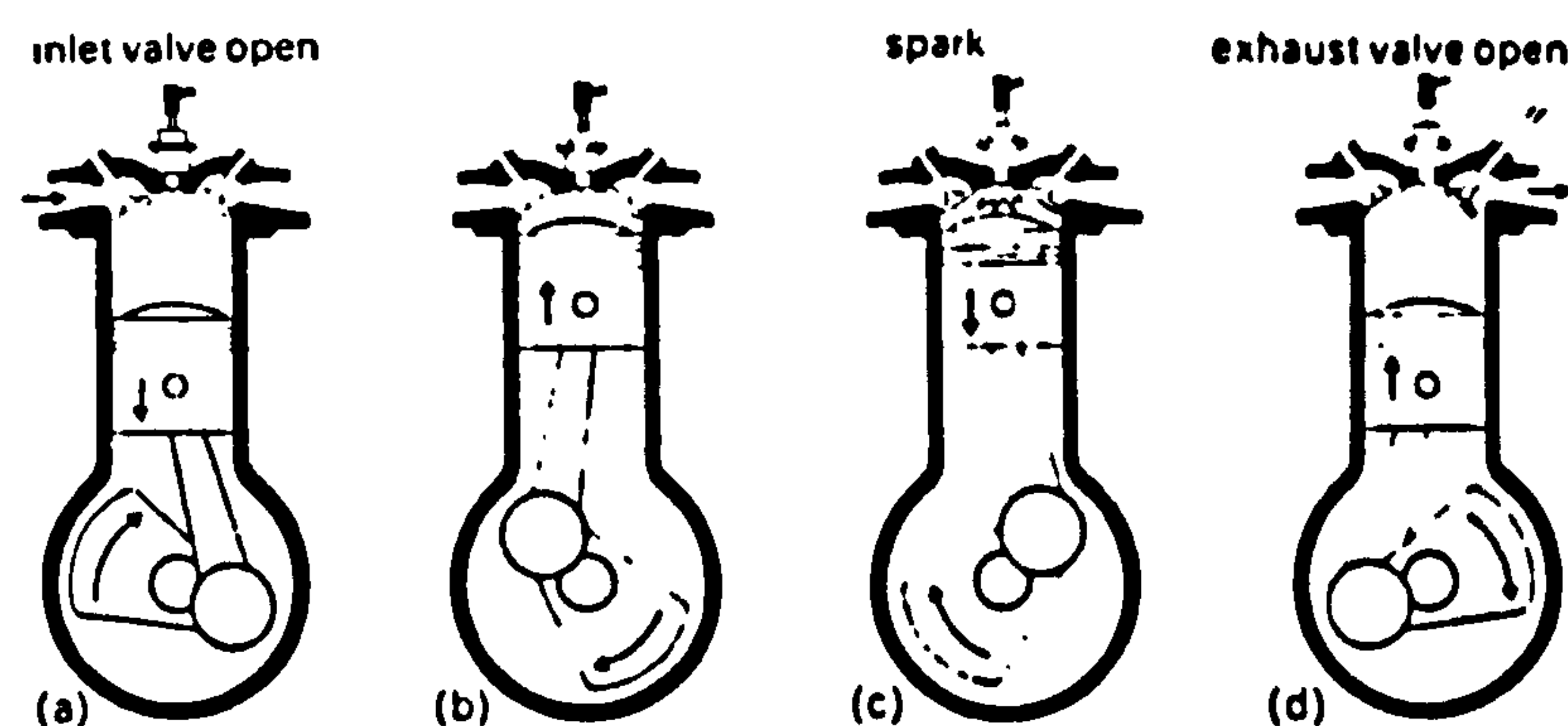
They were able to conclude that, as long as the five ground rules were adhered to, positive effects of pictures invariably appear and that, although they had concentrated on oral prose learning, they did not mean to imply that pictures would not similarly benefit those who were reading for comprehension. Haring and Fry (1979) addressed themselves to this problem, analysed a prose passage into 350 idea units, then interspersed throughout the text pictures depicting either the 179 main ideas or both the main ideas and the 171 non-essential details, or included no pictures. Pictures did facilitate both immediate and delayed recall, but only of the main ideas.

Peeck (1974) argued that a necessary and obvious approach to this area of study, as yet hardly explored, is the careful distinction between information present (a) exclusively in text, (b) exclusively in illustration(s), or (c) in both, and the investigation of the fate of these three categories of information when retention is tested. As a result of his investigations, however, he was able to conclude that subjects (fourth graders) who had used an illustrated text produced higher retention scores than the control group (text without illustrations) for questions concerning exclusively pictorial information and for questions concerning illustrated text contents. Brody (1981) notes that this and similar studies seem to concentrate on whether or not pictures help increase learning from reading, and argues that current research, instead of asking whether or not pictures help, should be asking how they help.

Levin (1981), in questioning whether visual illustrations are helpful, indicates that the evidence from the review of Levin and Lesgold (1978) clearly



permits the conclusion that “picture effects in children’s prose learning are positive, potent, and pervasive” (p 204). He notes that visual illustrations have been found to facilitate elementary school children’s learning of historical and scientific content (De Rose, 1976; Schallert, 1980), and that the findings of visual illustration have been generalised to an important class of prose materials, viz, newspaper articles (Levin & Berry, 1980). He concludes, therefore, that in response to the question, “are visual illustrations helpful?” the answer is “Yes, very!” Duchastel (1980) dismisses the need to demonstrate the superiority of an illustrated text over a text alone, arguing that there is no need to prove the value of illustrations in learning simply because there is already evidence on other grounds that illustrations can assist learning. Referring to the illustration below (fig 4.18), he claims that



*Operation of a four-stroke internal combustion reciprocating engine. (a) Suction stroke: petrol/air mixture is drawn into the cylinder. (b) Compression stroke: mixture is compressed by the rising piston. (c) Expansion stroke: burning mixture drives the piston down. (d) Exhaust stroke: rising piston pushes out the burnt gases*

fig 4.18

there is no doubt that such an illustration will enhance a student’s grasp of the operation of a four-stroke engine if it accompanies a verbal description of the process. No research is needed to make the point, as some illustrations will inevitably assist learning.

Levie and Lentz (1982) summarised the results of a number of experiments comparing learning from illustrated text with learning from text alone. The results of 46 comparisons of learning illustrated text information from passages with and without pictures reveal an overwhelming advantage for the inclusion of pictures. For 85% of the comparisons there was a statistically significant advantage for the illustrated text condition; and in no case was the text-alone condition better. They concluded:

“That illustrations can facilitate learning from text is clear. *How* they do it is not so clear”. (p 224)



4.5.2 The functions of illustrations in text

Schallert (1980), although unable to describe as definitively as Levin and Lesgold (1978) the ground rules that circumscribe the positive effects of illustration in text, does indicate that she can

“report that where pictures have been shown to be helpful, they have seemed to be related to the text in specific ways. A reasonable hypothesis is that pictures are likely to help readers learn from written material if they represent spatial information or information that is important to the total message.”

(p 519)

She notes, also, that there may be differences in the effectiveness of illustrations between situations in which the information to be derived from a picture is explicitly repeated by the text and citations in which the text provides merely the framework for certain information left to be derived from appropriate illustrations.

The emphasis on function is worth noting. As Duchastel (1980) indicates,

“the important consideration is that it is the type of illustration and its relationship with the verbal component of the text which will make it useful or not.”

(p 59)

Levin (1981), recognising that a variety of functions can be served by prose pictures, suggested eight, arranged in their likely increasing order of prose-learning benefits, based on an improved recall of explicitly stated text information (fig 4.19).

Proposed Functions of Prose Pictures

Function	General operating principle	Anticipated contribution to improved prose learning
1. Decoration	Pictures increase a text's attractiveness	Not applicable
2. Remuneration	Pictures increase publishers' sales	Not applicable
3. Motivation	Pictures increase children's interest in the text	Little or none
4. Reiteration	Pictures provide additional exposures of the text	Little
5. Representation	Pictures make the text information more concrete	Moderate
6. Organization	Pictures make the text information more integrated	Moderate to substantial
7. Interpretation	Pictures make the text information more comprehensible	Moderate to substantial
8. Transformation	Pictures make the text information more memorable	Substantial

fig 4.19

(p 212)



The *decoration* function relates only to the enhancement of a text's attractiveness and has no bearing on enhanced prose recall. The *remuneration* function is the commercial by-product of the decoration function, but is not related to the recall of text information. Some people believe that illustrations serve to increase interest in a text, but the empirical evidence in support of a *motivational* function is, according to Levin (1981), not conclusive and there is evidence from Pressley et al (1983) which seriously challenges the motivational account of picture effects on prose recall. Illustrations which simply repeat the information presented in text would be performing a *reiteration* function. The *representation* function assumes that prose content presented in a format or mode that is different from that of the original will aid learning, as in the case of text relevant illustrations and images which can take information that was presented in one mode (verbal) and represent it in another (pictorial). The assumption underlying the *organization* function is that well-organised text information will be better recalled than loosely organised or fragmented text information, and the amount of facilitation anticipated from this function is likely to be intimately connected to specific text and learner characteristics. With regard to the *interpretation* function, it is argued by Levin (1981) that a greater amount of facilitation would be expected when relatively abstract or difficult to comprehend information is made more understandable and, in general, an interpretation function would reflect content clarifications that are directed toward enhancing the student's understanding of that content. If the interpretation function is associated with prose materials that are difficult to comprehend, the *transformation* function is reserved for prose passages whose constituents may not be that difficult to comprehend, but that contain information that is difficult to remember, such as in medical and scientific texts where easily identified concepts, principles and functions have to be associated with unfamiliar technical terminology. Maximum prose-learning facilitation is, according to Levin (1981), believed to occur when the transformation function, rather than just the representation function is operative.

Earlier discussion in this section considered classification of illustration based on their physical attributes. However, as Duchastel (1978) has pointed out, that kind of consideration of illustrations is generally oriented to the morphological characteristics of illustrations rather than to their functional



properties. Taxonomies have been produced (Fleming, 1967; Twyman, 1979; Ashwin, 1979; Goldsmith, 1980), but they have a morphological basis. As Duchastel and Waller (1979) argue, “instead of a taxonomy of illustrations, what is needed is a grammar of illustrations” (p 21), which they interpret as being a set of principles which relates illustrations to the potential effects they may have on the reader or learner. This approach has considerable implication for the present study and will be discussed at some length.

The functional framework which Duchastel (1978) proposed involved three roles of illustration in instructional text. These are the attentional, explicative, and retentional roles, the first two of which he recognised as being fairly intuitive and commonly found in instructional texts, while the third one was less intuitive and, at that time, more speculative. Illustrations fulfilling an *attentional* role are meant to motivate the reader, make the text interesting enough to pick up, and more interesting to read. In the *explicative* role of illustrations, the illustrations take on a direct didactic role, explaining a given aspect of the topic or adding something which is not clearly expressible in words. The basis of the *retentional* role of illustrations is that iconic or pictorial memory is more resistant to forgetting than is verbal memory (Paivio, 1975b) thus permitting the important points in an instructional text to be more easily retrievable during later recall simply by illustrating them in the text.

Recognising that there is, on the whole, greater use made of explicative illustrations in instructional texts, and that explicative illustrations teach directly, explaining and clarifying, whereas attentional and retentional illustrations assist the learning process in a more general way, Duchastel and Waller (1979) attempted to break down the explicative function into its sub-roles and identified, initially, seven functions which it can fulfill. Using Open University instructional texts for analysis, the seven functions of explicative illustrations identified were as follows:

1. *Descriptive* — to show what an object looks like.  
The picture of an object, in the form of either a photograph or a drawing may give a holistic impression of it which is difficult to achieve in words.



2. *Expressive* — to make an impact on the reader beyond simple description. Pictures of war or famine victims may add to the credibility of a purely verbal message.
3. *Constructional* — to explain how various component parts of an object or mechanism fit together, possibly as an aid to an assembly or maintenance task.
4. *Functional* — to eliminate complexity in presentation by enabling the learner to visually follow through the unfolding of a process or the organisation of a system.
5. *Logico-mathematical* — to display mathematical or scientific concepts through graphs or diagrams.
6. *Algorithmic* — to show certain possibilities by providing a holistic picture of the range of possibilities for a course of action.
7. *Data-display* — to allow quick visual comparison and easy access to data.

Duchastel and Waller (1979) point out that the seven explicative functions must not be considered as mutually exclusive of one another, and that a given illustration could fulfill two or three of these functions if designed with that in mind.

In a later development of his proposals, Duchastel (1981) elaborated on the retentional role of illustrations by referring to the fact that any topic or domain of discourse has an internal structure which can be exploited in visual terms for the purpose of recall and that retentional illustrations can thus serve as memory retrieval cues after a text has been read and the student is trying to recall the major ideas which had been presented in the text.

In an attempt to reconcile his own proposals with those of Levin (1981), Duchastel (1981) dismisses three of Levin's functions — the decoration function, the remuneration function, and the reiteration function — as the first two are of no use to the educator or the learning theorist, and the third simply embodies the idea that repetition is helpful, but does not explain much. Taking the remaining five of Levin's functions, he then matched them with his own (fig 4.19), judging that the motivational function is



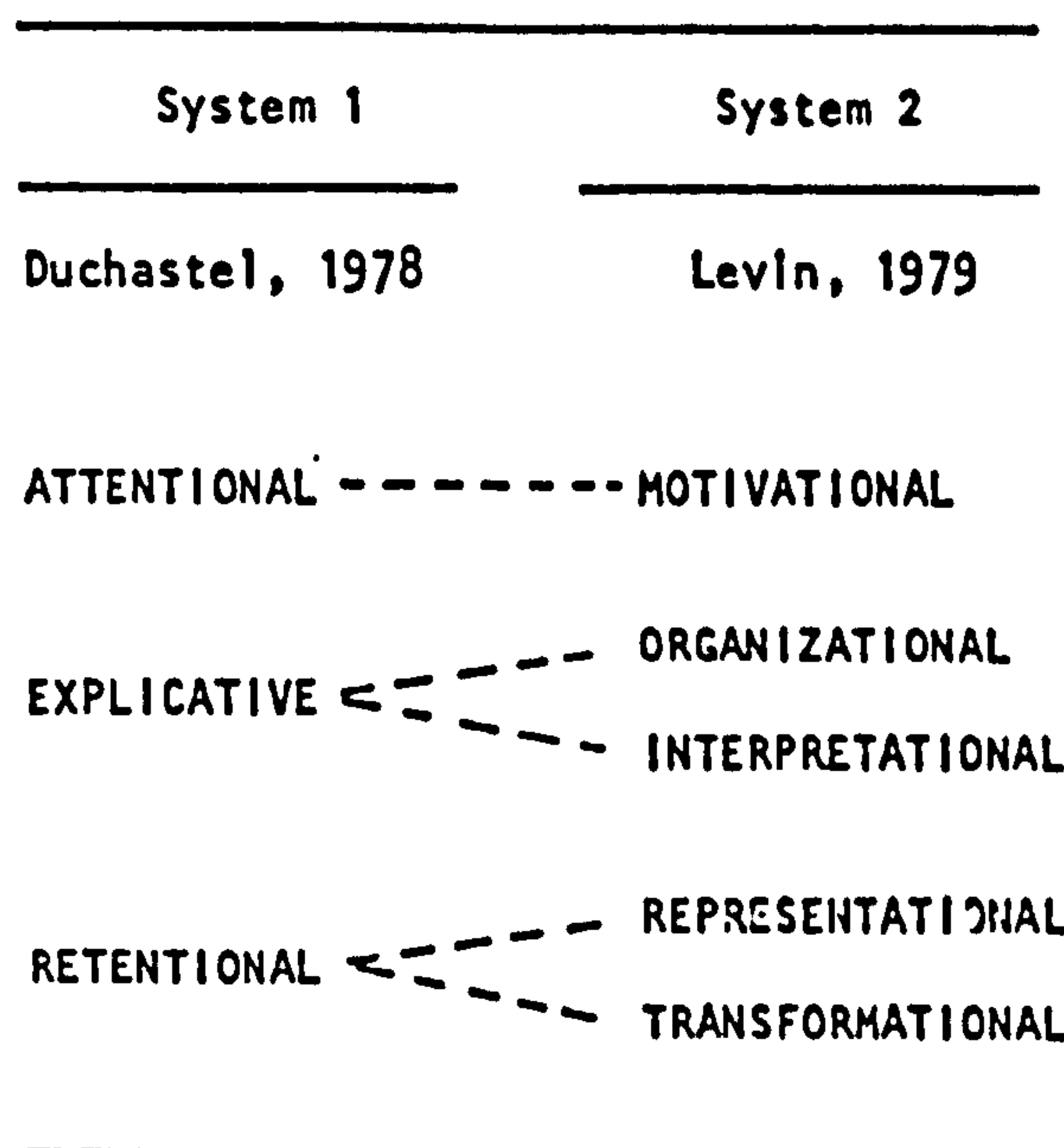


fig 4.20 FUNCTIONS OF ILLUSTRATIONS  
IN TEXT

identical to the attentional one, being simply different labels for the same process of increasing the reader's interest in the text; the organisational and interpretational functions are two facets of a more general explicative function; and that the representational and transformational functions are related to retention rather than comprehension.

The main point of the functional perspective, as Duchastel (1980) notes, is that illustrations have particular ways of affecting a learner's cognitive processes, with the actual effect expected dependent on how the illustrations designed for a text relate to the verbal components of the text. Levie and Lentz (1982) take the issue beyond cognitive effects and identify four functional areas as noted in fig 4.21.

Two kinds of *attentional* functions were identified in that pictures might attract attention to print materials and then direct attention within the materials. There is certainly evidence to support these ideas. For example, Vernon (1954) was of the view that it is useless to expect younger children to study books without pictures, and Bryant et al (1980) found that college students would be much more likely to purchase a psychology text if it contained illustrations. There is evidence that illustrations do direct attention within the material in that Paradowski (1967), in a situation approximating to free reading of a textbook, found that subjects through curiosity-arousing pictures appeared to direct attention selectively to certain portions



Possible Functions of Text Illustrations

<i>Functions</i>	
Attentional	1. Attracting attention to the material
	2. Directing attention within the material
Affective	3. Enhancing enjoyment
	4. Affecting emotions and attitudes
Cognitive	5. Facilitating learning text content via
	a. improving comprehension
	b. improving retention
Compensatory	6. Providing additional information
	7. Accommodating poor readers

fig 4.21

of the text; Baxter, Quarles, and Kodak (1978) found that adults ‘looking over’ a newspaper remembered more content ‘from an article adjacent to a large photograph; and Tennyson’s (1978) study of learning concepts from text passages suggests that illustrations can help focus attention on the critical aspects of concepts. Levie and Lentz (1982) caution, however, that, although the learning of illustrated portions of text is improved by pictures, this improvement is likely to be due more to cognitive functions than to attentional functions, as there is little reason to believe that pictures have an important attention-directing effect.

Two kinds of *affective* functions were also identified — in relation to enjoyment and the affecting of emotions and attitudes. From experiments with children (Samuels, Biesbrock, and Terry, 1974) through high-school students (Holliday, Brunner, and Donais, 1977) to college students (Rigney & Lutz, 1976; Sewell & Moore, 1980; and Bryant et al, 1980) it is very evident that readers find illustrated texts more enjoyable than non-illustrated texts. As Levie and Lentz (1982) point out, controlled experimentation is not required to demonstrate that pictures can have an emotional impact, although it has already been noted that Vernon (1953) observed that pictures produced, in several cases, “a considerable emotional impact such as might affect the attitudes of the subjects to the social problems described in the text” (p 187). There is also evidence that illustrations can alter attitudes



and beliefs in social concern areas such as health education (Leather, 1979; Leather & Hastings, 1980).

Levie and Lentz (1982) argue that, with respect to *cognitive* functions, pictures can function to facilitate learning information in the text by improving the comprehension of this information. From work done by Bransford and Johnson (1972) there is evidence that students who saw a "context picture" recalled more than twice as many ideas from the passage as those who did not see the context picture, and this was attributed to the picture helping readers organise information in the text, functioning primarily as an aid to comprehension during learning rather than as a retrieval cue during recall. As Bransford (1979) indicates:

"the written passage was not simply a description of the appropriate context picture . . . . the picture provided a basis for allowing people to interpret meaningfully and to connect or organize sentences they heard." (p 132)

However, Bernard, Peterson, and Ally (1981), in investigating the function of a "contextual image" found that it was no better than the control condition (no organiser) as far as immediate recall was concerned (this may have been due to the rather short 800 word passage, thus allowing normal memory strategies such as rote memorisation to operate), but that on the delayed post-test, the image organiser continued at a high level while the control fell off by 30%, and Bernard et al attributed this to the organising elements inherent in the image allowing for a more stable incorporation of concepts and passage details into memory. A second aspect of improving comprehension — the possibility that illustrations might lead readers to increase their depth of semantic analysis — finds support from Bock (1978) and Bock and Milz (1977) who devised a situation in which the addition of pictures affected the depth to which accompanying sentences were processed. Pepper (1981) found that the clarity of textual materials is greatly enhanced by the frequent use of examples, and it is not unreasonable to expect that pictorial exemplars could provide a similar effect.

With respect to the cognitive function of facilitating learning of text content through improving retention, Levie and Lentz (1982) suggest that one way



of determining if illustrations aid in the retention of text information is to compare score on immediate and delayed recall texts of learning from illustrated text versus text alone. Certainly, a number of the studies already cited (e.g. Peeck, 1974; Haring & Fry, 1974; Joseph, 1979; Bernard et al, 1981) and others such as Pressley et al (1983) and Whitaker and Sullivan (1980) support the increase retention hypothesis. In fact, of 24 comparisons of immediate and delayed recall examined by Levie and Lentz (1982), 19 showed that pictures helped more in delayed than in immediate recall. The 'levels-of-processing' approach of Craik and Lockhart (1972) referred to in the previous chapter could explain this effect in that it claims that repetition will aid recall only if the second presentation induces the learner to process the material at a different semantic or sensory level, and Levie and Lentz (1982) suggest that the addition of text-redundant illustrations may foster processing of the text content at a different level. Also, the dual code theory (Paivio, 1971) may well be relevant, and it has to be noted that Paivio and Csapo (1969) found that presenting a concept in both verbal and pictorial forms was superior to presenting it twice pictorially or twice verbally.

The final cognitive function of illustrations in text identified by Levie and Lentz (1982) was the provision of additional information. In the next chapter consideration will be given to pictures as 'adjuncts' in text, but it has to be recognised that pictures can be the primary vehicle for some types of information. Jahoda et al (1976) noted that although pictures facilitated the learning of illustrated text information, in a test of learning from picture-only information, little was learned of information presented in pictures but not also in text. Nevertheless, there is abundant evidence of the effectiveness of 'pictures only' presentations — what might be regarded as 'illustrations without text' — and this will be examined in the next section.

In concluding their review of the research in relation to the effects of text illustrations, Levie and Lentz (1982) were able to offer a number of guidelines for practice:

1. In normal instructional situations, the addition of pictorial embellishments will not enhance the learning of information in a text.
2. When illustrations provide text-redundant information, learning information in the text that is also shown in pictures will be facilitated.



3. The presence of text-redundant illustrations will neither help nor hinder the learning of information in the text that is not illustrated.
4. Illustrations can help learners understand what they read, can help learners remember what they read, and can perform a variety of other instructional functions.
5. Illustrations can sometimes be used as effective/efficient substitutes for words or as providers of extralinguistic information.
6. Learners may fail to make effective use of complex illustrations unless they are prompted to do so.
7. Illustrations usually enhance learner enjoyment, and they can be used to evoke affective reactions.
8. Illustrations may be somewhat more helpful to poor readers than to good readers.
9. Learner-generated imaginal adjuncts are generally less helpful than provided illustrations.

Discussing the format and layout of textbooks, Wilson, Pfister, and Fleury (1981) state:

“Generally, there are no well-determined rules to follow in textbook design or evaluation . . . . The empirical evidence is often contradictory. It frequently suggests guidelines and rarely offers established rules.”

(p 31)

Certainly, that seems to be the case with regard to illustrations in text, as already noted. Brody (1982), after discussing a number of issues in relation to illustrations in text, recognises that a clear conception of which pictorial elements, either alone or in combination, affect learning from instructional textbooks is missing and that, for the most part, information concerning these elements must be pieced together from disparate studies which are only tangentially concerned with the picture-text relationship. He concludes, nevertheless, by offering *suggestions* for increasing the instructional effectiveness of pictures placed in instructional textbooks.

1. Pictures should be referred to in the written narrative.
2. Captions can help students understand the relevance of the pictures.



3. Photographs and realistic detailed drawings are usually preferred to simpler formats such as line drawings. However, preference is not always related to students achievement.
4. Within limits, students will spend more time examining complex images.
5. Pictures containing dynamic images are generally more interesting than those which contain static images.
6. Placement of pictures should be based on the function the picture is to serve. (p 315)

An interesting approach to the text-illustration relationship is suggested by Stone and Crandell (1982). Having shown previously (Stone & Glock, 1981) that, in the reading of procedural information, the use of illustrations with text was found to produce significantly more accurate performance of the task, they carried out further work on procedures, integrating propositional analysis (Frederiksen, 1975) with eye-movement records to try to specify what information had been extracted from the visual and verbal sources, the sequence in which it was extracted (i.e. how readers combined information presented in text and pictures) and, perhaps, specific factors that cause the reader to refer from text to picture or vice versa.

It appears that subjects typically spend the first second or two (on each picture-text display) viewing the illustration and they then proceed to read the text. At various points in the text readers refer back to the illustration, and the average reader who viewed text with illustrations referred to the illustration 36 times during the reading session, with the mean duration of each of these glances being 1.84 seconds. The eye-movement data of Stone and Crandell (1982) is consistent with that of Loftus and Bell (1975) who observed that readers viewing an illustration spend the first few fixations extracting "gist" information. Stone and Crandell (1982) argue:

"Readers appear to be systematically comparing the semantic content of the pictures and text as demonstrated by their frequent looking from one to the other. It would be very useful to know exactly in what manner subjects selected and extracted information from each mode of presentation and how they combined such



information. To the extent that precise eye-movement information reflects cognitive events, such data should be helpful in this regard.” (p 301)

Fleming (1983b) examined the eye-movements of learners studying print materials combining text and illustrations, recognising that eye-movement patterns were useful indicators of the cognitive strategies employed (Gould, 1973; Hochberg & Brooks, 1978; Nesbit, 1981). Strategies were, therefore, inferred from the differential deviation of attention to word and picture areas. He was interested in determining the effect of picture before words or picture after words with regard to the provision of context, but the results did not indicate any superiority for either, but students did make more transitions between picture and text when complex materials were studied.

It is clear from this review that pictures can facilitate comprehension but that the way in which they do so is less clear. In the discussion of this chapter the relationship between illustrations as facilitators of learning and cognitive processes will be returned to in an effort to try to go beyond ‘guidelines’ to more general principles for the design of instructional materials.

#### **4.5.4 Illustrations without text**

Booher (1975) recognised that there is a particular kind of problem concerning the requirement of instructional text in relation to operating procedures, and noted that:

‘Writers of technical manuals, designers of programmed instructions, and designers of equipment are continually faced with the problem of selecting among pictorial, schematic, and printed formats to communicate information, with little or no knowledge of the format’s effect on the understanding or comprehension of the information presented. (p 266)

He found that the use of pictures as the primary channel and printed words as a secondary aiding channel to clarify the pictures resulted in performance of the procedure in minimum time and with minimum errors. Braby et al (1982) developed printed learning aids which contained a preponderance of



graphics with supporting text, and their results showed that these learning aids reduced errors and produced quicker learning compared with narrative manuals commonly used to teach procedures.

However, it is possible to reach a stage where the words are eliminated completely and the entire message is communicated pictorially. Hodgkinson and Hughes (1982) report an interesting case where IBM developed wordless instructions for the setup instructions for the IBM Selectric II typewriter. As a result of government controls in Europe, customers had to be able to set up the equipment without the aid of an IBM engineer, and these customers did not all speak the same language. The final ‘all-graphics’ instructions (fig 4.22) were used successfully for that particular product and are now in



Fig 4.22 Final version of the CSU instructions (p 79)



use for the Selectric III typewriter. Hodgkinson and Hughes (1982) offer recommendations including, *inter alia*, the following:

- (a) Drawings have many advantages over photographs. For example, they are easier to update and are not dependent on the variables of colour photography. Important items can be easily emphasised and restricted colour used to greater effect.
- (b) Begin the sequence of pictures with an "attention getter" showing the unpacker at the correct starting point for the procedure.
- (c) The correct amount of information is important. Show only the details necessary to convey the message in each drawing. Do not include every nut, bolt, label, etc; only include such items if they are relevant to that picture — too much information can be as confusing as not enough.
- (d) It is important that each picture depicts only one task in the unpacking sequence. This keeps the pictures from appearing more complicated than the unpacking actually is. If a task is repeated several times in succession, however, it is permissible to indicate all repetitions in one picture.
- (e) Show the procedure as the unpacker will see it and use the same view for sequential drawings whenever possible.

Unfortunately Hodgkinson and Hughes (1982) do not make these recommendations on any research basis; rather it has been a process of trial and error. Nevertheless, the *post hoc* rationalisation within a research oriented framework would not be particularly difficult.

However, there have been many investigations into the use of 'pictures only' for procedures and for other communication purposes, all of which have been based on research findings and most of which have developed, to a greater or lesser extent, from the Isotype concept of Otto Neurath. Hogben (1949) argued that:

"Easy recognition of the build-up of a circuit, like easy recognition of the make-up of a flower, is possible only when we strip the pictorial components of every feature irrelevant to immediate identification; and in so doing we



are retracing the steps by which picture-writing becomes sign-making with a grammar of its own.” (p 183)

He acknowledged that the need for such a grammar was evident by the end of the 19th century and that, early in the 20th century, an international picture language was evolving, a language that came to fruition through the work of Otto Neurath. The concept of Isotype and its historical development has been described by Neurath’s wife (Neurath, 1974), and it is clear

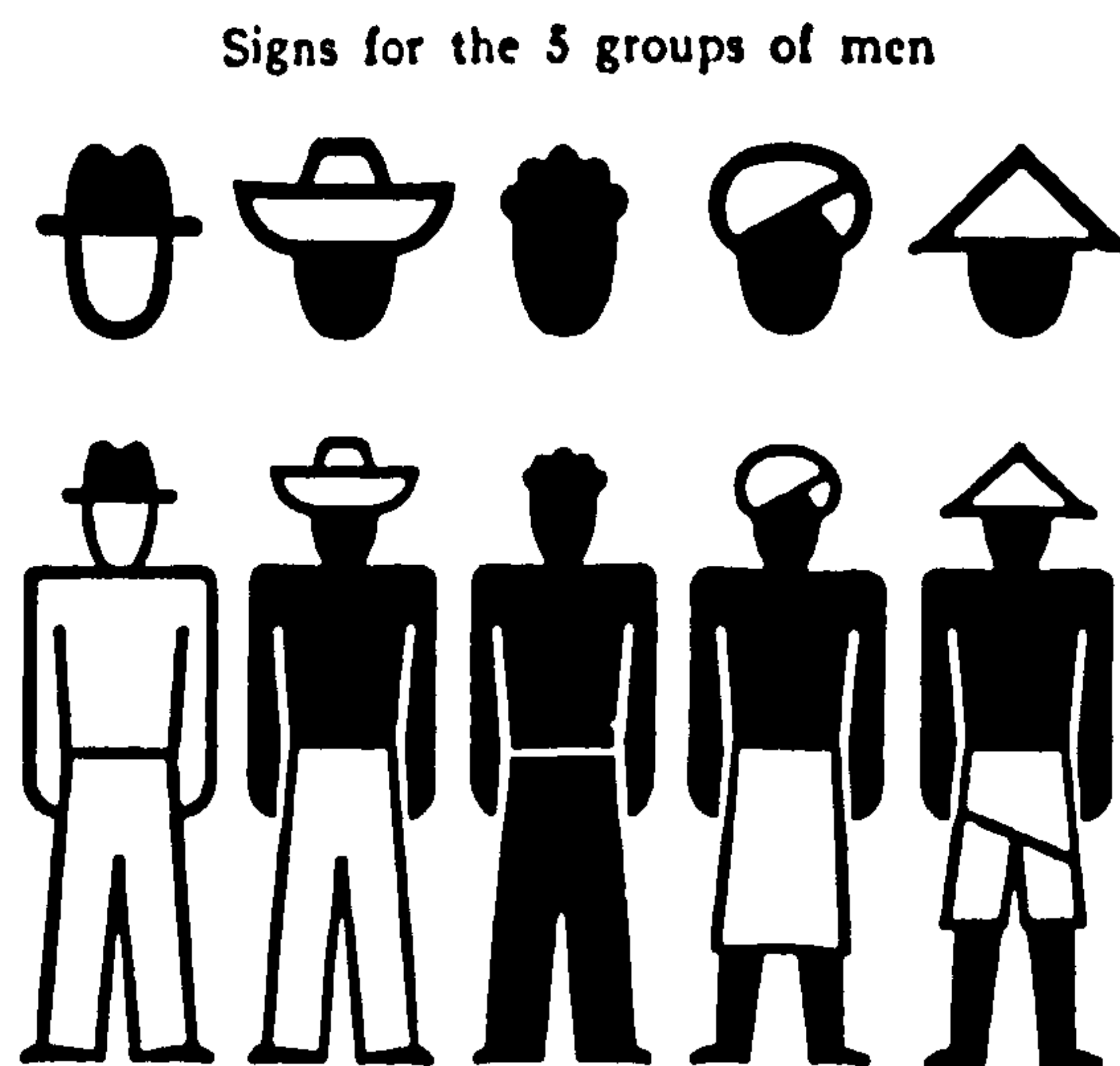


fig 4.23 Variations on the basic man symbol (from *International Picture Language*).

from this description that Isotype was developed for the presentation of social statistics to the general public and is the main alternative to bar charts for this purpose. As Macdonald-Ross (1977a) points out, the main principles of the Isotype system are:

1. The subject matter is represented by standard iconic signs.
2. Each sign stands for a given quantity or percent.
3. To show larger quantities, use more signs (*not* larger signs).
4. Arrange the signs to make a “visual argument.”

(p 65)

Otto Neurath considered “visual argument” as being of particular importance. He assumed that communication was for a purpose, that statistics had to be organised to communicate a message. As Neurath (1974) notes, he had hoped to be able to produce, eventually, a “visual thesaurus”. He saw the designer of visual symbols as the “transformer”, responsible for making the information understandable, linking it with general knowledge. Macdonald-



Ross and Waller (1976) consider the term 'transformer' particularly apt for those involved in ensuring effective communication , and they welcome the recognition of Neurath's pioneering work, albeit half a century after it was first carried out. Despite the intention of the Neuraths in developing an international picture language (fig 4.23), they gradually recognised that their symbolism was often international for western men only.

Cahill (1975), concerned about the "language-free" modes of communication and the need for graphic symbols or pictograms to convey information regarding machines and their use, tested the interpretability of some of the symbols being used on farm vehicles and industrial machinery (fig 4.24). Symbols were presented both in context and in isolation to persons who

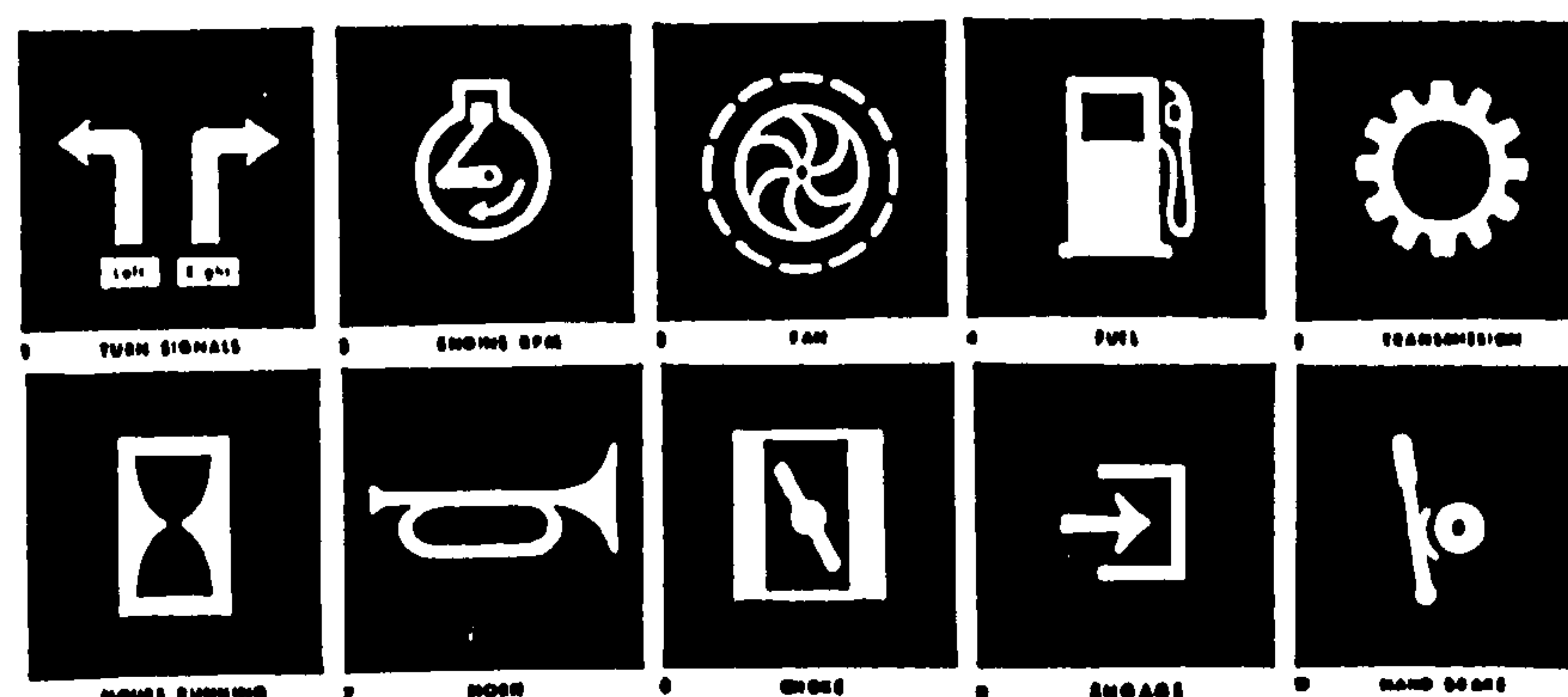


fig 4.24 .Graphic symbols presented for interpretation.

differed in the extent of their experience with such equipment , and it was hypothesised that the symbols, as a set, would be more often correctly identified in context and by those subjects with relevant prior experiences. She concluded that the results of the investigations indicate that claims for the power, immediacy, and universality of symbols cannot be sustained, that a good symbol is not able to convey its message unequivocally, regardless of context, to a wide range of persons, irrespective of cultural background or specific experience, and that

"rational analysis and good graphic design practice alone cannot guarantee a symbol which is optimal for the human user. Only the user himself, in actual practice, can complete the loop, and establish the suitability and interpretability of the design."

(p 380)



Leonard (1979), in reporting the development of printed materials on family planning for people who do not read, notes that, in field-testing of the materials, “a candle was found to be a universally recognizable indication of night”, but Stewart (1979) notes that while such a symbol may have been ‘universally’ recognisable within the Latin American countries where it had been tried out, it certainly was not recognised in Scotland and attempts had been made to convey the same message (family planning) with different symbols as appropriate for an Arabic culture, a Western culture, and a ‘universal’ or culture-free population, although only limited success had been achieved.

The level of literacy can be a problem, particularly in the medical field and in relation to prescriptions. Bratt (1978) attempted to design a prescription label conveying its information by clear diagrams and minimal clear text so as to be understood by the widest range of people, a system which he called ‘Vernacular Graphics’, in contrast to the highly stylised conventional style developed by the International Organization for Standardization which can be extremely abstract. He noted considerable success with the

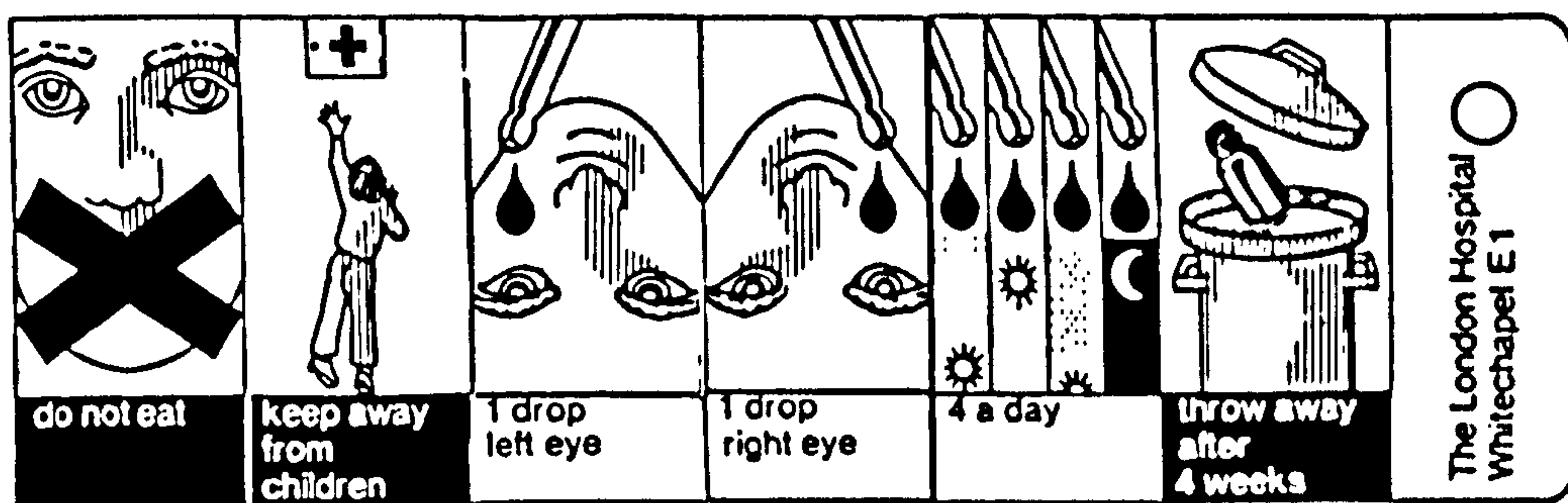


fig 4.25

labels (fig 4.25), but observed that “throw away after four weeks” was poorly understood. He counsels that labels designed in the developed countries will not necessarily be interpreted correctly in other cultures.

Marcel and Barnard (1979) examined pictorial means of communicating instructions for the use of equipment, which they considered as being different from the development of discrete symbols in that instructions require representation of states, actions, and conditional relations comparable to those represented in verbal language. They therefore adopted an approach which concentrated on analogues of linguistic factors and pictorial aspects of sequence and context. They concluded that the effects of graphic



variables and the error patterns implicated cognitive structures underlying comprehension of pictorial instructions (especially relations between actions and states) and that, amongst other comparisons with verbal language, the inferential nature of interpretation was emphasised. They further concluded that the effect of graphic variables can only be understood in the context of users' strategies and their preconceptions about the task.

No matter which aspect of illustration has been considered, there has always been a recurring theme of cognitive process, prior knowledge, and perception of the task at hand. It is clear, therefore, that the contribution of typographical factors, pictorial factors, and textual factors needs to be considered in a wider context, the context of textual structure and layout, and this is done in chapter 5.



## **4 Principles and practice in visual illustration**

### **– a discussion of the issues in chapter 4**

#### **4.1 Introduction**

Hochberg (1962) observed that

“as we learn more about perception and learning, we must revise our interpretation of how pictorial communication takes place. Reciprocally, what we have learned about pictorial communication has altered some of our conceptions about the underlying sensory structures and perceptual processes.”

(p 22)

The statement is as true today as it was then. The research reviewed in chapter 3 and in chapter 4 has contributed more to an understanding of learning than of perception, but the cognitive approach has made possible a reinterpretation of perception. The purpose of this discussion is to clarify the theoretical framework for visual perception and visual information processing, to analyse the reviewed research in the context of that theoretical framework and that of chapter 3, and to derive principles for the use of visual illustration in text as a contribution to comprehension.

#### **4.2 The nature of visual perception and visual information processing**

In his introduction to a collection of papers on perception theory and education, Norberg (1962) comments on the need for educators to understand the nature of perception as related to communication and learning and, in particular, to understand the importance of the psychology of visual perception because it is the conceptual key to instructional materials technique. Part of the problem for the educator is in disentangling the various theories of visual perception and visual information processing. It is clear from the review in this chapter that each of the approaches is correct in



one or more aspects. It is equally clear that they are not all equally correct. The attempt by Palmer (1982) in trying to present a theory which incorporates features of the competing approaches is commendable, but there probably is not a need for a composite theory. Perhaps it can suffice, as in so many other areas of scientific enquiry, to recognise that none of the theories is sufficient and to draw, therefore, from each as appropriate.

Arnheim (1962) comments that

"We have no right . . . to rely on the student's  
expectation or knowledge. The picture itself  
must steer perception". (p 19)

But perception must be an interactive process. The Gestalt approach which Arnheim upholds depends for its generalisations on widespread evidence of interaction between the perceiver and the perceived. Just as reading comprehension is an interactive process, so also is perception and the long term memory established through perception. There is an overall organisational impact of visual material and the Gestaltist approach is, thus, of considerable value. So, too, is the Gibsonian view of direct perception. The immediate direct perception concept cannot be ignored since it could be so closely related to motivation. The more recent formulations of perception theories such as those of Neisser (1976), Hagen (1980), Leeuwenberg (1978), and Palmer (1982) are also very helpful, particularly as they attempt to coordinate and incorporate main features of the earlier approaches and, in doing so, highlight the essential characteristics of these earlier theories.

For the purposes of the discussion later in this section, and, in particular, the discussion in relation to cognitive processes examined in chapter 3, no single theory will be adopted and essential features from each will be accepted as appropriate. However, from the various theories of perception and visual information processing reviewed, the following general principle is derived.

---

"If information is visually organised and  
contextually congruent, the perceptual  
processes of the viewer will accommodate  
it to maximise cognition".

---



### **4.3 The nature of perception with respect to visual illustrations and pictures**

The classifications of images by Arnheim (1969), Wileman (1980), and Doblin (1980), although variously detailed, have important implication for the use of illustration in learning, particularly since, as is discussed later in this section, educators have built theories of visualisation on the abstract/realism continuum. The classifications are important also because of the implication of a dimension of complexity in addition to the realism/abstraction dimension. The need for the individual to process complex visual information highlights the relationship to general comprehension processes reviewed earlier.

The evidence from eye-movement research of the inherently selective nature of perception and, thus, selective processing with respect to complex visual material is worthy of note. The influence on selectivity of purpose and prior knowledge is even more worthy of note. These two aspects of perception can readily be considered within the cognitive processing framework discussed in chapter 3 and, within that context, it can be argued that the interactive nature of perception will be influenced by the visual design of the material and by the available schemata and prior knowledge of the viewer. Thus, interaction can be enhanced if the overall Gestalt of the visual material can activate the viewer's relevant schemata, a possibility which is of considerable importance for the use of visuals in instruction.

The further evidence from eye-movement research which suggests a macro-level perception followed by a micro-level perusal of detail and the conclusion from this that complex visual processing occurs in a global-to-local fashion (Printzmetal & Banks, 1977; Navon, 1977; Antes & Penland, 1981; Biederman, 1981) is also of considerable significance. Frequently, research suggests an either/or choice as in the case of top-down or bottom-up processing yet, as was observed in Rumelhart's (1980) view of the reading process, both forms of processing are normally involved. The idea of Kinchla and Wolfe (1979) in bringing together the notions of global/local and top-down/bottom-up is, therefore, helpful. What is important for the design of instructional text is the idea that there is an interaction between the visual and the viewer and that there are, therefore, visual-based and viewer-based



variables. The viewer-based variables parallel those identified in chapter 3: the visual-based variables are to be found in the degree of organisation and in the classifications of visuals to which reference has already been made. Thus, although Spoehr and Lehmkuhle (1982) have concluded that three main aspects of a visual, viz. the theme or overall topic, the nature of the visual information, and the spatial organisation of the objects and parts of the visual, determine how processing will proceed, it is necessary to expand upon that by highlighting the role of the viewer and, in particular, his/her purpose, prior knowledge, and available schemata.

The findings of Pazdek (1978) and Kolars (1977) which suggest that pictures can be integrated into thematic wholes in the same way as linguistic material is integrated, and that viewers process pictures for theme and gist without remembering exact visual details are particularly important. They suggest not only a similarity between visual and verbal processing, but a visual dimension of verbal presentation (c.f. the concept of text as diagram) where perception of the page of print could contribute to the over all 'gist' of the textual and visual material.

From the above discussion of the processing of complex visual materials, the following general principle is derived.

---

"If visuals are designed to convey a finite number of idea units, the viewer's perceptual processes, influenced by the design of the visual and the available schemata of the viewer, will extract the gist and, subsequently, the detail of the visual information".

---

#### **4.4 The general issue of visuals in learning**

Arnheim's (1969) comments regarding visual perception being concerned with the grouping of generalities and laying the ground work of concept formation is not only consistent with his view of visual perception and



visual information processing, but is consistent with the issues discussed above. Perhaps it is in the very ease with which visual stimuli can be processed and remembered through interaction with past experience that the danger in their use lies. The basic misunderstanding of the use of visuals in learning lies in a belief that the message is in the visual. The message is not in the visual alone: the message is constructed in an interaction between the visual stimuli and the prior knowledge etc. of the viewer such that common interpretation of the visual results only where shared experiences elicit common response. In education, too great an emphasis has been placed on the role of the visual and too little on the internal processing of the viewer as Winn (1982a) and Salomon (1979) have noted. Herein lies the major distinction between verbal and visual communication: while words and phrases can be interpreted in an idiosyncratic way, there is always an external referent such as a dictionary which can provide a degree of commonality, but visuals have no external referent and can be widely misinterpreted. Arnheim's (1969) argument that instructional visuals will be aids to learning only if they meet the requirements of visual thinking, and his plea for visuals to be designed to state relevant propositions perceptually, is extremely important. Unfortunately, there does not appear to be any attempt, even within institutions which train graphic artists, to help the designers of visual material to operate within the kind of framework which Arnheim (1969) advocates.

Visualisation (i.e. in an instructional sense) may facilitate learning. Whether it facilitates the *desired* learning depends to a large extent on the skill with which the visual is designed, a skill which is not related to aesthetics or technique, but which is derived from an understanding of the visual communication process and the message to be communicated.

It is interesting to note from the work of Dwyer (1972, 1978) that the attributes of visuals are almost always described in terms of their functions. This is reminiscent of the work reviewed in chapter 5 in relation to the use of adjunct aids in text. There is a tendency to describe how they are used and for what purpose without ever considering the theoretical framework for such use. Attempts to generalise functions (e.g. Kennedy, 1974) or to generalise design factors (e.g. Fleming, 1967, 1979; Mandler & Johnson, 1976; Kennedy, 1982, Newton, 1984) are helpful, but there is a tendency to become involved in analysis of the wrong issues. For example, the work



of Dwyer (1972, 1978) in relation to the realism/abstraction continuum may have identified instances where either realistic or abstract visuals were more effective but, as Arnheim (1969) has noted, deficient pictures can be found at any level of abstraction and they fail not because they are not lifelike or devoid of detail but because they are ambiguous or misleading.

Winn (1982b) has pointed out that realism theories and cueing theories embody a belief in the naive hypothesis that there is a direct link between media format and learning, rather than being conceived of in terms of the kind of cognitive processes they model. Many of the characteristics attributed to visuals in learning are probably valid, but that is because they happen, fortuitously, to model the relevant cognitive process. Bovy (1981) has argued that there is a need to relate cognitive processing to external stimuli: the discussion of the research reviewed in this section suggests that there is a need to relate the visual stimuli in their various forms to the kind of cognitive processing which they initiate. Perkin's (1980) observation that practical picture making is a matter of recipe rather than principle is, unfortunately, correct. The purpose of this study, however, is to try to identify principles rather than recipes, and from the foregoing discussion, the following principle is derived.

---

"If a visual is designed in accordance with visual perception organisational principles to be an integral part of an identified cognitive process, the activation of that cognitive process is more likely to take place".

---

#### **4.4.1 The issue of diagrams, graphs, and charts**

Diagrams, graphs, and charts are, of course, only specific examples of the use of visuals in learning, and there has been a tendency in investigating their usefulness, to cover areas which have already been reviewed above. Equally, there appears to be the same a-theoretical approach to the use of these particular visuals, but the work of Winn and Holliday (1981, 1982) is of



interest because it attempted not just to identify how learning in general, and cognitive processes in particular, are related to diagrams, but to derive valid general principles from the findings. The principles which they enunciated are, despite their cognitive-research basis, really a compilation of practical advice. Although practical application is the end purpose of this present study, the sort of principle being sought is intended to be much more basic and one from which practical application can, subsequently, be sought. Therefore, rather than reiterate the principles of Winn and Holiday (1981, 1982) as already listed, the cognitive basis for their derivation will be discussed and a more general principle or principles, derived.

The fact that diagrams present information in an abbreviated way and are arranged on the page in ways that express the logical relationships among ideas by means of spatial layout rather than through syntax is of particular interest since, as Winn and Holliday (1981) have observed, "any isomorphism they exhibit with a domain of referents is logically rather than iconically derived" (p 3) and the emphasis is on conceptual structure rather than on realism. The notion of a visual advance organizer is, of course, in the same category, as is the layout of text as a whole (text as diagram). Spatial layout can indicate logical relationships and in the cognitive processing of such material, imagery will be involved and will contribute both to encoding and retrieval. There will be a necessity, however, to ensure isomorphism between the spatial arrangement of the diagram and the logical relationships of the concepts concerned. The ability of diagrams to provide structural organisation for conceptual domains is probably their most important attribute, and from this can be derived the following principle.

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"If a diagram represents spatially the logical organisation of concepts, their comprehension will be facilitated".

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## **4.5 The issue of visuals in text**

Although diagrams were referred to in the previous section, it has to be acknowledged that their most frequent or common use is within text, and



the work of Winn and Holliday (1981,1982) is of considerable value in this context. Winn and Holliday (1981) have drawn attention to the fact that diagrams relate to the text within which they occur or are embedded as a result of which there is a certain amount of redundancy between the diagram and the text which should improve learning. As an integral part of the text, the diagram is, in effect, indicating which concepts are highlighted and is achieving the same function as verbal cues in drawing attention to the 'height' of ideas in text ( c.f. Meyer 1975). Therefore, when considered as an integral part of text, i.e. as an essential element in the design, a diagram can direct attention, a function which can be shared with other verbal and non-verbal devices as is noted in chapter 5.

With respect to the research reviewed in relation to visuals in text, the key point to be discussed is that identified by Brody (1981), namely, *how* do visuals assist learning from text, even although, as Levie and Lentz (1982) have noted, the *how* is not quite as clear as the fact that illustrations *can* facilitate learning from text.

The review of the research to identify the *functions* of illustration in text is an important first step in explaining *how* illustrations facilitate learning, but the danger lies in merely explaining the *how* in terms of functional achievement without identifying the underlying theoretical framework from which principles can be derived. The attempt by Levin (1981) to classify illustrations by function is quite helpful, particularly as it is firmly based on many of the cognitive principles identified in chapter 3 and is certainly to be preferred over those classifications based on physical attributes. The argument by Duchastel and Waller (1979) which advocates the identification of a set of principles which relates illustrations to the potential effects they may have on the reader or learner is particularly apposite to this study.

Duchastel's (1978, 1981) notion of *attentional*, *explicative*, and *retentional* functions of text appears to be well founded in the cognitive and visual processing systems discussed earlier, and it corresponds fairly well with Levin's (1979, 1981) approach. Levie and Lentz's (1982) work is consistent with that of Duchastel and Levin and is certainly equally well founded in the theoretical frameworks discussed in earlier chapters. Perhaps the separation of functions into attentional, affective, and cognitive categories is artificial,



just as the separation of objectives into psychomotor, affective and cognitive is artificial (Gillis, 1973).

The idea that illustrations attract attention to materials is, intuitively, acceptable, but it would be interesting to test the hypothesis by eye-movement research to ascertain whether illustrations on a page were the initial focus of attention, or by reader introspection techniques to determine what they thought of the 'attraction' role of illustrations. There is a very real sense in which the text as a whole (c.f. text as diagram) can either attract or repel, a feature which is related to congeniality (see chapter 2), and it is very likely that illustrations do play an important role in this respect. The other functional aspects of illustration proposed by Levie and Lentz (1982) can not really be disputed and their theoretical basis has already been extensively discussed in the earlier part of the chapter.

From the above discussion the following principles can be derived.

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"If illustrations are developed as an integral part of the text design they will perform a motivational or attention getting function".

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"If illustrations are designed to support organisational or conceptual aspects of a topic in text, they will facilitate comprehension".

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Reference has been made to illustrations being an 'integral' part of a text, but the use of illustrations in text is often analagous to the use of headings in text, i.e. they are used to break up continuous text and often bear little relationship to what is said in the text. It would appear from the research reviewed that illustrations need to be used for a specific affective or cognitive purpose, and that there needs to be cross-reference between the text and the illustration. The evidence from eye-movement research is certainly



revealing and is indicative of the interactive nature of reading — an interaction which is increased because of the presence of illustrations. The research reviewed in this study has identified the reader-text interaction and the viewer-picture interaction and the various hierarchical frameworks which support each of these. There has been an attempt in the research relating to visuals in text to consider the contribution of visuals to an understanding of text: there has not been an attempt to consider the contribution of text to an understanding of visuals. Presumably those advocates of propositional representation for either verbal or visual materials would propose a processing based on the integrity of text (verbal and visual integration), and dual-code advocates would support a processing which avoided the integrity of text.

In instructional text there should be no question of lack of integrity, in which case there is a relationship between words and pictures which has to be recognised as different from that between words and words. The information in the illustration should not be merely redundant and available to those learners of lower verbal ability. There has to be an interaction between the visual and the verbal, the end result of which is that the reader interacts with the text as a whole and with the verbal and visual separately, in the process of which comprehension is facilitated.

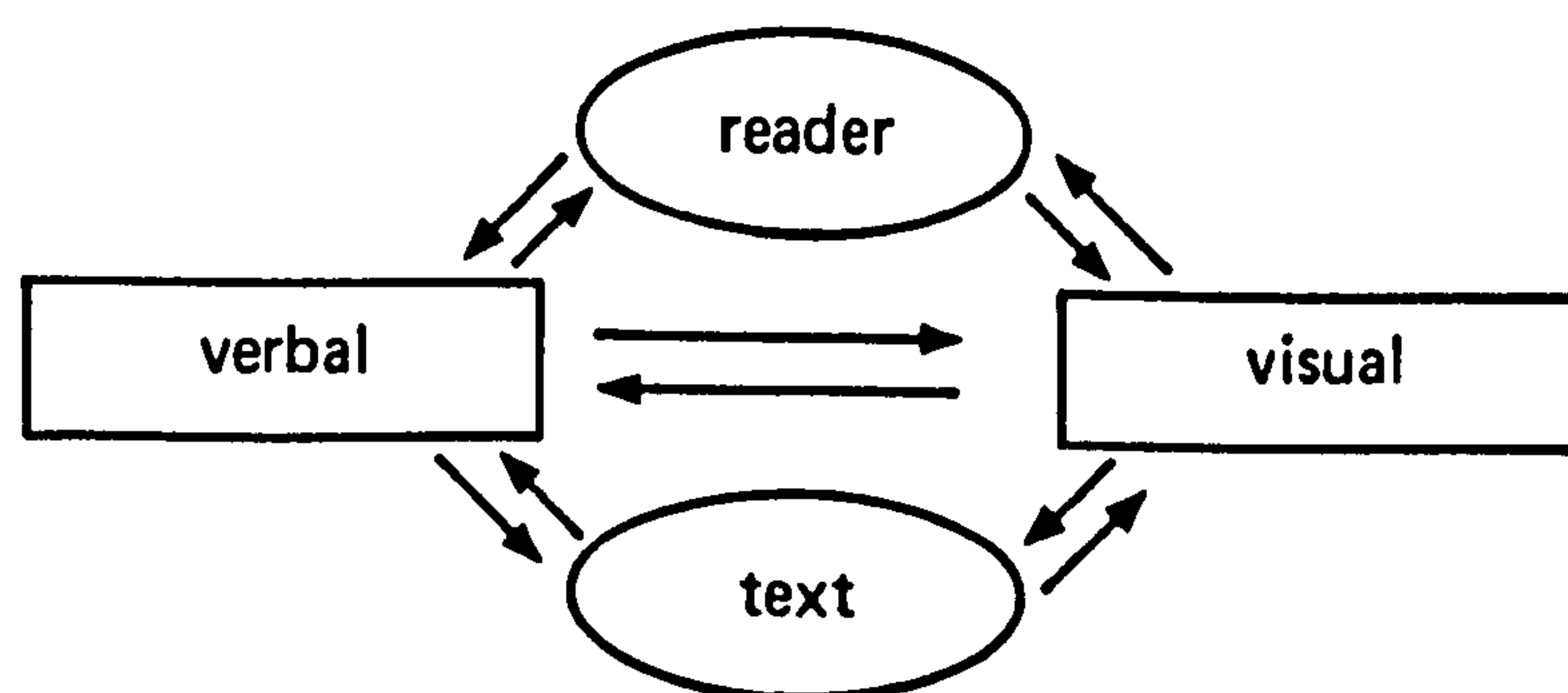


fig 4.26

The reading process has now become a very complicated system, and will be explored further in the conclusion of the study.

In the meantime, the following principle can be derived.

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“If illustrations are developed to support the verbal argument of text the integrity



of the text will be enhanced if the illustrations are appropriately embedded, and alluded to, in the text".

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## 4.6 The issue of illustrations without text

In the previous part of the discussion, the question was raised as to whether the illustration supported the text or was integral with the text. The other possibility is where the text supports the illustration as is frequently the case in procedural manuals, an extreme case of which is the total absence of any text. The brief review here of some of the research in this field is of interest and sheds some light on the presentation of information by purely visual or illustrative means. However, the main thrust of this study has been a concern for the deep processing of information and the construction of meaning rather than the following of directions, and no attempt is made, therefore, to derive a principle from that work.

## 4.7 Conclusion

The analysis of research and its discussion has been carried out first of all in the context of visual perception and visual information processing then in relation to the facilitating of learning and, finally, in the particular setting of learning from text. As a result of the analysis and discussion the following principles were derived.

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visual perception	“If information is visually organised and contextually congruent, the perceptual processes of the viewer will accommodate it to maximise cognition”.
	“If visuals are designed to convey a finite number of idea units, the viewer’s perceptual processes, influenced by the design of the visual and the available schemata of the viewer, will extract the gist and, subsequently, the detail of the visual information”.

---



visuals in learning	<p>“If a visual is designed in accordance with visual perception organisational principles to be an integral part of an identified cognitive process, the activation of that cognitive process is more likely to take place”.</p> <p>“If a diagram represents spatially the logical organisation of concepts, their comprehension will be facilitated”.</p>
visuals in text	<p>“If illustrations are developed as an integral part of the text design they will perform a motivational or attention getting function”.</p> <p>“If illustrations are designed to support organisational or conceptual aspects of a topic in text, they will facilitate comprehension”.</p> <p>“If illustrations are developed to support the verbal argument of text, the integrity of the text will be enhanced if the illustrations are appropriately embedded, and alluded to, in the text”.</p>

These principles highlight both the text-based and viewer-based aspects of visual communication in learning and have practical implications for the design of text. There can be no doubt about the indiscriminate use of visuals within text in current practice due to the mistaken belief that visuals automatically enhance learning. Putting these principles into practice will require instructional designers and instructional materials developers to have a better understanding of the role of visuals in comprehension, particularly in relation to cognitive processing, and to have a higher level of visual literacy to enable them to incorporate visual elements in ways which will maximise their contribution to learning. Educational practice has, in the past, considered visuals in learning to be either an automatic enhancement of learning or, merely, as an adjunct to learning. Application of the principles identified in this chapter implies the rejection of the former practice and a reconsideration within a cognitive framework of the latter practice.



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## **5    Comprehension through organisation**

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### **5.1    Introduction**

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### **5.2    Organisation and cognitive processes**

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#### **5.2.1    Advance organizers**

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#### **5.2.2    Prior knowledge**

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#### **5.2.3    Behavioural objectives**

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#### **5.2.4    Adjunct questions**

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5.2.4.1    position and type of questions in text

5.2.4.2    frequency of inserted questions

5.2.4.3    questions, expectation, and attention

#### **5.2.5    Mathemagenic behaviours**

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#### **5.2.6    Visual organizers**

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#### **5.2.7    Typographical organisation**

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5.2.7.1    the use of space

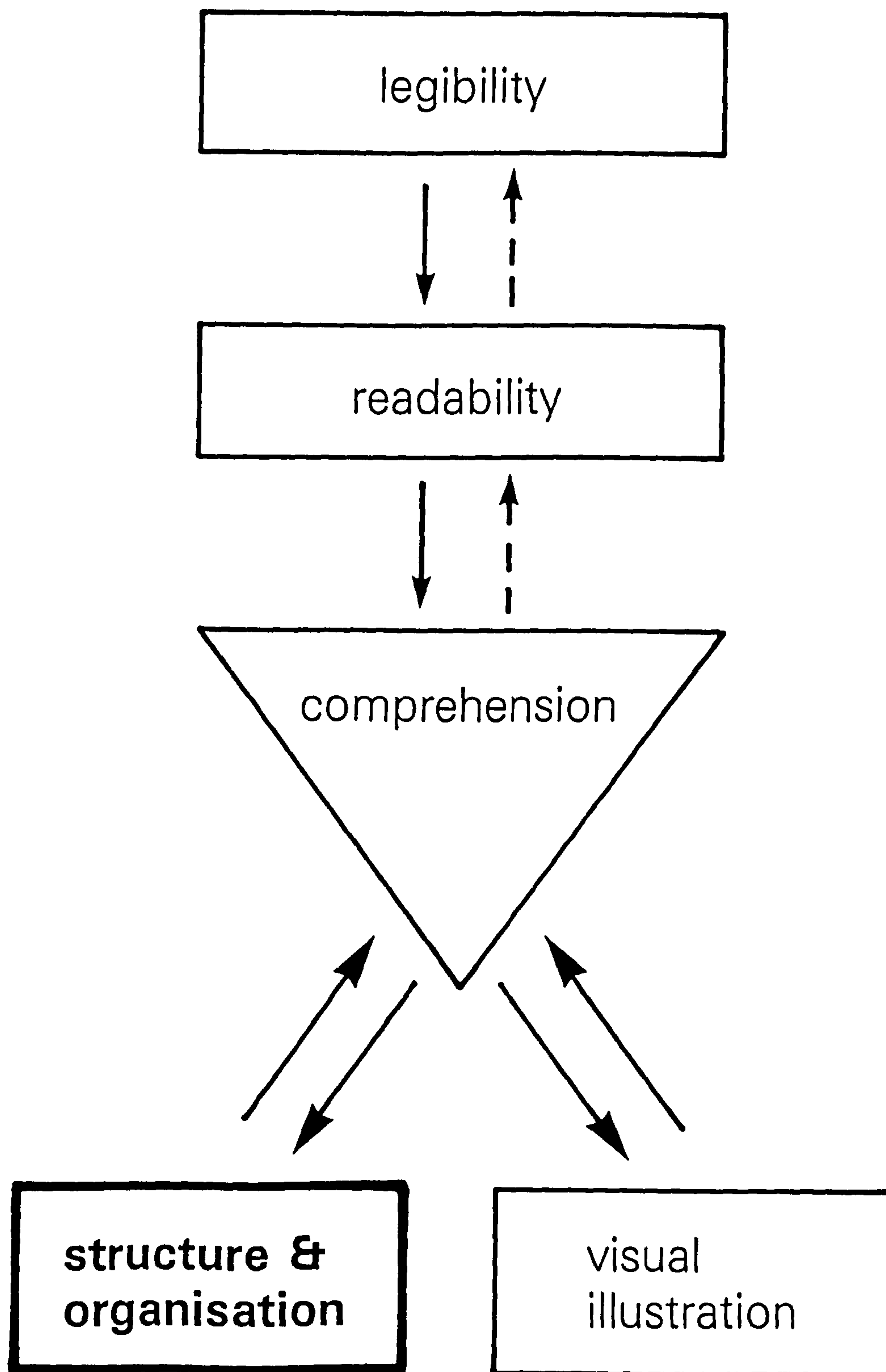
5.2.7.2    the use of typographical cueing      o headings

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**Discussion of the issues  
in chapter 5**

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## 5. Chapter orientation

The nature of the reading comprehension process related, as it appears to be, with the structured and organised nature of knowledge in memory and the construction of meaning through relationships of forms of information in memory (Winne, 1985), suggests implications for the structure and organisation of text.

The purpose of this chapter is to review the literature relating to textual organisation, reviewing, in particular, various forms of verbal cueing strategies including advance organizers, prior knowledge, behavioural objectives, adjunct questions, mathemagenic behaviours, visual organizers, and typographical cueing devices including the use of space, headings, and layout.

The contribution of these structural and organisational devices to the reading comprehension process is considered not only in the historical context of their respective developments, but, in the discussion section of the chapter, from the perspective of a cognitive framework for reading comprehension which, it is argued, provides a more defensible theoretical foundation for historical practice. It is argued that the way in which organisational devices contribute to the reading process is determined by the nature of the reading comprehension process and that there is, thus, an interaction between the theoretical foundation for reading comprehension and those devices whose utilisation can contribute to its achievement. Within that framework, appropriate organisational principles are derived.



## **5 Comprehension through organisation**

### **5.1 Introduction**

It has been pointed out by Carrol (1972) that reading comprehension involves skill in following the organisation of a passage. That organisation may be in terms of what was earlier noted, by Meyer (1977a, 1977b), as textual organisation based on "top-level structures": alternatively, the comprehension may arise from, as van Dijk and Kintsch (1977) have noted, a matching of the organisation with the schema which the reader has in mind or, as Rumelhart (1977b) has indicated, the selecting and verifying of conceptual schemata to account for the organisation of the text being encountered.

Brandt (1978) argues that the content and structure of passages of text are inextricably linked and that students will learn from text better if they can follow the organisation of the material and later use that organisation. Glynn and Britton (1984) argue that, since comprehension of text can be a cognitively demanding task, authors can help readers to comprehend and recall text information by making sure that the design of their text supports each of the component comprehension processes that the readers must perform, including, *inter alia*, identifying the important ideas in the text, organising those ideas, and integrating those ideas with prior knowledge.

The purpose of this chapter is, therefore, to consider the ways in which the organisation of text can be made explicit and the ways in which this organisation can be related to the cognitive processes of the reader.

### **5.2 Organisation and cognitive processes**

Since information in memory is extensively organised and since one purpose of comprehension processing must be to assimilate new information into organised memory, it seems reasonable to assume that structure and organisation within new information are important, a conclusion which is supported, in general, by the available research.

"The better organized the text and the more apparent the structure to the reader,



the higher the probability that the reader will learn from reading" (Armbruster & Anderson, 1985a) (p 90)

As Jonassen (1985b), notes,

"The better organized the passage, the easier it will be for the reader to interpret the intent of the author, and the better will be the reader's comprehension of the text". (p 59)

Pearson and Tierney (1984) have described their perspective of reading as a process of negotiating meaning between a reader and an author through the medium of a text, and Gibson and Levin (1975) have described the principle of cooperation between author and reader, thus:

"We comprehend the meaning of a word, the meaning of a sentence, or the meaning of a passage of discourse when we apprehend the intention of the writer and succeed in relating the message to the larger context of our own system of knowledge". (p 400)

It would appear, therefore, that one purpose of organisation in text is to clarify the structure of the message which the author intends so that the message can more readily be assimilated within the reader's existing knowledge structure.

As Brandt (1978) has noted, readers must recognise how the ideas in a passage are organised, and integrate that information with knowledge they already possess: until they relate the message of the author to their own system of knowledge, the text is void of meaning for them. This interaction between a reader's previous knowledge and the new information contained in the text is, according to Brandt (1978), the essence of a schema-theoretic view of comprehension, which he summarises as follows:

"Essentially, when a reader encounters a text, a schema is activated. This schema enables the person to interpret the text in a meaningful way. The information from the text is assimilated into the schema. At the same time, the schema accommodates the text and is slightly modified because new information has been added to it.



What then remains in memory is a generalized impression of the text material plus some particular instances from the text which may or may not be retrieved, depending upon the demands of the task. At the time of retrieval, the schema is activated, and it guides the memory search and subsequent output.” (p 31)

Ways of activating the relevant schema are therefore an important consideration, not just because of consistency only with the schema-theoretic view of comprehension but with the related processes of comprehension described in chapter 3. Hartley and Davis (1976), acknowledging that organisation is the hallmark of good teaching and that any procedure which makes organisation more obvious and striking is likely to facilitate the learning of meaningful material, suggest that procedures such as *pretests*, *behavioural objectives*, *overviews*, and *advance organizers*, which they refer to collectively as *pre-instructional strategies*, can supply the student with a useful perspective of what lies ahead and serve as a framework on which subsequent learning can be arranged and related. They argue that pretests *alert*, behavioural objectives *inform*, overviews *prepare*, and advance organizers *clarify*. These techniques could all be considered in relation to the activation of schemata and, since much of this approach has evolved from a widespread interest in advance organizers, it is probably wise to consider that concept first, although it must be noted that these various organisational features of text have usually been investigated independently in the absence of any organisational principle, an issue which will be explored in the discussion section of this chapter.

### 5.2.1 Advance Organizers

The concept of advance organizers was developed by Ausubel (1960) and refined over a number of years (Ausubel, 1963, 1968; Ausubel & Fitzgerald, 1961, 1962; Ausubel & Youssef, 1963; Fitzgerald & Ausubel, 1963; Ausubel & Robinson, 1969). The concept was developed within a framework of ‘meaningful verbal learning’ which was later described (Ausubel, 1978) as an advanced form of meaningful reception learning.



Ausubel (1980) distinguishes between reception and discovery learning by pointing out that, in reception learning, the principal content of what has to be learned is presented to the learner in a more or less final form, and the learner is required to internalise the material or incorporate it into his cognitive structure, whereas, in discovery learning, the principal content of what is to be learned is not given but must be discovered by the learner before he can internalise it. Because reception learning is frequently perceived as rote learning and discovery learning invariably regarded as meaningful learning, Ausubel (1980) points out that the distinctions constitute entirely independent dimensions of learning and that reception and discovery learning can each be rote or meaningful, depending on the conditions under which learning occurs:

“... meaningful learning takes place if the learning task is related in a non-arbitrary and non-verbatim fashion to the learner's existing structure of knowledge. This presupposes (i) that the learner manifests a *meaningful learning set*, that is, disposition to relate the new learning task non-arbitrarily and substantively to what he already knows, and (ii) that the *learning task* is *potentially meaningful* to him, namely, relatable to his structure of knowledge on a non-arbitrary and non-verbatim basis.”

(p 17)

“... by non-arbitrarily relating potentially meaningful material to established ideas in his cognitive structure, the learner can effectively exploit his existing knowledge as an ideational and organizational matrix for the understanding, incorporation, and fixation of new knowledge.”

(p17)

“... the substantive or non-verbatim nature of thus relating new material to, and incorporating it within, cognitive structure circumvents the drastic limitations imposed by the short item and time spans of verbatim learning on the processing and storing of information. Much more can obviously be apprehended and retained if the learner is required to assimilate only the substance of ideas rather than the verbatim language used in expressing them.”

(p17)



Learning from text as Jonassen (1982) points out, generally represents reception learning and for the material presented in a text to be effective, it has to be meaningful. He argues that the goal of the text writer/designer is, thus, to engage the reader in meaningful reception learning (fig 5.1).

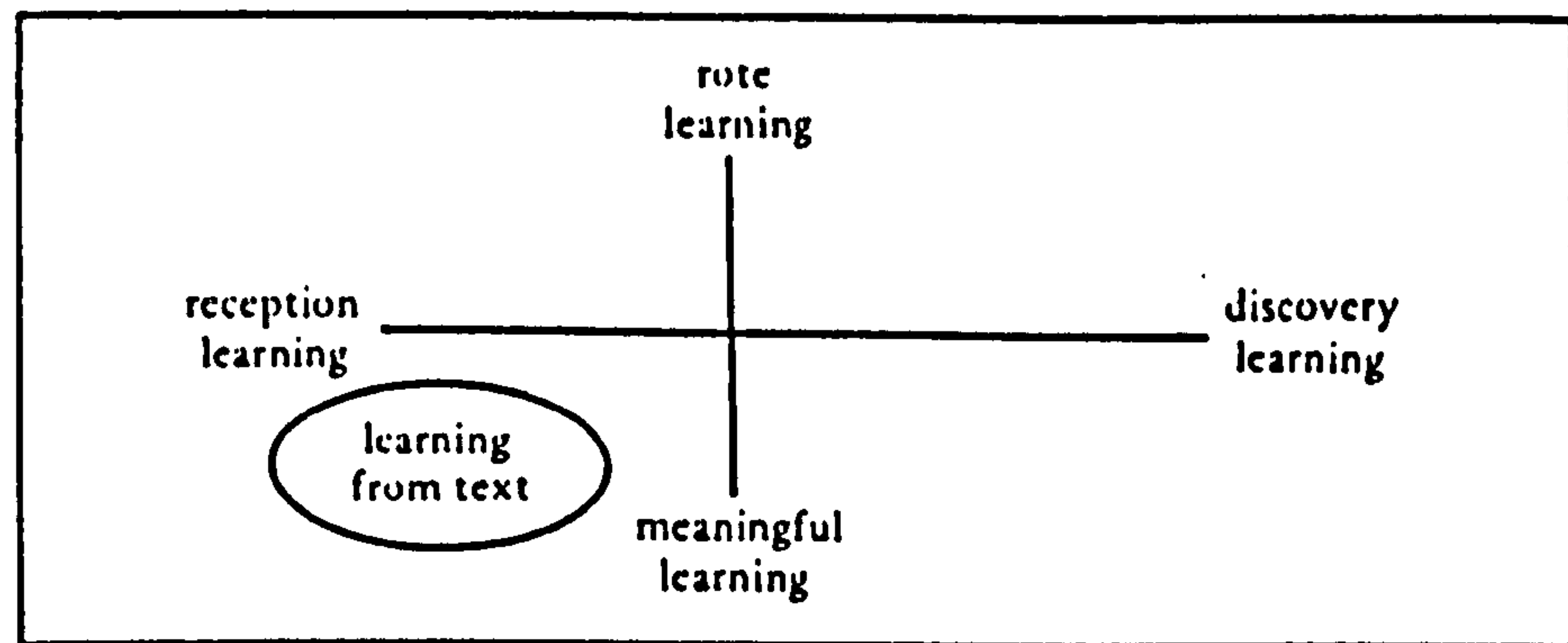


fig 5.1

(Jonassen, p 254)

Ausubel claims that the argument that meaningful reception learning and retention occur most readily and efficiently when, by virtue of prior learning, general and inclusive ideas are already available in cognitive structure to play a subsuming role relative to the more differentiated learning material that follows, is simply restating the principle that subsumptive learning is easier than superordinate learning, and it is on this same principle that his argument for using organisers rests.

Jonassen (1982) has defined an advance organizer as

“Introductory material in advance of instruction presented at a higher level of abstraction, generality, and inclusiveness than the information presented in the text passage.” (p 258)

Ausubel (1980) elaborates in terms of a given organizer being introduced in advance of the new learning task *per se*; being formulated in terms that relate it to and take account of generally relevant background ideas already established in cognitive structure; and being presented at an appropriate level of abstraction, generality, and inclusiveness to provide specifically relevant anchoring ideas for the more differentiated and detailed material that is subsequently presented. The principal function of the advance organizer is to bridge the gap between what the learner already knows and what he needs to know, and is conditioned by what he wants to know.



Hartley and Davis (1976) note that two broad types of organizer are recognisable: expository and comparative, where expository organizers are used in relation to new material which is completely unfamiliar and comparative organizers are used in relation to new material which is not completely novel. While these two broad types of organizer may be said to be 'recognisable', it is the 'recognition' of what is an advance organizer which has resulted in much disagreement over their effectiveness. In fact, Hartley and Davis (1976) say that:

"there is currently no acceptable way of  
generating or recognising advance organizers" (p 256)

and report one researcher having complained that "If it works, it's an advance organizer; if it doesn't work, it isn't!", a comment which Ausubel (1978) considered as both unfair and unworthy.

A major challenge to the effectiveness of advance organizers came from Barnes and Clawson (1975) who, having analysed 32 studies, concluded that the efficacy of advance organizers had not been established and that advance organizers, as presently constructed, generally do not facilitate learning. Lawton and Wanska (1977) responded to this challenge, questioning the basis for comparisons made, and pointing out that many of the 'advance organizer' studies might more appropriately have been regarded as 'overview' studies since the nature of the advance organizer was not always clearly defined in the research reviewed by Barnes and Clawson. However, Lawton and Wanska (1977) did suggest that before asking whether advance organizers facilitate learning, more definitive and stringent tests of the structure of organizers are required.

An extensive meta-analysis of the effects of advance organizers on learning and retention was carried out by Luiten, Ames, and Ackerson (1980) who, after reviewing 135 studies, concluded that

"The average advance organizer study shows a small, but facilitative effect on learning and retention . . . Moreover, the findings indicate that advance organizers facilitate learning in all content areas examined, albeit broadly defined, and with individuals of all grade and ability levels."

(p 217)

Jonassen (1982), on commenting upon the criticisms of advance organizers states that:



"Organizers do not *a/ways* work, nor should they. Their effect is relative to the learner and the subject matter. If the learner's cognitive structure (schema) for a particular topic is adequate for assimilating (linking) new information, organizers will not have a noticeable effect. It is only when one's schema for a topic is insufficiently developed that organizers will serve the bridging function described by Ausubel." (p 264)

A more fundamental criticism of the concept of advance organizers was made by Macdonald-Ross (1978) who argued that the conceptual framework was false because neither the structure of subject matter nor the process of cognition can be adequately modelled as a hierarchy. He claims that modern theories of cognition agree that a *heterarchy* is the basic logical structure of cognition. A further criticism which he makes is that there is no particular reason for the typographic primacy of organizers, and that the initial position of the organizer is

"conflated with an unjustified assumption that effective reading consists of starting at the top, reading everything once, and finishing at the end. Everything we know about effective readers suggests that their strategies are far more sophisticated than this." (p 254)

This criticism is somewhat drastic: clearly there are circumstances where a hierarchic structure would be concerned and there are occasions when a reader's access strategy will begin at the beginning. However, these possibilities will be returned to in the final chapter.

Mayer (1979), having reviewed forty-four research studies involving advance organizers concluded that

"Twenty years of research on advance organizers has clearly shown that advance organizers can affect learning, and the conditions under which organizers are most likely to affect learning can be specified." (p 161)

Mayer (1975a) offered an "assimilative theory", similar to Ausubel's subsumption theory, but which referred to the idea that learning involves relating new, potentially meaningful material to an assimilative context of



existing knowledge, and was able to interpret research relating to advance organizers in the context of his assimilative theory. Thus he was able to conclude that

“As a general rule, advance organizers will result in broader learning outcomes in situations where the learner does not normally possess or use an assimilative context for incorporating the new material. In particular, advance organizers will result in broader learning when the material is potentially conceptual but appears unorganized or unfamiliar to the learner, when the learner lacks a rich set of related knowledge or abilities, when the organizer provides a higher level context for learning, and when the text measures the breadth of transfer ability.” (Mayer, 1979, p 161)

In a series of studies (Mayer, 1977, 1978, 1979; Mayer & Bromage, 1980; Mayer, 1983) he pursued his concept of assimilation-to-schema being dependent upon the three conditions of (i) the reception of the to-be-learned material, (ii) the availability of a cognitive structure to which the new material may be assimilated, and (iii) the activation of the structure during learning, and concluded that advance organizers serve as an assimilative context for unfamiliar organizations, that they facilitate the recall of conceptual idea units, and that they produce recall and problem-solving performance similar to that obtained with repeated presentations of material.

The notion of advance organizers is, clearly, consistent with the theories explored in chapter 3 regarding the process of comprehension, and is, equally clearly, related to the role of organisation in comprehension. Accordingly, it will be returned to in the discussion section of this chapter.

### **5.2.2 Prior knowledge**

Prior knowledge is, obviously, an essential element in the idea of schema and the concept of advance organizers. However, the role of prior knowledge *per se* and, in particular, its activation in learning from text has been investigated by a number of workers and needs to be reviewed at this point.



Peeck, van den Bosch, and Kreupeling (1982), having regard to Ausubel's subsumption theory and Mayer's assimilation theory, investigated the effect of promoting the active use of a learner's existing knowledge prior to learning from text. This was done by encouraging the readers to "bring to mind" relevant prior knowledge and so differed from the use of advance organizers. The results of the study, claimed to be in agreement with assimilation theory, demonstrated that activation, or mobilisation of relevant pre-existing knowledge can facilitate learning, but the effect seemed to be confined to information inconsistent with what the learners already knew.

Entin (1980) observed that objective measures of prior knowledge were more strongly related to comprehension than subjective measures of prior knowledge, but she was not investigating the use of the test of prior knowledge as an organisational aid. Similarly, Adams and Bruce (1980) identify the importance of prior knowledge, noting that comprehension is the use of prior knowledge to create new knowledge and that, without prior knowledge, a text is not just difficult to interpret, it is meaningless, but they do not investigate the role of prior knowledge, or its activation, in organisation prior to learning.

Brandt (1978), on the other hand, noted that Ausubel's concept of advance organizers proposed that learning was facilitated if the learner was supplied with an appropriate frame of reference so that new, or to-be-learned information could be *related* to knowledge the learner already possessed. He also noted that Haviland and Clark (1974) had demonstrated that students comprehended sentences faster if these sentences were *related* to information the student had previously learned. Brandt (1978) identified this as demonstration of the psychological reality of a *relatedness* phenomenon, and argued that, although the research concerning the effectiveness of advance organizers had been inconclusive, there was evidence for much of Ausubel's theory, particularly the *relatedness* phenomenon, viz, that a person's previous knowledge generally facilitates the learning of new information.

According to Brandt (1978), prior knowledge of content, i.e. the giving of information about a passage prior to reading of the passage, should enable readers to relate the information given to the new information in the passage and improve their comprehension of the passage. At its simplest, the



provision of a title could be regarded as the giving of information of content, and the work of Dooling and Mullet (1973), who observed that such an action facilitated comprehension, supports the contention that prior knowledge of content can improve comprehension. The demonstration by Bransford and Johnson (1972) that knowledge of the theme and the context are important for comprehension is also supportive of the contention.

However it is not only prior knowledge of content which may affect comprehension. Prior knowledge of organisational structure may be equally important. With regard to organisational structure, it was noted in chapter 3 that Meyer (1975) identified the content structure or organisation of information in a passage as the most powerful variable related to recall, and demonstrated that readers, in general, use as a strategy, the ready-made organisational structure of the passage, an important element of which is identification of the "height" of idea units in the structure of the text. Meyer (1975), in demonstrating that readers tend to recall the idea units high in the content structure of the passage more readily than those at lower levels (i.e. the details), is consistent with Ausubel (1963) and his subsumption theory which predicts that general ideas will tend to remain in memory and be recalled easily while specific details will tend to be integrated, or subsumed, under the general ideas and will, thus, be less likely to be recalled.

Meyer, Brandt, and Bluth (1980), having tried to determine whether readers were able to recognise the top-level structure of a passage, concluded that it might be necessary to train readers to recognise and use the author's top-level structure if there was to be improvement in comprehension. Meyer, Bartlett, and Woods (1978) presented college students with information regarding the top-level structure of passages before the reading of the passage, but the students did not recall more than those students who had not been given the prior information, and it was concluded that college students, being sophisticated readers and familiar with a variety of top-level structures, were likely to recognise the top-level structure of a passage without assistance. Less able readers are, perhaps, more likely to benefit from prior knowledge about the organisational structure of a text.

Arkes, Schumacher, and Gardner (1976) directed undergraduate readers attention to the organisation of prose material through a reader-generated



outline, and observed significantly increased recall of material, whereas Caterino (1977), who presented sixth-grade readers with an outline before the reading of the passage, observed that the outline was not particularly helpful. However, as Brandt (1978) notes, the students in the Arkes et al study were forced to interact with the material and, possibly, be involved in deeper processing of the material. In his own investigation, Brandt (1978) concluded that providing students with information about the top-level structure of passages, and instructing them to use that information to recall the passage, did not improve the comprehension of these students.

Perhaps the term "prior knowledge", whether applied to content or to organisation, is less than helpful in trying to identify the relationship between organisation and comprehension. What is really of greater importance is the extent to which the "pre-instructional strategy" (Hartley & Davis, 1976) contributes to the "set to learn" factor (Klare, 1963), albeit in a dimension other than the motivational dimension referred to in chapter 2. In fact, that is the framework within which advance organizers, prior knowledge, and the other adjunct aids described in the following sections need to be considered.

### **5.2.3 Behavioural objectives**

Mager (1962) claimed that

"If you give each learner a copy of your objectives, you may not have to do much else."  
(p 53)

While this may be a rash statement on the part of a confirmed believer in behavioural objectives, and others, such as Macdonald-Ross (1978) may argue that there are good reasons for thinking that the conceptual flaws in the behavioural-objective approach are so serious that they will never be repaired, there has been, over the years, a significant level of investigation into the effectiveness of stating desired learning outcomes in the form of behavioural objectives at the beginning of a passage of text.

Kaplan and Rothkopf (1974a, 1974b) investigated the use of instructional objectives as directions to learners; in particular, the effect of passage length and amount of objective-relevant content, and the effect of objectives when



used as orienting stimuli or as summary/review on prose learning. They concluded, in the first case, that when instructional objectives are known, substantial gains in instructional effectiveness can be gained by "communicating these objectives to students embarking on reading assignments", but they noted that the likelihood of attaining any given objective was reduced as the number of relevant sentences in the passage increased. In the second case, they concluded that performance on information relevant to an objective was relatively high whether the objectives were presented before or after the text. Royer (1977), on the other hand, having based her investigation on the work done by Kaplan and Rothkopf, concluded that pre-text objectives significantly increased learning more than post-text objectives. The typographic position of the objectives in the learning package is one which Macdonald-Ross (1978) considers important. Acknowledging that objectives at the beginning of material are supposed to act as attention directors or goal statements, he argues that the evidence collected in the British Open University suggests that objectives are not used in this way by students and that they are, rather, part of the access structure of the text.

Duchastel (1979) acknowledged that learning objectives accompanying a text can often direct the student's learning activity, and he attempted to determine the joint effects of learning objectives and structure of a text upon the recall of the content of a prose passage. He observed that the strongest effect revealed was the effect of objectives on learning, lending support to the view that objectives influence learning through a process of selective attention. Structure, by itself, does orient learning but his findings indicated a relatively weak effect, and there was no evidence of joint effects of objectives and structure. He concluded that

"... objectives and text structure can each provide the learner with orientation, but both together do not increase that orienting effect further. Whether objectives render the structure redundant or whether the structure makes the objectives redundant is somewhat unimportant, for the strength of each orienting factor will vary from situation to situation." (p 106)

Hartley and Davis (1976) acknowledge that, despite a general lack of agreement as to the level of detail to which behavioural objectives should be



written, the majority of studies indicate that behavioural objectives provide a useful pre-instructional strategy. Klauer (1984), after carrying out a meta-analysis for 1970–80, observed that instructional objectives produced significant, positive, medium-sized effects on intentional learning, and concluded, therefore, that providing students with advanced instructional objectives leads to an improvement in intentional learning. The influence of instructional objectives on intentional learning is, however, reduced through longer texts. Objectives were not the only pre-instructional factor investigated by Klauer: he also analysed the role of learning directions and questions, and concluded that

“Behavioural objectives (e.g. the Magerian type of objectives) proved to be less favourable than learning directions and questions.” (p 334)

#### **5.2.4 Adjunct questions**

It is widely acknowledged that Rothkopf (1965) is to be credited for having created what has become a highly active area of educational research known as “adjunct questions”, but Rickards and Denner (1978) point out that the inserted questions paradigm was first introduced by Washburne (1929) in an investigation of the effects of questions upon the retention of social science material. In general, the research into the effectiveness of adjunct questions has been concerned with the position (before or after), type (factual or meaningful), and frequency of inserted questions, although, more recently, there has been some concern with respect to individual differences and inserted questions, and question generation by the reader.

The development of research on adjunct questions reflects the development of research on reading and comprehension from a behaviouristic approach to a cognitive approach as outlined in chapter 3, since the original work of Rothkopf (1965) took place prior to the emergence of a cognitive theory of learning concerned with learners actively organising incoming information and, in particular, the “levels of processing” approach ( Craik & Lockhart, 1972). Rickards and Denner (1978) suggest that the early approach to inserted questions can be characterised as a “variables orientation” whereas the more recent approach can be characterised as the “processes orientation” to inserted question research.



#### 5.2.4.1 Position and type of question in text

In carrying out the initial investigations into the position of questions, Rothkopf (1965, 1966) and Rothkopf and Bisbicos (1967) did so within a framework of "mathemagenic behaviors" which Rothkopf (1971) explains thus:

"I called the study of activities in which the subject was engaged during practice *mathemagenic behavior*. . . . *Mathemagenic* is a handy adjective. It comes from the Greek words *mathemain*, "that which is learned" and *gineisthos*, "to be born." Mathemagenic behavior is behavior that gives birth to learning."

(p 288)

Factual (verbatim) questions were inserted immediately before or immediately after related text segments, and both groups participating were given the correct answers to the questions after they had made their responses. Another two groups were given the questions but not the answers, and a fifth group received all the experimental questions and their answers prior to reading the text. Two control groups read the text without adjunct questions, with one of these groups being given instructions to read carefully and slowly as there was a great deal of factual information in the passage. Two measures of retention were used: one which measured the *direct* or *intentional* learning of questioned information and one which measured the *indirect* learning of information, i.e. information *incidental* to the information required to answer the experimental questions. Rothkopf (1971) summarised the results as follows:

"If the testlike event occurred *before* reading the material to which the questions were relevant, then they only had direct instructive consequences. Their effect on mathemagenic behavior, on the other hand, was not substantially different from no question at all. If the questions were presented just *after* the zone to which they were relevant, then post-test performance indicated a marked elevating effect due to mathemagenic as well as direct instructional components."

(p 291)

Or, as Rickards and Denner (1978) summarise the issue:



"The results indicated that students learned more incidental information when given the questions after the related paragraphs (postquestions) than when given the questions before (prequestions) or given no questions at all . . . . The incidental learning effect of the postquestions group . . . was found to be of the same magnitude as that of the control group instructed to read carefully and slowly. On the measure of intentional learning, all groups receiving adjunct questions exceeded the two control groups, and there was no significant effect due to the placement of questions (before or after)."

(p 320)

According to Anderson and Biddle (1975), authors of one of the major reviews in the area, this last finding has been replicated many times. The finding regarding superior recall of incidental information of a postquestion group relative to a reading only control group has been confirmed by Frase (1967, 1968), Frase, Patrick, and Schumer (1970), and Rickards (1976a). The general conclusion (Anderson & Biddle, 1975; Frase, 1970) has been that verbatim postquestions yield greater performance than verbatim prequestions and that only the verbatim postquestion group exceeds the control group. In most cases, the retention has been measured immediately after the reading, but Boker (1974) found that subjects in questioned groups retained significantly more question-relevant information than a non-questioned control group on both an immediate and seven-day delayed retention measure, and that the post-questioned group retained more question-incidental content than either the pre-questioned or control groups on both retention tests. Wixson (1984) found that postquestions directed at information from all levels of importance within a passage enhanced children's memory for directly questioned information on both recall and test question measures. She argued that postquestions resulted in a cognitive review of the textual information that was limited to the directly questioned ideas and that there was no support for a general review hypothesis even when postquestions were directed at the most important passage information.

However, the research referred to above has been concerned, primarily, with the recall or recognition of the exact words of a sentence, and is con-



cerned, therefore, with what Ausubel (1963) identified as 'rote learning' rather than 'meaningful learning'.

Allen (1970), basing his investigation upon a hypothesis suggested by Sanders (1966) that questions which demand cognitive processing above the level of mere factual recall will, through practice, develop intellectual skills and will not result in poorer learning of factual information, tested this hypothesis and considered possible interacting effects of advance organizers in that higher order questions requiring students to search through and mentally manipulate data might enhance the facilitative effects of advance organizers. The results, however, did not support the hypothesis that higher order questions will result in equal retention of factual information, nor did the higher order questions result in general facilitative effects on learning. Allen (1970) noted that, when combined with advance organizers, the specific learning resulting from review questions appears to be more resistant to forgetting for students of average and below average intellectual ability than for students of above average intellectual ability.

Meaningful textbook type materials were used by Hiller (1974) and by Hunkins (1969), but anticipated differences in measures of incidental learning were not observed. However, Hunkins (1969) observed that higher-order questions can enhance learning at the more advanced levels of Bloom's taxonomy, such as comprehension and application, without depressing learning at the knowledge level.

The level of adjunct questions was also manipulated by Frase (1969b, 1971) whose inserted questions required the use of inferential reasoning prior to the reading of the test paragraph. He found very little evidence for the learning of inferences other than those given in the prequestions themselves, but he did find that readers given inferential prequestions retained more passage material than those given verbatim prequestions. Rickards and Di Vesta (1974), recognising that rote learning implies that each sentence is processed as a discrete unit with the subject making no attempt to inter-relate the various sentences of the passage, and that meaningful learning involves the organisation of facts under given, higher level, related ideas, hypothesised that meaningful-learning postquestions would facilitate retention more than rote-learning postquestions, since questions requiring



subjects to organise or subsume facts in a passage under superordinate ideas provided in the questions would be likely to produce meaningful learning of the questioned material. The subject had to answer questions after every two or four paragraphs of text — meaningful learning questions requiring subsumption of facts under given ideas, questions involving rote-learning of facts, and questions demanding rote learning of ideas. Rickards and Di Vesta (1974) found that different types of adjunct postquestions produced processing behaviours that varied in both direction (either a *forward* process which shapes or elicits appropriate reading skills, or a *backward* process which reviews previously read material for answers to questions posed [Frase, 1967]) and kind. Rote-learning-of-facts questions produced a general review (general backward effect) of material thematically related and adjacent to the ideas questioned and, possibly, a set to learn ideas (a forward effect); and meaningful-learning questions engendered both a set to subsume (forward effect) and a review (backward effect) process. Meaningful-learning questions were influenced by question frequency, and the investigators suggest, therefore, that, in order to be effective, such questions should be spaced relatively close together.

In a related study, Rickards (1976b) investigated the interaction of position and conceptual level of inserted questions, attempting to induce, via 'conceptual' questions, an abstractive process which required the reader to interrelate text statements in order to derive generalisations from the whole paragraphs of material, and to require via 'verbatim' questions, the recall of specific information from a single sentence of the related text. Conceptual prequestions seemed to produce higher-level text processing, and he concluded that,

"by inducing readers to derive superordinate concepts from the text, conceptual prequestions apparently resulted in hierarchical arrangement of passage information (structured or meaningful learning) which thereby enhanced long term retention."

(p 331)

Felker and Dapra (1975) also investigated the effect of both question type and question placement on problem solving ability from text. Specifically, they used 'comprehension' questions which required the student to identify new instances of a concept presented in the text, and 'verbatim'



questions which required only the recognition of instances drawn directly from the text. The problem solving measure required the application of concepts and principles from the text, and the group receiving comprehension post-questions performed better than all others. A similar investigation by Mayer (1975b) regarding mathematical concepts used three types of question — 'definition' questions which required the reader to define a concept or translate a formula into a sentence; 'calculation' questions which required the reader to compute values using a formula presented in the text; and 'model' questions which asked the reader to translate a story problem into a conceptual model. The groups receiving the 'model' questions or all the questions performed significantly better than the other conditions, and the position of the question did not appear to be significant. Mayer (1975b) concluded that the higher-order questions indicated to the students that 'understanding' was the goal of instruction, a conclusion consistent with that noted in chapter 3 (Marton & Saljo, 1976a, 1976b; Entwistle & Ramsden, 1983).

Andre and Womack (1978) pursued the idea of the value of higher-order questions with respect to levels-of-processing ( Craik & Lockhart, 1972) by using verbatim and paraphrased adjunct questions, and concluded that, under appropriate conditions, paraphrased questions influence the state of encoding of items of information presented in a passage. Friedman and Rickards (1981) extended this line of enquiry by manipulating depth of processing through inserting verbatim, paraphrase, and inference questions, and concluded that inference questions were superior to paraphrase questions, which were, in turn, superior to verbatim questions on test performance, confirming the hypothesised continuum of verbatim to paraphrase to inferential semantic processing as representing shallow to deep processing.

#### **5.2.4.2 Frequency of inserted questions**

It has already been noted that Rickards and Di Vesta (1974) found that verbatim rote-learning-of-facts and rote-learning-of-ideas postquestions were unaffected by question frequency, but that meaningful-learning postquestions were found to be more effective when they occurred more



frequently in the text. Sefkow and Myers (1980), investigating the effect of initiating a review, demonstrated that it is possible to substantially enhance recall of specific segments of text through the use of inserted questions which force a review of information to answer the questions, and they pointed out that the passage preceding an inserted question must still be available at the time the question is presented, implying a high frequency of questions.

Duchastel and Whitehead (1980) explored student reactions to inserted questions in text and noted that, while varied, student reactions were mainly supportive of the notion that inserted questions were useful adjunct aids to learning, but since most of the students preferred the questions to be at the end of the topic being presented, there is little support for the idea of frequent interspersion.

Wood (1982), on the other hand, argues that interspersing questions in text can enhance learning of content area textbook material for some subjects, particularly where, as in her investigation, the text segment, the question, and three lines for response, appear on the same page, thus implying a fairly frequent interspersing of questions. She argues further that materials of this sort are ecologically representative of the classroom environment, and it is worth noting that Duchastel (1983) has urged caution in attempting to derive instructional principles from adjunct question research because much of it has lacked ecological validity.

#### **5.2.4.3 Questions, expectation, and attention**

Consistent with the idea of ecological validity, Sagaria and Di Vesta (1978) required subjects to write answers to adjunct questions at the time of their appearance in the text, a condition which, they claim, closely approximates the condition under which typical study takes place, since, if an adjunct question is placed within the text, the intent of the author is that the student will use the question by providing an answer. The most general conclusion drawn from their study was that the use of adjunct questions adds to the retention and retrieval of items presented in the *intentional* score, but when they appear *before* the paragraph to be read, adjunct questions signifi-



cantly interfere with retrieval/retention of incidental material, a disadvantage which they attribute to the influence of adjunct questions on learner expectations that affects the selective processing of information.

Howe and Colley (1976) have argued that experiments studying the effect of set and expectancy in human learning have most often manipulated factors that are peripheral to the actual material being learned, and which do not closely involve the detailed contents, citing, for example, the parameters such as spacing of questions, position of questions, and the length and number of prose passages, which have been varied in relation to 'mathematical' studies. They have contended that least marginal significance ought to be attached to the effects of expectancies set up by the precise nature of the material, since studies of perception have drawn attention to the significance of the relationship between the material the individual encounters and his own attitudes over expectancies. Howe and Colley (1976) attempted to discover whether or not the presentation to students of successive prose passages that were similar in content and were followed by highly similar sets of questions related to them, had the effect of inducing a 'set' or expectancy, whereby subjects studying subsequent similar passages concentrated their attention on those aspects of the new passage which corresponded to the parts of the preceding passages about which questions had been asked. The experimental findings strongly confirmed the prediction that prose learning would be influenced by the 'set' induced by the nature of the questions following previous prose passages.

In an attempt to examine evidence beyond the purely circumstantial that the improvement in learning due to inserted questions is attributable to an increase in attention caused by the questions, Reynolds and Anderson (1982) devised an investigation, the primary purpose of which was to provide a further and stronger test of the idea that questions facilitate learning by leading readers to change their allocation of attention, and a secondary purpose of which was to explore the usefulness of the concept of a *volume* of attention. The results of the investigation were consistent with the conclusion that questions cause readers to selectively attend to question-relevant information and that readers allocate a greater volume of attention to target than to non-target information.



Working from the notion that questions focus attention — a notion derived from the assumption that students in a learning situation form hypotheses about what is important to study and that adjunct postquestions facilitate this process by focusing students' study behaviours and information processing — Ellis, Konoske, Wulfeck, and Montague (1982) investigated whether instructions to students about how and what to learn can facilitate learning as effectively as adjunct postquestions, and concluded that, in general, students should be told explicitly what to expect on a test, as well as given adjunct questions. They argued that the strategy of giving instructions plus adjunct questions should allow students to concentrate more broadly on all information relevant to the final test rather than focusing on the portion of the content covered by the adjunct questions.

Bull (1973), in investigating the role of questions in maintaining attention to textual material, has noted from the work on adjunct questions by Rothkopf and by Frase, that prequestions tend to narrow the range of attention by providing the individual with a criterion for acceptable behaviour, and postquestions facilitate both question specific and general learning because attention is paid to the whole passage and not to a particular stimulus within the passage. However, she argues that these studies omit two important considerations, the arousal aspect of questions and the differential effect of arousal on long and short term retention, but little or no work seems to have been done in this area.

Freedle and Carroll (1972), taking a more cognitive view of the concept of mathemagenic activities, considered them to be inferred intervening variables, in the form of attention and motivation, causing the reader to observe and retain particular aspects of text information. They suggested that the real effect of adjunct questions on the learner's strategy in reading is a heightening, expansion, or focusing of the observational powers of the reader, in the sense that he pays attention to more aspects of the text — both those that may be immediately critical in the light of the questions themselves and those that the reader may *expect* to become critical upon being tested. Freedle and Carroll (1972) therefore regarded the effects of these manipulations as a means of controlling the reader's expectancies concerning what may be critical in the text and, thus, of his attention to particular classes of details.



Ellis, Wulfeck, and Montague (1980) have pointed out that adjunct questions, in their focusing of attention role, have mathemagenic effects because students use them to 'figure out' what the final test will be like. Perhaps the concept of mathemagenic behaviours should now be given further consideration.

### **5.2.5 Mathemagenic behaviours**

In a major review and critique of mathemagenic behaviours and efficiency in learning from prose materials, Faw and Waller (1976) point out that many of the studies in advance organizers predate Rothkopf's work and that only the studies on the use of objectives and inserted questions grew directly out of Rothkopf's theory. They strongly criticised the lack of concern which many of the researchers had shown towards study time since, they argue, variations in time are of considerable importance with respect to the application of the techniques discussed. Other commentators, such as Rickards and Denner (1978) have been more concerned with the theoretical framework of mathemagenic behaviours, noting that, in the early stages the theory was firmly rooted in the 'associative model' but was later more oriented towards a cognitive model. Macdonald-Ross (1978), however, while acknowledging that the general adoption of cognitive theory is encouraging, comments that the particular cognitive models adopted in adjunct questions research have been rather primitive.

In a more recent exposition on adjunct aids and the control of mathemagenic activities during purposeful reading, Rothkopf (1982) makes it clear that he coined the phrase 'mathemagenic activities' to draw attention to the importance of readers' activities in learning from text, because, at the time, practitioners and researchers were preoccupied with structural characteristics of text.

"The idea for application that underlies work on structure and organization focuses on writing and editing more effectively. If we know how structure and organization influence learning we would be able to do a better job of producing instructional text. . . .



The idea for application that has guided work on mathemagenic activities centers on the efficient local use of centrally produced text. Schools select text material rather than produce them. . . . A better understanding of mathemagenic activities would allow the teacher to guide students so that they can achieve locally chosen goals with centrally produced material and to help students overcome learning obstacles that result because available materials are not well suited to the task at hand."

(p 110)

Rothkopf's conclusion that "information about effective structure and organization is useful to the manufacturer of text — information about learners' activities is of value to the user of manufactured instructional goods" (Rothkopf, 1982) may be consistent with his particular approach to the subject, but, for improved learning from text, it is essential to bring both perspectives together.

Rothkopf (1982) considers that adjunct aids can serve two major functions — they can provide additional information or they can alter, foster, or maintain learning-related reading processes. He argues that the notion of mathemagenic activities provides a guiding conceptual framework and a simple functional guide as to an understanding of the effective use of adjunct aids. The functions of mathemagenic activities most relevant to the successful use of expository text are seen as *selection*, *analysis*, and *interpretation*.

With particular reference to adjunct questions, Rothkopf (1982) argues that

"Adjunct questions have at least two demonstrable effects on learning from text. These are (a) a direct effect that strengthens recall specifically related to the subject of the questions . . . . and (b) they modify mathemagenic activities and in this way influence learning of a reasonably broad class of information contained in the text."

(p 127)

Singer (1982b), in commenting upon Rothkopf's views, suggests that Rothkopf has outlined the concepts of an instructional theory for learning from text, included within which are concepts from an interaction theory of reading, a purposive theory of learning, and components of teaching that Rothkopf calls adjunct aids.



Brody and Legenza (1980) point out that non-verbal or pictorial aspects of material might serve a mathemagenic function similar to inserted questions. They determined that it is possible for some media attributes, specifically picture location, to have positive mathemagenic effects. This is consistent with some of the research reviewed in chapter 4, but is there a methemagenic or advance organizer role for pictorial or non-verbal material?

### **5.2.6 Visual organizers**

Recognising the similarity between established effectiveness of visual devices, based on research in the visual media field, and the described effectiveness of advance organizers, Weisberg (1970) examined the application of an advance organizer to a specific learning task to determine if a conceptual framework facilitating subsequent learning was developed by two types of visual advance organizer, viz. a map and a graph. He concluded that the map functioned very well and the graph almost as well, and both visual advance organizers functioned at a highly significant level whereas the expository organizer did not function for any of the groups in his study.

Snowman and Cunningham (1975), acknowledging that the use of pictorial materials within a mathemagenic framework had not been attempted, accepted that pictures could serve the same purpose as questions — as devices to induce rehearsal or memory search — and could be employed within a basically linguistic context. They attempted to replicate previous findings concerning the effect of question position on retention of practiced and non-practiced information and to further evaluate the robustness of the mathemagenic concept by comparing the effectiveness of subject-generated pictures as adjunct aids with written multiple choice questions. Results showed that reader-generated pictures and experimenter-provided questions were equally facilitative and resulted in increased retention over the control group.

In an investigation of the interaction of learner characteristics with pictorial adjuncts in learning from science text, Koran and Koran (1980) postulated that, when used in advance of text, pictures may provide a scheme for organising incoming textual material and may also have an attention-directing and controlling effect as the learner proceeds through related text.



They established that the presence of a pictorial adjunct appeared to benefit low-ability learners by providing an organisational structure to facilitate the semantic processing of the textual material as well as a pictorial alternative to verbal storage and retrieval. Bernard, Peterson, and Ally (1981) posited that retentional images — those that are employed for the purpose of increasing the memorability and retentional value of the prose to which they are related — are similar in purpose to adjunct prose processing aids such as overviews, outlines, and advance organizers. Overviews and outlines they considered as reiterative organizers, so designated because of the overlapping nature of their content. Contextual organizers, on the other hand, were considered as those advance organizers which provide a mediational function by operating as bridges between passage content and the learner's past experience. As a result of their investigation, they established the functional equivalence of a contextual image and a verbal contextual organizer, both designed to promote the retention of passage content — the verbal organizer by providing a verbal context for the passage and the image by relying on verbal labels organized within a pictorial structure. The predicted advantage of images over verbal adjuncts did not appear.

The fact that it was the verbal part of the visual organizer which seemed important is not surprising. It is consistent with some of the findings reviewed in chapter 4 and is consistent with the findings of Winn (1981) that diagrams (picture-word diagrams) can show the relationships between concepts in a particular content area, and that there are organizational aspects of diagrams.

The term 'graphic organizer' has evolved from work done by Barron (1969) on the 'structured overview' which is a graphic representation of the key vocabulary of a learning passage designed to show the relationships among new concepts and previously learned concepts. The information is in both the verbal content and the visual and graphical content of the organizer. Moore and Readence (1980) conducted a meta-analysis of the effect of graphic organizers on learning from text. In a later analysis which included qualitative as well as quantitative measures, and which attempted to answer the question "What does research evidence reveal about the effect of graphic organizers on learning from text?", Moore and Readence (1983) noted that, on quantitative findings, the results were similar to their earlier investigation, and that graphic post organizers seemed to produce greater effects than graphic advance organizers.



The superiority of graphic post organizers was first noted by Barron and Stone (1974) in an investigation where one group was given an experimenter-constructed graphic advance organizer (an arrangement in schematic form of terms relevant to the major concepts in the learning package), and the other group read the learning passage then constructed their own graphic post organizers (having been given a short demonstration about how to construct a graphic post organizer). It is hardly surprising that the latter arrangement should be superior since there is every likelihood that considerably more processing took place because of the mental exercise required. Huard (1983) observed that students can be trained to construct graphic post organizers, but she was unable to show that this training could be transferred and increase general learning ability. However, the use of post graphic organizers is a generative activity and is really in a different conceptual sphere from advance graphic organizers. Interest at this point is more in line with the work of Alverman (1981), investigating the relationship between graphic organizers and text structure, and noting that the group which received a graphic organizer and read text organised with a description top-level structure recalled more idea units on immediate and delayed recall. She argues that the organizer may have influenced the learner's encoding process by providing anchoring ideas which helped 'hold' incoming information from text that was less than optimal in its organisation until that information could be pieced together or reorganised or, alternatively, that the fact of the organizer's top-level structure not matching the top-level structure of the description passage (and thus requiring organisation) may have facilitated greater depth in processing with a concomitant increase in recall.

In an investigation with health professionals coping with conceptual change (viz. curriculum reorientation for primary health care), Stewart (1984) noted that the availability of a teacher-provided graphic organizer based on the topic analysis, and which was reflected in the typographically-cued structure of the text, was particularly helpful. Subjects were required to demonstrate an understanding of the structure of the passage rather than the detail of its content, and it was observed that only those subjects provided with the graphic advance organizer were able to outline the hierarchical structure of the text.



Obviously, typographical cueing can contribute to an understanding of structure and organisation and it is appropriate, at this point, to examine the available evidence.

### **5.2.7 Typographical organisation**

Incorporating structural cues within the text by using typography to distinguish levels of content was seen by Foster (1979), in the context of the mathemagenic hypothesis, as a more economical form of influencing mathemagenic behaviour than the adjunct questions normally employed.

It has been argued by Hartley (1982b) that the clarity of instructional text can be improved by manipulating its typographical layout, and that by manipulating the spatial arrangement of the text on a page, clarity, retrieval, and comprehension can be enhanced. Elsewhere (Hartley, 1980a) he has argued that what affects most of all the ease of comprehension and retrieval from printed text is the use that is made of the space on a page rather than the print, and that space, in aiding the reader's perception of the structure of the document as a whole, helps the reader to comprehend the document's organisation.

Duchastel (1982), referring to the manner in which text information is presented on a page or in a chapter as 'textual display', argues that, since many students may be deficient in their use of text processing strategies, the text should encourage the use of appropriate strategies through the design features of the text itself, i.e. through textual display techniques. In his judgement, text features can positively influence text processing, and he suggests that textual display techniques are aimed primarily at assisting the student in the task of focusing on the important points by displaying the structure of the text in some way, and, secondarily, at enabling the student to selectively process the text when necessary.

On the other hand, Waller (1980a) argues that there is no consistent set of rules on which to base the kind of effective-reading instruction that advises students to make sensible use of visually signalled text structure, and proposes that typographic signals and the use of space need to be seen as an organ-



isational system operating at the macro-text level in much the same way as punctuation operates at the micro-text level. He compares four common functions of punctuation with their corresponding typographic devices as shown in fig 5:2.

Some functions of micro- and macro-punctuation.		
	Micro-level	Macro-level
Delineation	initial capital full point comma semi-colon colon	headings title pages space rules
Interpolation	parentheses dashes commas	footnotes boxed inserts marginalia indentation
Serialization	commas semi-colons oblique strokes bullets numerals	headings, numerals tabular format regular spacing/styling
Stylization	quotation marks exclamation marks question marks	size variation style variation layout variation

fig 5:2

explaining that

- (a) delineation refers to methods of indicating the beginning and end of text segments;
- (b) interpretation refers to the insertion or juxtaposition of a short segment into a larger one;
- (c) serialization refers to the organisation of segments into clear structures, sets, or series; and
- (d) stylization refers to the indication of a mode of discourse differing from the main body of text.

Nevertheless, having proposed the concept of typography as macro-punctuation, Waller (1982) points out that, within the notion of 'text as diagram', layout can serve as part of the writer's repertoire of syntactic cues for giving a discourse direction and coherence, and as an aid to selective reading, making accessible the structure of the content of a text. He argues that the structure of texts can be made accessible by the provision of special typographically structured devices and by the graphic treatment of the text itself.



Hartley (1984) claims that it is possible to capitalise on the space in text to convey the structure of instructional text, perhaps more easily and with more effectiveness, than in capitalising on the type. He maintains

“spacing helps the readers to perceive redundancies in the text and thus read faster; it enables them to perceive more easily the effective from the nominal stimuli, and thus focus on what is personally important; and most importantly, it is space that aids the readers’ perception of the structure of the document as a whole, and thus helps them to comprehend it.” (p499)

5.2.7.1 The use of space

Glynn (1978) has pointed out that a parallel has been drawn between the operation of typographical cues in text and the operation of the isolation effect, or *Von Restorff* effect which occurs when certain events have been set apart perceptually from other events, the result of which is that the isolated events have a higher probability of being recalled at a later time. However, in the design of text, the purpose is not to isolate, but to show structure through the use of typographic cueing devices and through the use of space.

In an investigation of the effectiveness of ‘square span’ and ‘spaced out’ typography, Klare, Nichols, & Shuford (1957) noted that square span and spaced unit arrangements which reflected ‘thought units’ (as shown in fig 5:3) could possess certain advantages over normal typographic arrange-

- 1. Standard:  
The remaining 30% to 40% must be dissipated through the cooling system.
- 2. Square span:  
The remaining 30% to 40% must be dissipated through the cooling system.
- 3. Spaced unit:  
The remaining 30% to 40% must be dissipated through the cooling system.

fig 5:3

ments in that they effected an increase in test scores for more able readers. Carver (1970), investigating the effect of a ‘chunked’ typography on reading rate and comprehension, concluded, however, that the spatial separation of reading materials into groups of meaningfully related words does not



improve the reading efficiency of mature readers when they are reading at their normal rate.

It was argued by Frase & Schwartz (1979) that phrase segmentation and indentation could be used to facilitate comprehension, citing the fact that meaningfully segmented and indented text resulted in 14%–18% faster response times than standard text, and identifying the critical variable as whether the format results in a display of easily encoded units, regardless of length or neatness of margins. However, these findings were challenged by Hartley (1980b) who observed that, although he tacitly shared the rationale that the way to make technical text easier to comprehend was to segment it or space it out in some way, attention had to be paid to the *content* and *purpose* of a document, as well as to its layout, in deciding how best it can be presented.

The fact that *short* segments of text can be made more comprehensible by segmentation and the use of space is probably self-evident. The definition of 'educational technology' (AECT, 1977) in its original continuous prose version is not particularly clear (fig 5:4).

*Educational technology* is a complex, integrated process involving people, procedures, ideas, devices, and organization, for analyzing problems, and devising, implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning.

(p 59)

fig 5:4

However, when segmented and spaced out (fig 5:5, Stewart, 1985) it is obviously much clearer.

Educational Technology  
is  
a complex, integrated process  
involving people, procedures,  
ideas, and organization  
for analyzing problems  
and devising,  
implementing,  
evaluating, and  
managing solutions to those problems  
involved in all aspects of human learning.

(p 63) .

fig 5:5



As Hartley (1984) points out, the structure of complex text can be demonstrated more clearly to the reader by the consistent and planned use of spacing in both its vertical and horizontal dimensions, and he argues that space can be manipulated, in particular, to group and separate functionally related parts of a piece of text. This is certainly consistent with the work of Stewart (1978) who adapted a guide for the training of primary health workers, set out as shown in fig 5:6,

1. THE WOMAN IS THREE TO SIX MONTHS PREGNANT

1.1 She does not complain of anything

If she is healthy, do not give her any medicines because they may harm the baby  
Advise her not to get too tired and to eat well, adding to her usual meals a little more oil, some peas, nuts, fresh fruits and milk if available.  
Tell her to come back and see you during the sixth and eighth months, but that if she feels there is something wrong she should see you any time.

1.2 She vomits, especially in the morning

This often happens, especially in a first pregnancy  
Advise her to eat less at a time but more often, and not to drink while she is eating but to drink a little often between meals  
Tell her to rest and to eat nourishing food, as in 1.1  
If after a week the woman is still vomiting everything she eats and drinks, send her to the hospital or health centre.

1.3 She is losing blood through the vagina

1.3.1 She is losing no more blood than when she has her period, and her belly does not hurt

Tell her to stay in bed but to call you if she loses more blood  
See her again the next day:  
- she is losing less blood or no blood at all:  
    tell her to rest as much as possible for a week  
- she is no better, or she is losing blood again although she has not been losing any for several days:  
    send her to the hospital or health centre and tell her to drink plenty of liquid on her way there.

1.3.2 She is losing more blood than when she has her period, and she has pains in the belly

Send her to the hospital or health centre and tell her to drink plenty of liquid on her way there

1.3.3 She has lost some blood but there were lumps in it like flesh

If she is no longer losing any blood, tell her that she probably had a miscarriage and that she must stay in bed and drink plenty of liquid.  
See her again the next day. If she is losing more blood, give her 1 or 2 tablets of ergotamine (see page 250)  
If the blood does not stop after one day, send her to the hospital or health centre  
If she is no longer losing blood one day after she has taken the tablets, tell her to come back after one or two weeks to see if she is still pregnant (put your hand on her belly: where is the top of the womb?)  
If she is no longer pregnant and she does not want another child for the time being, see "Family welfare"  
If she is still pregnant, tell her to come back and see you during the sixth and eighth months and to eat well (see 1.1).

1.4 She feels tired and weak

Take her temperature

1.4.1 She is feverish:  
See "Fever"

1.4.2 She is not feverish:  
Advise her to eat well (see 1.1)  
Give her iron sulfate tablets (see page 250)

1.5 She has belly pains

If she is losing blood, see 1.3  
If she is not losing blood, see "Belly pains".

. fig 5:6



so that the functional relationships between the parts of text were more obvious through the manipulation of both vertical and horizontal spacing as shown in fig 5:7.

# 1

The woman is 3 to 6 months pregnant

## 1.1

The woman has no complaints .. .. .

- *do not give her any medicines* because some of them may harm the baby
- advise her to avoid tiredness and to take more rest.
- tell her to eat plenty of vegetables, beans, fruit, and if possible milk, eggs, meat and fish.
- instruct her to come back to see you during the 6th and 8th months, *unless she feels something is wrong*, then she must see you immediately.

## 1.2

The woman suffers from vomiting, especially in the morning.

This is something that often happens, especially if the woman is expecting her first baby .. .. .

- Advise her
- to increase the number of times, she eats, but to eat less food at the one time. She should try to eat the nourishing food described in 1.1.
  - not to drink when eating. She must take frequent but small drinks through the day but she must not drink one hour before or after each meal.
  - to take more rest.

if after 1 week, the woman is still vomiting everything she eats and drinks .. .. .

- send her to the hospital or the health centre.

## 1.3

The woman is losing blood through the vagina.

- If the woman is losing *no more blood than when she has her period* and her belly does not hurt .. .. .

- tell her to stay in bed but to call you if she loses more blood than when she has her period .. .. .

See her again on the following day.

- If she is losing less blood or no blood at all .. .. .

- tell her to rest as much as possible for 1 week.

- If she is no better .. .. .

- send her to the hospital or the health centre and instruct her to drink plenty of liquid on the way there.

If the woman starts to lose blood again after she had stopped losing any for several days .. .. .

- send her to the hospital or the health centre and instruct her to drink plenty of liquid on the way there.

- If the woman is losing *more blood than when she has her period* and she has pains in her belly .. .. .

- send her to the hospital or the health centre and instruct her to drink plenty of liquid on the way there.

- If the woman has *lost some blood*, but there are *lumps like meat* in it, and if she is no longer losing any blood .. .. .

- tell the woman she has probably had a *miscarriage* and that she must stay in bed and drink plenty of liquid.

See her again on the following day.

- If she is losing blood .. .. .

- give her 1 or 2 tablets of *Ergometrine* (see page )

- If the blood still has not stopped after one day .. .. .

- send her to the hospital or the health centre.



	○ if she is no longer losing blood one day after having taken the tablets .. ..	● tell her to come back in 1 or 2 weeks to see if she is still pregnant.
1.4 The woman feels tired and weak	Take the woman's temperature: ○ if the woman is <i>feverish</i> .. .. ○ if the woman is <i>not feverish</i> .. ..	see the chapter on "Feverishness" (page ) ● advise her to eat well (see paragraph 1.1) ● give her iron sulphate tablets (see page )
1.5 The woman has belly pains	○ If the woman is <i>losing blood</i> .. .. ○ If the woman is <i>not losing blood</i> ..	see paragraph 1.3. see the chapter on "Belly pains" (page )

fig 5:7

Although Hartley (1984) contends that legibility is a function of clearly defined structural relations, and that this is most easily achieved by the consistent manipulation of space, it has to be acknowledged that it is not only space that has been manipulated in the above example. The typographical cueing devices of the original have also been modified and certainly contribute to the clarity of the document.

#### 5.2.7.2 The use of typographical cueing

Typographical cueing was defined by Hershberger (1964) as "using heterogeneous typography to differentiate several categories of lesson content differing in importance and difficulty". He was arguing that, in order to promote optimal learning, it would appear advantageous to cue the student as to the importance of the material he is reading at the time that he is reading it, and that by using several styles of typography to cue several styles of reading it might be possible to promote optimal reading and learning of materials composed of several levels of difficulty and importance. However, he found that complex typographical cueing failed to increase learning of either essential or enriching content.

Hall, Harden, Marcus & Jackson (1977) in the design of a new style of medical textbook, used one typeface (roman) to present the basic foundation of information with additional material being presented in a different face (italics). It was argued that during the first reading of the book the student could assimilate the material in italics or he could concentrate on the main type only and study the materials in italics on a subsequent reading. However, no evaluation of the design was carried out.



It has been pointed out by Foster & Coles (1977) that with the increasing use of computer-aided typesetting, it is becoming a relatively easy matter to change type weight or face at almost any point in a printed text. Accordingly, they investigated the effectiveness of two typographic variations — capitals and bold face — to distinguish levels of information, and noted that both cueing conditions were superior to the control, indicating that the typographical cueing helps the reader in extracting important information from text. They also noted that bold type is a better means of visually distinguishing important information than is capitals. Spencer, Reynolds & Coe (1973a) and Spencer (1974), investigating the effectiveness of typographic variations in making distinctions between the logical elements comprising a piece of text, concluded that differences in type weight are more effective than differences in type style or typeface.

Wendt & Weckerle (1972) investigated the effects of indentation and underlining of key words in reference work, but noted that only indentation was effective. In a series of investigations, Spencer, Reynolds, and Coe (1973b; 1974a; 1974b) compared the effectiveness of ten alternative systems of typographical/spatial coding which could be used in the presentation of highly structured information such as bibliographical material. The results suggested that the most effective coding systems are those which make a distinction between successive entries and between the first word of each entry and the rest of the entry. The purpose of the search was of immediate importance: if an author index was to be searched by author only, spatial coding was adequate and the material could be set in one typeface, but if titles of entries were to be scanned, strong typographic coding considerably improved performance.

Duchastel (1982) suggests that textual display techniques can be grouped into three general types — labelling, highlighting, and illustrating techniques — the purpose of which is either to assist the student in the task of focusing on the important points or to enable the student to selectively process the text. Waller (1978), in similar vein, argues that typographically signalled devices can be used to help readers overview the text and locate relevant parts efficiently, and he sees the coordinated use of typographically signalled structural cues providing an 'access structure' which can help students to read texts using selective sampling strategies. The access structure



helps the reader in two ways (Waller, 1977) in that it has an orienting function that *identifies* particular parts of the text, and it has a planning function that *structures* the text and shows how the different parts relate.

The concept of 'highlighting' (Duchastel, 1982), in typographical terms, is exemplified in some of the investigations to which reference has already been made. In these cases, various typographic devices such as italics, bold-face type, colour, etc. have been used to signal the status of the information, and have thus, been helping the reader overcome the problem of focus. Such highlighting techniques have been defined (Duchastel, 1982) as 'explicit highlighting' since they are concerned, not with the prose itself, but with physical typographic devices, whereas 'implicit highlighting' involves either structural means such as advance organizers and summaries or linguistic means such as semantic signalling.

Despite the typographic signalling of different types of information, it has been argued by Williams (1979) that, at any given time, the information needed by the reader is less than that presented by the author and that there is a case for the separation of a subject into separate types of information because different types of information are appropriate to different users, and to the same users at various times (fig 5:8).

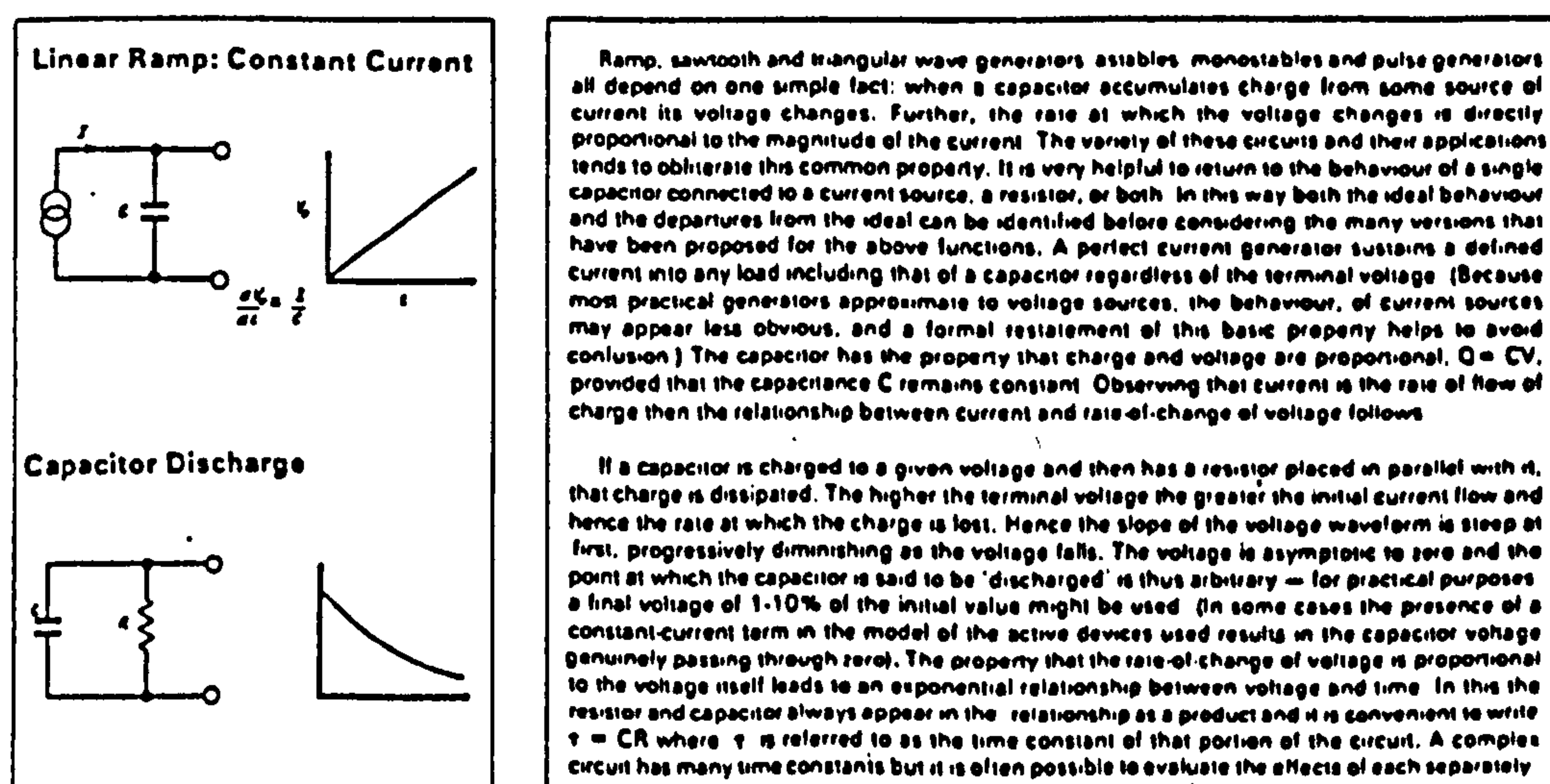


fig 5:8

(p 50)

He contended that in this adjacent page-based 'series-parallel' presentation, the first time reader could scan the left-hand column of the left-hand page and perceive the nature and scope of the topic at a glance, and, that through



this clear development of the ideas, the reader would know whether the text analysis or examples are most likely to meet his needs (fig 5:9).

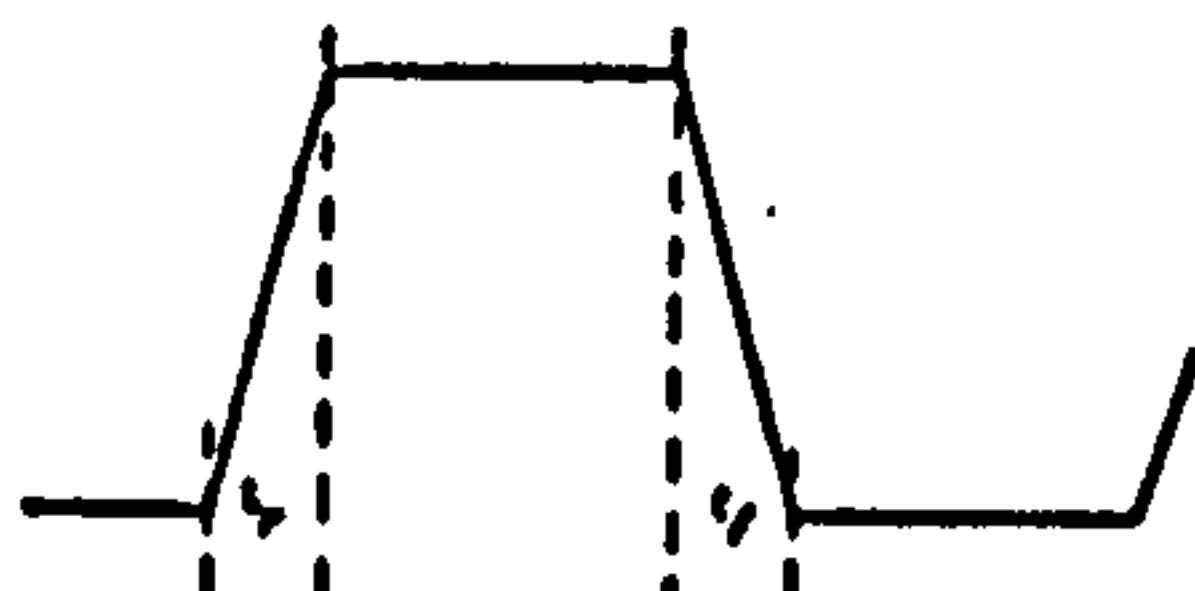
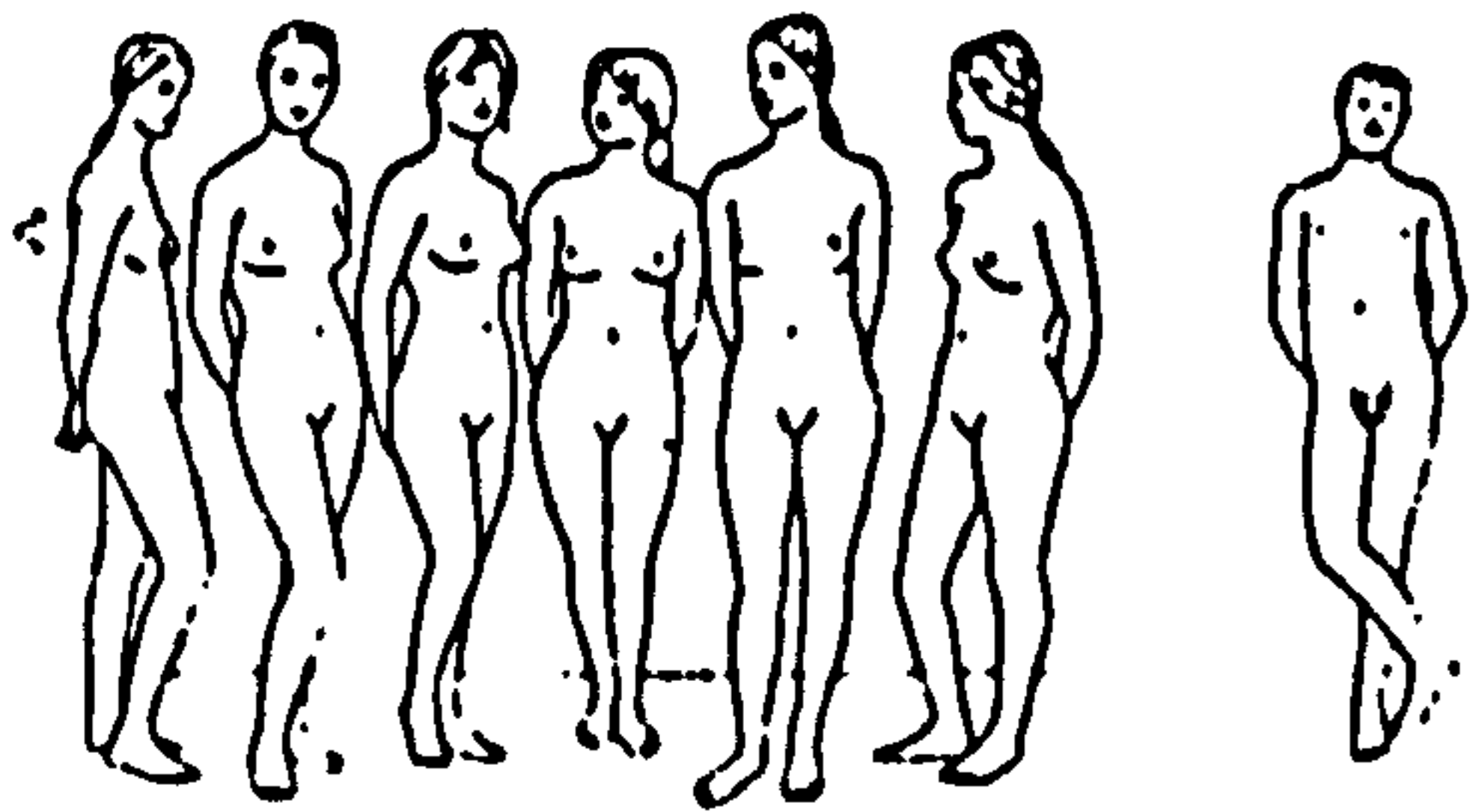
THEORY	EXAMPLES
<p>The voltage built up across a capacitor when charged from a constant-current source follows from the basic relations</p> $Q = CV$ $I = dQ/dt$ $\frac{dV}{dt} = \frac{1}{C} \frac{dQ}{dt} = \frac{I}{C}$ <p>and <math>V = \int_0^t \frac{I}{C} dt</math></p> <p>For <math>I</math> constant, and <math>V_1</math> the initial value of <math>V</math></p> $V = \frac{I}{C}(t_2 - t_1) + V_1$ <p>In many practical circuits the initial voltage across the capacitor is zero giving</p> $V = It$ <p>The discharge cycle would be similar, with a constant current discharge; in most cases the discharge is through a resistor. Let the initial voltage be <math>V_1</math>, with the current flowing into the capacitor still <math>I</math></p> $\frac{dV}{dt} = \frac{I}{C} = -\frac{V}{CR}$ <p>For convenience write <math>CR = \tau</math> the time-constant of the CR network</p> $\frac{dV}{dt} = -\frac{V}{\tau}$ <p>Hence <math>V = V_1 \exp -t/\tau</math>  with <math>V = V_1</math> for <math>t = 0</math>  and <math>V = 0</math> for <math>t = \infty</math></p>	<p>1. An operational amplifier has a compensating capacitor of 30pF into which its first stage can deliver a maximum current of <math>\sim 20 \mu A</math>. Calculate the slew rate i.e. the maximum rate-of-change of voltage across the capacitor</p> $\frac{dV_c}{dt} = \frac{d(Q/C)}{dt} = \frac{1}{C} \frac{dQ}{dt} = \frac{I}{C}$ $\frac{dV_c}{dt} = \frac{I_{max}}{C} = \frac{20 \times 10^{-6}}{30 \times 10^{-12}} V/s$ $= 0.67 \times 10^6 V/s$ $= 0.67 V/\mu s$ <p>2. An amplifier is loaded by a stray capacitance of 10pF and is to reproduce 10V peak-peak square waves at a 10MHz clock-rate. What should the peak current-capability of the amplifier be, if the rising and falling edges are to occupy less than 10% of the total time?</p>  $t_r + t_f < \frac{100ns}{10}$ <p>i.e. <math>t_r, t_f &lt; 5ns</math></p> <p>As before <math>\frac{dV}{dt} = \frac{I_{max}}{C}</math></p> $\frac{10V}{5ns} = \frac{I_{max}}{10pF}$ $I_{max} = \frac{10 \times 10 \times 10^{-12}}{5 \times 10^{-9}} = 20 \times 10^{-3} A$ <p>Hence the amplifier output current must be at least 20mA</p>

fig 5:9

The approach by Harden and Sowden (1983) was similar in that the information was broken down into a series of frames covering one concept or aspect of the subject and with the text confined to the left half of each frame and the right half of the frame being used for an illustration or diagram relevant to the subject of the frame (fig 5:10).

INCIDENCE OF GRAVES' DISEASE	
<p>The most common form of hyperthyroidism is Graves' disease. In this condition the thyroid gland is diffusely enlarged. It occurs most commonly in women between the ages of 30 and 50 and is six times more prevalent in women than in men.</p>	

(p 125)

fig 5:10

Unfortunately, in neither case was evaluation of the design undertaken.



The use of illustrations in the two preceding examples is consistent with what Duchastel (1982) identifies as one of the three types of textual display technique in that the illustrations can embody in visual form the essential ideas made in the text and serve as summary statements in a graphic form.

Identifying and summarising the different elements that comprise the text is the purpose of 'labelling', the third type of textual display technique proposed by Duchastel (1982). Labelling includes the use of headings, terminology markers, content markers, and marginal notes, where headings permit the student to perceive the organisation of the text and thus are part of the access structure; terminology markers serve both as signals to the student that an item is important and as location markers for later retrieval of the item; content markers indicate the type of content treated (as opposed to headings which indicate the substantive content treated in the text); and marginal notes, which since they can be viewed as either elaborated labels that facilitate access to the ideas discussed at length in the text or as a running summary that replaces the summary at the end of a chapter, can perform both an access function and a summarising function.

#### **5.2.7.2.1 Headings**

Samuels and Eisenberg (1981), in discussing a framework for understanding the reading process point out that, within an understanding of reading comprehension as an interactive process of bringing meaning to a text as well as getting meaning from a text, it is the context and the environment surrounding a text that guides the reader in the search for concepts that will give meaning to experience.

"Each of the contextual cues found in a textbook, ranging from titles to side headings, guide the reader in the selection of concepts that can be used to interpret what is being read. . . . it is through the addition of contextual cues found in a textbook that we are aided in the activation of those concepts and schemata that facilitate text comprehension." (p 60)

There have been a number of investigations into the use of headings in text, either in terms of headings as an aid to recall or an aid to retrieval, (or,



occasionally, both) but some of these (e.g. Dee-Lucas & DiVesta, 1980; Doctorow, Wittrock, & Marks, 1978) have been concerned with learner-generated headings which, like learner-generated visual organizers already discussed, really elicit a completely different cognitive processing. Of the others, the concern has been primarily with the position and kind of headings, although some work has been done with regard to instruction in the use of headings.

Hartley and Trueman (1983), basing their investigation on earlier work (Hartley, 1981; Hartley, Keneley, Owen & Trueman, 1980; Hartley, Morris, & Trueman, 1981) which suggested that retrieval from text is easier with marginal headings than with embedded headings and that headings in the form of questions are helpful, at least to less-able readers, concluded that headings could aid recall, search and retrieval from text, but that the position of the headings (marginal or embedded) had no effect. They also observed that the kind of heading, whether question or statement, was of relevance only for the low-ability readers who, they confirmed, appeared to do better in recall tasks with headings in the form of questions.

Jonassen (1983), recognising that headings may function in two ways in helping the reader acquire knowledge from text — either during the initial encoding into memory of information decoded from text or as a retrieval mechanism for either the retrieval of information from memory or the location of desired information in the text — pursued the issue of types of heading in relation to recall and retrieval but concluded that headings of any type benefit only those readers who are less capable of organising and structuring materials for themselves and who rely on the structural cues provided by the headings. Brooks, Dansereau, Spurlin and Holley (1981) observed no significant difference between a 'headings' group and a control group, but noted that when students were instructed to use embedded headings to facilitate both the input and output stages of prose processing there was a significant enhancing of recall.

In a related study, Dansereau (1982) — working on the assumption that headings influence cognitive processing by acting as cues for prior knowledge relevant to a given topic, accentuating the relationships among the concepts and facts given in a text, and providing retrieval cues for subsequent recall,



and that these potential effects can be most easily explained within the context of schema theory — assessed the effects of headings on the processing of complex scientific prose material. He concluded that embedded headings within the text were effective in improving text performance and that the effects of such headings were stronger on delayed recall than on immediate recall. He also concluded that instructions on the use of headings produced a significant positive effect and explained the earlier findings regarding presentation of headings without instruction (Brooks et al, 1981) as being due, possibly, to procedural changes affecting participants' sensitisation to the passage headings. These findings were elaborated by Brooks, Dansereau, Spurlin, and Holley (1983) who observed that embedded headings reliably improved delayed test performance and that instructions in the use of headings as processing aids facilitated test performance. However, they also noted that there was no combined effect between headings and outlines, and suggest that this might be due to students having to divide their attention between the outline and the headings. Stewart (1984), on the other hand, noted that the use of structural cues in the form of headings and sub-headings which matched exactly with an author-provided outline or graphic organizer based on the topic analysis of the material facilitated comprehension of the structure of the material in question.

As Waller (1979b) has noted, the coordinated use of typographically signalled structural cues can provide an access structure that helps students read texts using selective sampling strategies. What is needed, however, is a co-ordinated use of typographically signalled structural cues to initiate cognitive processing relevant to the structure of the topic. This is in line with the findings of Glynn and DiVesta (1977) who used an outline which mirrored the structural organisation of the text and who observed that, at the time of retrieval, the learner who has been provided with logically and hierarchically organised text, generates thematically correct combination because he learns more about, or at least can process more of, the organisation of materials and the relationship among ideas.



## **5 Principles and practice in structure & organisation**

### **– a discussion of the issues in chapter 5**

#### **5.1 Introduction**

In the discussion in chapter 3 of comprehension processes, it was noted that there were implications for the structure and organisation of text, the first, and major, implication arising from the structured and organised nature of knowledge in memory. As Winne (1985) has noted, information in permanent memory is highly organised and can be pictured as a complex network or a hierarchical array, with three basic forms of information being theorised – concepts, propositions, and schema – where a concept is a basic unit of information that represents a category, a proposition is like a sentence that relates two or more concepts, and a schema is a collection of propositions organised to describe prototype of phenomena or events. Not only are the forms of information organised; they achieve meaning by their relationships to one another.

Analysis of the research reviewed in chapter 3 and in chapter 5 indicates that the organisation of text can be made explicit through both verbal and typographical cueing systems (Glynn, Britton & Tillman, 1985) and it is within that framework that the issues of chapter 5 are discussed.

#### **5.2 The role of verbal cueing**

It is clear from the research reviewed that verbal cueing can be either of a linguistic nature, i.e. concerned with the semantic and syntactic structure of the text, or of an instructional design nature, i.e. verbal support such as advance organizers and adjunct questions which, although an integral part of the text, are not really part of the content.

The concern of this study is not basically with the linguistic aspects of text. However, since linguistic factors are implicated in the comprehension



process, their relevance for the design of text will be discussed briefly, particularly as they can be related to typographical factors.

### **5.2.1 Linguistic factors**

Singer (1985) has identified three organisational features of text which, if recognised and used by students, will lead to better process and recall of information.

These are:

- (a) cohesion, a means of tying sentences together through various devices such as pronouns or any grammatical element that represents information in previous sentences;
- (b) content that can be divided into events and non-events; and
- (c) staging, ways of featuring information either by its location in a passage or by the use of rhetorical devices such as problem-solution and question and answer.

In similar vein, Armbruster and Anderson (1985b) relate fundamental patterns of human thought to basic rhetorical structures such as:

- (a) simple listing — a listing of items or ideas where the order of presentation of the item is not significant;
- (b) conclusion/evidence — a special case of simple listing, consisting of a proposition and a list of reasons serving as evidence for the fact;
- (c) comparison/contrast — a description of similarities and differences between two or more things;
- (d) temporal sequence — a sequential relationship between items or events considered in terms of the passage of time;
- (e) cause/effect — an interaction between at least two ideas or events, one considered a cause or reason and the other an effect or result, and
- (f) problem/solution — similar to the cause/effect pattern in that two factors interact, one citing a problem and the other a solution to that problem.

These conclusions are consistent with the comprehension issues raised by a number of the researchers whose work was reviewed in chapter 3, such as that of Kintsch (1979) in relation to gist and macrostructure, Hayes-Roth and Thorndyke (1979) in relation to propositional networks, Pace (1982)







the topic Meyer (1985a) argues that the structure of a topic no longer looks like a network, but is now a hierarchy representing the writer's perspective of the topic, and can be displayed as a content structure diagram which is revealed by unpeeling successive layers of rhetorical relationships in a top-down fashion (fig 5.11, Meyer, 1985b).

According to Meyer (1981) there are three major levels of text — top level structure, macropropositions, and micropropositions. The organisational pattern can be characterised according to the type of top-level structure that interrelates the text's topics and which can be equated with the 'superstructure' concept of van Dijk (1977) or the 'author's textual schema' notion of Meyer, Brandt, & Bluth (1980). The level beneath the top-level structure is the main idea, gist, or macroproposition level (Kintsch & van Dijk, 1978) and the next level is the microproposition level concerned with very specific details. Thus, authors show their perspective on a topic by the top-level structure employed to organise the text, the main ideas or macropropositions that fill the slots of this structure, and the structure of propositions at lower levels in the text (Meyer, 1981; 1985a). Signalling the structure of text can clarify both hierarchical and semantic relationships and can, on a larger scale, indicate how whole blocks of content are related. The result of each signalling appears to be an increase in recall of the ideas and relationships most central to the organisation of the text (Meyer, 1985a).

As indicated earlier, it is not the purpose of this discussion to be concerned with details of language construction in text. Nevertheless, the fact that such construction can influence the readability and comprehension of the text necessitates consideration being given to the broader issues, if not to the detail. Meyer's (1985a) conclusion that her research findings lend support to the use of organisational techniques for planning a text in such a way that it can be remembered by wide audiences without undue effort, justifies the noting of her suggestions for the design of text as listed below:

1. After identifying a potential topic, select an organisational plan that best organizes the critical ideas for communication.
2. Explicitly signal writing plans and major structural relationships.



3. Use preview statements to highlight upcoming major propositions.
  - (a) Use titles and subtitles to focus on main ideas and explicitly signal the structure; e.g. a text with a problem/solution plan explaining how breeder reactors can solve the energy crisis would be titled "Nuclear Breeder Reactors: A Solution to the Energy Crisis" rather than "Fast Breeder Reactors".
  - (b) Use abstracts, introductions, or figures to explicitly preview the main ideas.
4. Use summary statements to review major points.
5. Use pointer words to emphasize the structure (e.g. a critical problem) and highlight the main ideas.
6. Check to be sure that important ideas are not buried at low levels in the structure of the text.
7. Check to be sure that signalling complements the structural plan.
8. If after working with a topic you change your perspective on what is important, be sure you systematically change your organizational and highlighting plans. (Meyer, 1985a). (p 85)

From the above discussion, a principle of textual structure and organisation could be stated as follows:

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"If the critical information to be communicated is appropriately emphasised as part of an overall text structure, comprehension will be facilitated".

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The application of this principle in practice has similar implications to some of the principles discussed in chapter 3 in that, while being ostensibly linguistic or psycholinguistic in nature, there is really an instructional design dimension. The need for instructional designers or instructional materials developers to be concerned with linguistic factors is highlighted and this is



not a skill which is necessarily expected to be part of the instructional design armoury. Perhaps there is a requirement either for greater integration between linguistic and instructional design approaches to text design or for the instructional design dimension to be expanded to include linguistic concerns. This latter possibility is more consistent with an instructional design philosophy.

The work of Armbruster and Anderson (1985a) in relation to textual organisation is of interest, not so much because of the notion of 'frames' which they propose, but because of the emphasis on content analysis which it requires. They noted that

"Our reason for introducing the notion of frames was the need to capture the structure of the 'real' text of longer than a paragraph or two. We found that before the text organization became clear to us, we had to analyse the underlying organization of the content itself" (p 101)

This emphasis on the need for content analysis should hardly be surprising for the designer of instructional text since a prerequisite to the design of instructional materials must necessarily be a task or topic analysis, and this is really what is involved in Meyer's (1981, 1985a) 'content structure' and Armbruster & Anderson's (1985a) 'frames' approach. It is, in essence, an analysis of a topic to find the logical hierarchical relations in the topic so that instruction can be sequenced accordingly (Tiemann & Markle, 1985).

One other aspect of the content itself is worthy of note, viz., the notion of 'idea density' (Kintsch et al, 1975) which led Armbruster and Anderson (1985b) to conclude that the denser the text (i.e. the greater the number of new ideas per unit of text), the longer it takes to read and the less the likelihood of remembering it.

It is clear from the above discussion that various features of the text itself including its structure, coherence, and content, influence learning from reading. As noted earlier, however, there are other textual factors supplementary to the main content which play an important part in the comprehension of text and are, thus, important elements in the design of text.



5.2.2 Instructional design factors

In a recent review of instuctional psychology Resnick (1985) acknowledges that the current view of reading comprehension is too recent to have yet generated many instructional applications, but that (a) a few efforts to teach reading strategies have been made, and (b) older lines of work on advance organizers, questions, and other adjuncts to text may eventually be reinterpreted in light of the constructivist view of the reading process.

Reference will be made, albeit briefly, at the end of the discussion of this chapter to the reading strategy research, but the main area for discussion at present relates to the adjuncts to text and to their reinterpretation in the light of the comprehension processes discussed in chapter 3.

By 'adjuncts to text' is meant those devices such as the statement of behavioural objects, the provision of advance organizers, the inserting of questions, and the activation of prior knowledge, which were reviewed in chapter 5. Jonassen (1985a) uses Rothkopf's (1980) 'mathemagenic' process to refer to this group of devices, contrasting them with 'generative' processes which he considers to be more in line with a cognitive approach to learning. The mathemagenic approach, in the judgement of Jonassen (1985a), seeks to orient the learners to the text, and to show them what is relevant and important. Thus, it is, in essence, text control of the learning process. The generative approach, on the other hand, emphasises not only learner involvement but learner control of the processes that produce comprehension. All of the devices referred to above are considered by Jonassen (1985a) to be 'constructive' mathemagenic strategies which address

*Examples of Processing Strategies*

Generative Processing	Mathemagenic Processing
Constructive	Constructive
Notetaking	Instructional objectives
Paraphrasing/summarizing	Branching programmed instruction
Synthesizing	Advance organizers
Generating questions	Inserted questions (pretest)
Imaging/illustrating	Titles/headings/markers
Mapping/networking	Graphic organizers
Learner control	Text control

(Jonassen, 1985a, p 15)

fig 5:12



meaningfulness by attempting to orient learners to the textual content or by affecting the way they process it, whereas constructive generative processes are intended, primarily, to increase the meaningfulness of textual content (fig 5:12).

This dichotomy by Jonassen (1985a) is based upon the work of Wittrock, (1974) with respect to a generative model of learning which suggests that reading comprehension is facilitated when, during encoding, learners use their memories of events and experiences to construct meanings for the text. The actively constructed individualised meanings represent each learner's comprehension of the text. This is, of course, consistent with the schema-theoretic view of reading comprehension, but later work on generative processes (Doctorow, Wittrock & Marks, 1978) indicates that generative processing involves instructions to the reader to generate associations among words, to generate pictures and to generate meaningful elaborations, activities which go beyond the constructivist schema-theoretic view of reading comprehension. In this sense of 'generative' learning, the reader is not only generating meaning, but generating overt performance which can contribute to learning. Perhaps different terms need to be used to distinguish between those cognitive processes required for the generation of meaning and those involved not just in the generation of meaning but in the overt articulation of that meaning. For the purpose of this discussion, the term 'constructive' will be used when referring to a covert cognitive process of reading comprehension and the term 'generative' will be used to denote an overt performance associated with reading comprehension.

Thus, those devices falling within the mathemagenic approach need to be discussed, not in relation to 'generative', but to 'constructive' processes.

#### **5.2.2.1 The issue of advance organizers, prior knowledge, and schema-theory**

Anderson (1984b) has claimed that schema theory supports the practice of providing advance organizers or structured overviews along the lines proposed by Ausubel (1968), whom he regards as one of the pioneer schema theorists. Nevertheless, he has reservations about Ausubel's insistence that organizers must be stated at a high level of generality, abstractness, and



inclusiveness. Resnick (1985) also suggests that current work on the role of schemata in reading comprehension echoes Ausubel's (1968) work on the role of advance organizers in facilitating comprehension and retention of prose materials, and she also notes that the notion of schema as a framework for interpreting text is central to virtually all of the work done on prior knowledge. Resnick's (1985) summary of the reading comprehension process sets the scene for a discussion of the inter-relationship between schema, prior knowledge, and advance organizers.

"Reading comprehension proceeds, roughly speaking, by the reader's using the first part of the text to decide what schema is most likely to make sense of the text and then using that schema as a hypothesis for interrogating the text. This interrogation fills the schema's slots, thus completing the reader's mental model of the situation . . . .

More recent work shows that the kinds of schemata people are most likely to activate because of their own background and interests can also influence how a passage is understood . . . .

Directions to adopt a particular perspective can also affect what is learned and remembered from a text and what is rated important . . . .

Individuals with high prior knowledge of a topic remember more propositions from a text on that topic . . . . probably because prior knowledge aids readers in building and carrying in memory the propositions needed to make the text coherent."

(pp 2571/2572)

Jonassen (1985c) asserts that advance organizers function, according to Ausubelian cognitive theory as conceptual anchors in the reader's knowledge structure for subsuming new information presented in text. Bransford (1984) argues that advance organizers must differ depending on whether the problem is of schema activation or schema construction. The suggestion by Derry (1984) that advance organizers operate through an "assimilation and correction" process enabling ideas in the text that are



consistent with the schema to be assimilated with active prior knowledge and novel ideas or ideas inconsistent with the schema to be recalled as “discrete schema corrections” is a possible explanation for the problem. Assuming for the moment that schema construction is not for totally novel knowledge, and that existing prior knowledge can be utilised, the issue that needs to be considered is how advance organizers can be effective in helping the reader to comprehend the text.

The evidence reviewed in chapter 5 certainly indicates that advance organizers can be effective. Similarly, the evidence reviewed with regard to the activation of prior knowledge indicated that that, too, can be effective. As mentioned in chapter 5, is the question really one of facilitating a ‘set to learn’ disposition toward the text?

In essence, there seems to be little point in debating the precise nature of an advance organizer. The suggestion that “if it works, it is an advance organizer” is worth considering, whether the degree of abstractness or generalisability necessary for a true organizer has been demonstrated. Perhaps the phenomenon of success is more important. Thus, if verbal material provided prior to the main text is able to activate schema and prior knowledge in the reader, and is able through this and through its own structure to set the framework and organisation of the following text, then it is creating a set to learn context and is, in a real sense, an advance organizer.

Recent work by Dinnel and Glover (1985) suggests that the degree to which readers process the advance organizer, i.e. when they can actually paraphrase the organizer, determines the memorability of the subsequent reading material. Hopefully this will not lead to the development of ‘pre-advance organizers’, but it does suggest that the organizer, particularly in the case of expository organizers, needs, itself, to be well structured and to convey the structure of the forthcoming text.

A disposition toward learning depends, of course, on more than an advance organizer, and the reader’s contribution to this will be discussed later in this section.



It is clear that there are three main components in a reading system involving advance organizers – the text, the advance organizer, and the reader. The text has, in turn, three main variables – its content, cohesion, and staging (Singer 1985); the advance organizer has three main variables – its generality, abstraction, and isomorphism with the text; and the reader has three main variables – purpose, world knowledge, and reading/studying skill. It is proposed, therefore, that the following diagrammatic representation of the system be considered to account for the possible functioning or malfunctioning of advance organizers (fig 5:13).

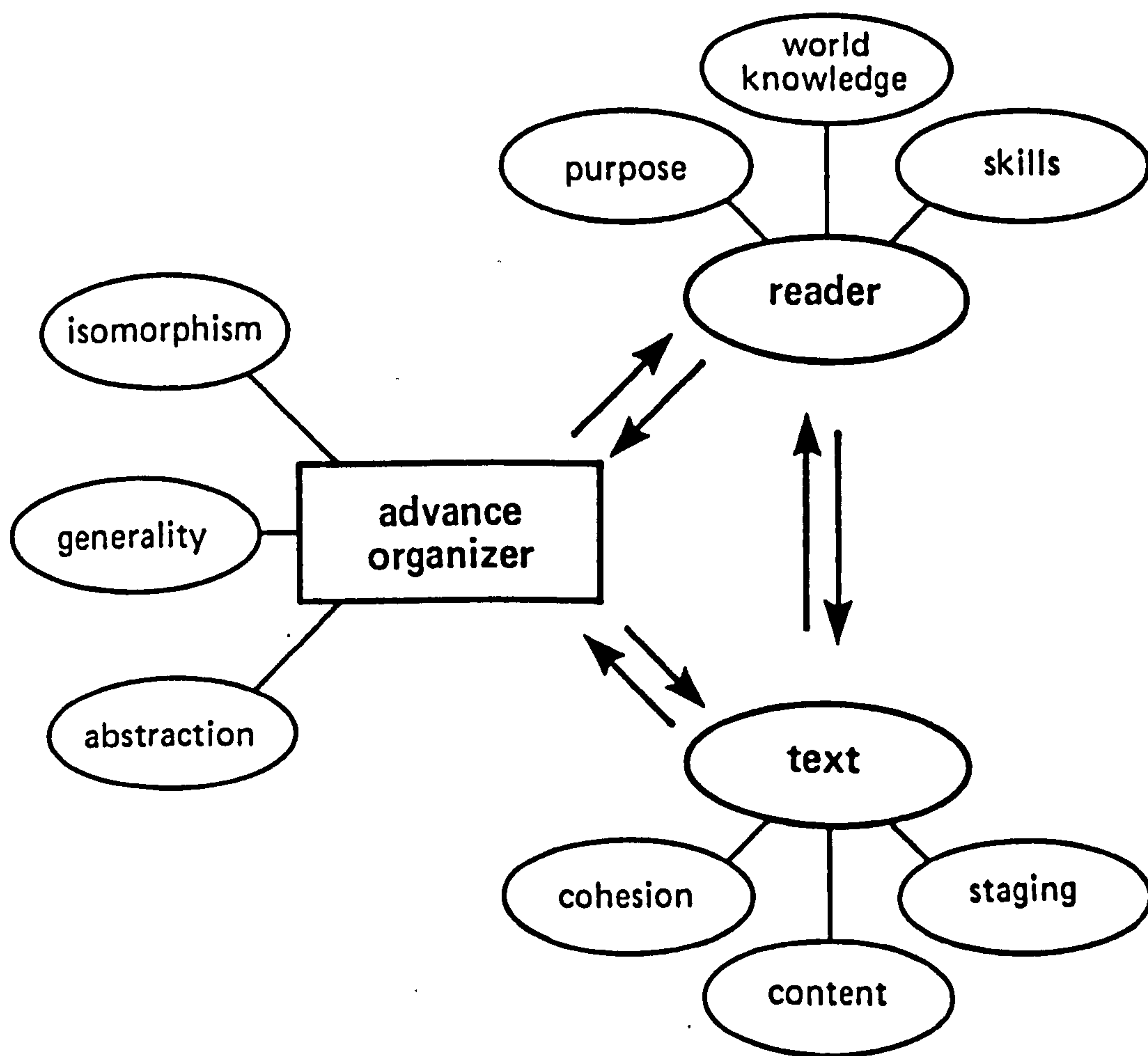


fig 5.13

In the system outlined above, the text is the starting point since it is the first part of the system to be created. From the text, the advance organizer is developed, then the reader interacts, first with the advance organizer and then with the main body of the text.



### **The text**

As already noted, the way in which the text is written, i.e. the way in which the content is treated with respect to top-level structure etc., the way in which main features are highlighted, and the way in which cohesion is achieved, will affect not only the comprehension process as the reader reacts with the text, but will also affect the possibilities available for the construction of the advance organizer. The text, therefore, may be well structured or poorly structured with respect to all three variables, or it may be anywhere in between.

### **The organizer**

Whether it is prepared in accordance with Ausubelian parameters or not, the *de facto* advance organizer may extend from a single word (as in a title) to, perhaps, a 1000 word mini-discourse and, within that continuum, may have a varying degree of isomorphism (i.e. the extent to which it reflects the structure of the text), and may have varying degrees of generality and abstraction.

### **The reader**

The advance organizer will probably be the first part of the printed material to be read by the reader, and the parameters affecting his/her ability to interact with and learn from text are really just as important in interacting with and learning from the advance organizer (cf Dinnel & Glover, 1985). The reader may or may not have the pre-requisite world knowledge, the declared purpose for reading, or the developed strategies and metacognitive skills necessary to benefit from the advance organizer and, subsequently, from the text.

The many variables, often internally infinitely variable, make it virtually impossible to be definite about when advance organisers will or will not be effective. Nevertheless, having regard to the research evidence concerning prior knowledge and advance organizers and the discussion of this with respect to schema theory, a general principle could be stated as:



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“If the reader is oriented by a brief verbal organizer toward the application of existing knowledge to the assimilation of the main features of new knowledge in text, then comprehension of that new knowledge will be facilitated”.

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Application of this principle is demanding on instructional design practice. While the use of advance organizers (however defined) is widespread, the incorporating within the organizer of material which encourages application of existing knowledge to key features of the new knowledge presents a challenge to the instructional designer which has to be accepted but which is possibly beyond current practice.

#### **5.2.2.2 The issue of graphic organizers**

The research reviewed relating to graphic organizers identifies two problems. First, what can be classified as a graphic organizer, and second, the issue of pre- or post- application. The second problem is more easily dealt with. The research dealing with graphic post-organizers was also dealing with reader generated as opposed to author-provided organizers and, as has already been noted, this sort of activity involves the reader in a generative activity which could require substantially more cognitive processing since overt performance is required. The first problem of definition is more difficult, but likely to be more useful if resolved.

Jonassen and Hawk (1983) refer to two types of graphic organizers, *participatory* and *final form*. Students participate in the completion of the former, but in the latter the teacher presents all of the information graphically related in its final form. With respect to this latter (final form) type of graphic organizer they make several important points including

- (a) ensuring that the location of graphic elements depicting the main points and the way they are spatially related on an organizer corresponds to the semantic relationships between the main ideas, and



- (b) ensuring that the graphic relationships are structurally isomorphic to the semantic relationships in the content.

This second point has also been identified by Schwarz and Kulhavy (1982) as being of importance.

Based upon a verbal-pictorial continuum as proposed by Wileman (1980), Hawk, McLeod, and Jonassen (1985) argue that graphic organizers can contain both pictorial (iconic sign) and verbal (digital sign) information and that, in accordance with Paivio's (1971) dual coding hypothesis, graphic organizers in text induce dual coding of information.

The question of what constitutes a graphic organizer is readily answered: any appropriate mixture of verbal and graphic material which relates to the structure of the text could, conceivably, act as a graphic advance organizer. At the intuitive level, there is a case for graphic organizers being particularly effective when the intention is to relate to structure because there is the potential not only to activate schema and indicate emphasis but, because of the possibility of dual coding or whatever other explanation there is for imagery, a higher level of cognitive operation, viz. relationship between ideas, can be presented as a starting point. For example, in an overview of the historical development of educational technology developed by Stewart (1983), the structure of the content had to reflect

- (a) a hierarchical development,
- (b) a bifurcation,
- (c) a coming together of two strands, and
- (d) a linear development.

A verbal advance organizer would have been possible, but considerable mental effort would have been required to identify the structure of the content from a verbal organizer. On the other hand, a graphic organizer which consisted only of verbal material in a spatial arrangement which reflected the semantic structure of the text conveyed immediately the overall shape of the argument (fig 5:14).



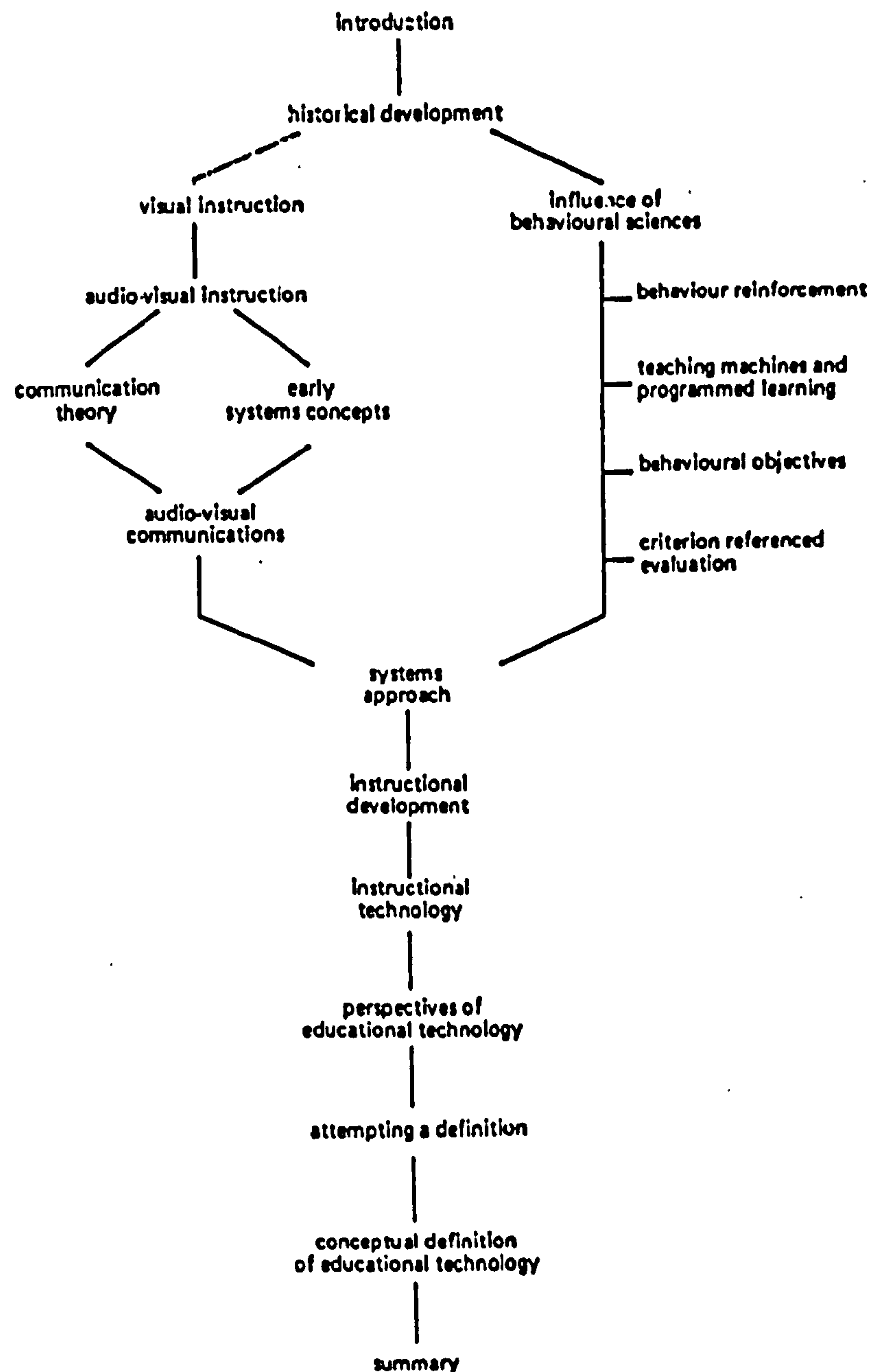


fig 5:14

It is doubtful whether there has been sufficient research carried out in this area to be particularly definite about graphic organizers, especially since there is lack of agreement between the nature of the organizer and the position of its placement. Nevertheless, from the available evidence relating to advance organizers in general and graphical organizers in particular, the following principle can reasonably be derived.

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“If a graphic organizer is used to convey isomorphically the structure of ideas in text, then comprehension of the structure will be facilitated.”

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It is interesting to note that the concept of graphic postorganizers has, recently, been considered within the context of spatial learning strategies (Barron & Schwartz, 1984) which, according to Holley and Dansereau (1984), are of importance because they tend to capitalise on many of the implications suggested by the formal models of comprehension such as (a) requiring encoding activities that compel the reader to process the material in greater semantic depth, (b) providing for the achievement of greater degrees of elaboration during encoding via reorganisation or dual encoding, (c) providing a reconstructive retrieval mechanism for the memory trace, and (d) providing for the bottom-up extraction of top-level schemata.

#### **5.2.2.3 The issue of adjunct questions**

The research reviewed in this chapter relating to adjunct questions appears to leave no doubt as to the effectiveness of adjunct questions. Recently, Hamilton (1985), in an evaluation of the effectiveness of adjunct questions concluded that with respect to the retention of verbatim and semantic verbal information, both verbatim and semantic adjunct questions have produced robust positive effects and that for the retention of verbatim verbal information the position of the verbatim adjunct question seems to be unimportant whereas, for the retention of semantic verbal information, semantic post-questions tend to produce larger increases in amount of semantic information retained from the prose passage. In similar vein, Lindner and Rickards (1985) have concluded that, in general, factual adjunct postquestions facilitate learner performance, and higher-level questions facilitate both the amount and organisation of information recalled from text.

The nature of the cognitive processing initiated by adjunct questions needs, of course, to be clarified. Lindner and Rickards (1985) have observed that Rothkopf (1965) began his investigations under the theoretical banner of neo-behaviourism but that over the last decade and a half, most of the subsequent research involving adjunct questions has assumed a cognitive perspective which emphasises the active and constructive role of the learner. Further indications of this change from behaviouristic to cognitive orientations are suggested by Rickards (1979) by the shift of interest from the effects of factual, verbatim-level questions to those of higher conceptual-



level questions and the attempt to examine the nature of the processing activities associated with the use of adjunct questions.

It has been suggested by Hamilton (1985) that, in experiments, subjects normally process the passage at a very superficial semantic level and that verbatim questions, whether pre- or post- are answered on the basis of this level of processing. However, in the case of semantic questions, the pre-questions would not only focus the subject on the relevant prose material but also induce more than a superficial semantic level of processing of the target material, whereas postquestions would have minimal effects on the processing of the target material because they occur after the target material.

This emphasis on level of cognitive processing associated with adjunct questions is of particular importance for this study. Lindner and Rickards (1985) conclude that higher-level questions affect not only the level at which material is processed but the manner in which such material is organised in memory, and that higher-level questions therefore affect the quality as well as the quantity of recall, a finding which is not supported by Andre and his co-workers (Andre, 1979; Andre, Mueller, Womack, Smid, & Tuttle, 1980). Perhaps the cognitive psychology research will never be the most useful source of an explanation for the uncertain findings discussed here, due to the large number of variables involved. As McConkie (1983) has noted

“the growth of cognitive approaches to theorizing has been stimulated by the recognition that . . . the organism often processes the information in different ways, depending on the task being performed”. (p 66)

Resnick (1985) has noted that there seems to have been only slight progress in the direction of accounting for questioning effects in terms of cognitive processes. She asserts that there also has not emerged an integrative account capable of linking questioning effects either to schema theories of reading or to general propositional models of reading such as that of Kintsch and van Dijk. The context in which this research could be considered, however, is that of ‘qualitative outcomes of learning’ (Marton & Saljo, 1984; Entwistle & Ramsden, 1983; Saljo, 1984) discussed in chapter 3. If the reader can be induced through the adjunct questions to adopt a ‘deep approach’ to



learning from that particular reading experience, then not only a deep semantic processing, but a more meaningful processing is likely to occur. Setting the work on adjunct questions in that context, leads to the derivation of the following principle.

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“If higher-level questions are inserted in text they are likely to induce a deeper level of processing on the part of the reader”.

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#### **5.2.2.4 The issue of mathemagenic activities**

Singer (1985) notes that teacher-provided activities that initiate or stimulate learning (i.e. mathemagenic activities) include, in addition to questions embedded in text, the establishment of purposes and goals by the reader. Certainly, the research reviewed in this chapter seems to suggest that the statement of learning objectives or desired learning outcomes facilitates learning. In a recent evaluation of the effectiveness of objectives, Hamilton (1985) notes that objectives have consistently produced positive effects only for the retention of verbatim verbal information while producing inconsistent effects for the retention of semantic verbal information. It appears, too, that this effect is in relation only to generally described goals or objectives and that the inclusion of other information consistent with the Magerian definition of objectives may, in fact, hinder the effects of the objectives.

To set the above in context consideration needs to be given to the nature of the instructional objective or learning goal stated. In the literature reviewed, most of the objectives have been low-level recall of information. It remains to be seen what would be the effect of a high-level objective. While an advance organizer may activate a particular schema or set of schemata, it is unlikely that the statement of an objective would have the same effect. What is much more likely is that the statement of a high-level objective (i.e. high-level in the Bloom or Gagne sense) would induce a set-to-learn from which deep processing would ensue. There does not appear to be any research which examines the effectiveness not only of high-level objectives



but of high-level inserted questions which measure achievement of the high-level objectives. It could be hypothesised on the basis of the evidence reviewed in this study, that such an interaction would virtually certainly lead to the desired deep processing and, consequently, comprehension of the text.

Perhaps it would be reasonable to consider the following principle in relation to the above.

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‘If a high-level learning outcome is stated as an objective in advance of reading, the learner is likely to adopt a deep approach to reading of the passage’.

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It is unfortunate that the concept of mathemagenic activities has been so widely criticised, particularly when contrasted with so-called ‘generative’ processes (Jonassen, 1985a). Rothkopf (1970) has made it clear that the study of mathemagenic activities is the study of the student’s actions that are relevant to the achievement of specified instructional objectives; that the concept of mathemagenic activity implies that a learner’s actions play an important role in determining what is being learned; and that the most important determinant of the capabilities a student acquires from printed material is what the student *does* with the instructional material. This is not inconsistent with a cognitive, constructivist, view of reading comprehension, nor does it imply that control of the comprehension process lies in the text. Reading comprehension is an interactive process between reader and the text and it is appropriate that verbal cueing (whether it be considered mathemagenic or not) should be used to facilitate achievement of the desired learning outcome.

### **5.3 The role of typographical cueing**

Shebilske and Rotondo (1981), in reviewing some of the research relating to non-verbal cueing, suggest that surface representation is an integral part of memory and sets the stage for developing typographies that facilitate



memory. From their own work they identify both typographical and spatial cues which can improve learning and memory of important information without reducing the learning and memory of unimportant information. Spatial and typographical cues frequently occur together, and probably are most effective when operating in concert. However, as Hartley (1985) has noted, spatial and typographic cues need to be used consistently. As already noted, this is often not the case, so it is relatively rare for both spatial and typographical cues to be used not only consistently, but in concert.

Since the use of space is, in effect, a grouping process within a Gestalt framework, it is easy to see how it can contribute to organisation and, hence, to comprehension. This assumes, however, that the use of space parallels the syntactic and semantic structure of the text. The theoretical framework within which spatial cueing can be considered is, therefore, primarily the Gestalt approach to visual information processing, strengthened, when there is correspondence between the spatial arrangement and the syntactic arrangement, by the cognitive information processing approach reviewed in chapter 3.

However, typographical cueing devices have greater potential for the design of print than do spatial cueing devices, and greater consideration needs to be given to a discussion of the theoretical framework within which the effectiveness of their use rests.

Perhaps the first, and vital, point relating to typographical cues is that made by Hartley (1985) viz. that cues only work when the reader knows what they signify, a reality which is not always realised as has been noted in the review.

Rennie, Neilson, and Braun (1981) claim that the theoretical framework and rationale for typographical cueing studies related to the superordinate structures of discourse are drawn from schema theory, metacognition, and typographical cueing, since schema-theoretic research demonstrates the psychological reality of macro-structures in the reading of expository text and the influence of prior knowledge on comprehension, metacognitive research, in exploring reader's introspective judgements about text processing, has shown that successful identification of top-level structures is a develop-



mental skill, and research related to the effect of typographical cueing has shown that cues provide an isolation effect by visually setting apart the cued words, resulting in a higher probability of recall of cued information.

Glynn, Britton, and Tillman (1985) set the effect of typographical cues firmly within a cognitive framework, but they see the role of typographical cues in relation to management of the reader's attention by helping him/her to identify, organise, and interpret the most important content in a text. In their view, the comprehension of instructional text is a formidable cognitive task since it requires the reader to call upon large bodies of relevant prior knowledge and concurrently carry out 'component comprehension processes' which include: recognising the words in the text and retrieving their meanings, identifying the important ideas in the text, organising these ideas, and integrating them with prior knowledge. Typographical cueing can therefore contribute to the identification of important ideas in text and, potentially, to the organisation of those ideas, and help to bring about the cognitive structures associated with text comprehension.

It is clear from the review of research in chapter 5 that headings play a particularly important part in typographical cueing, especially in helping readers to perceive the organisation of the text. Hartley and Jonassen (1985) have set the theoretical framework for the effectiveness of headings by proposing that headings function in two different ways to help learners acquire knowledge from text. They suggest that during the initial encoding of the information from the text into memory, headings help to organise and structure the incoming information, and that headings also provide an access facility for the location and retrieval of information from text. These purposes for headings are elaborated fig 5.15.

The diagram implies, however, that access and retrieval relate not only to the text but to its representation in memory. While the research reviewed does suggest that this is a possibility, it also suggests that such access and retrieval is more likely for low-level or subordinate information and is dependent upon the reader being instructed in the use of headings (Brooks, Dansereau, Spurlin, & Holley, 1983; Dee-Lucas & DiVesta, 1980). Such a representation in memory would be a purely propositional representation. If, however, the headings in the text have some spatial arrangement, then the



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*Graphic Heading on Information-  
Processing Functions of Headings*

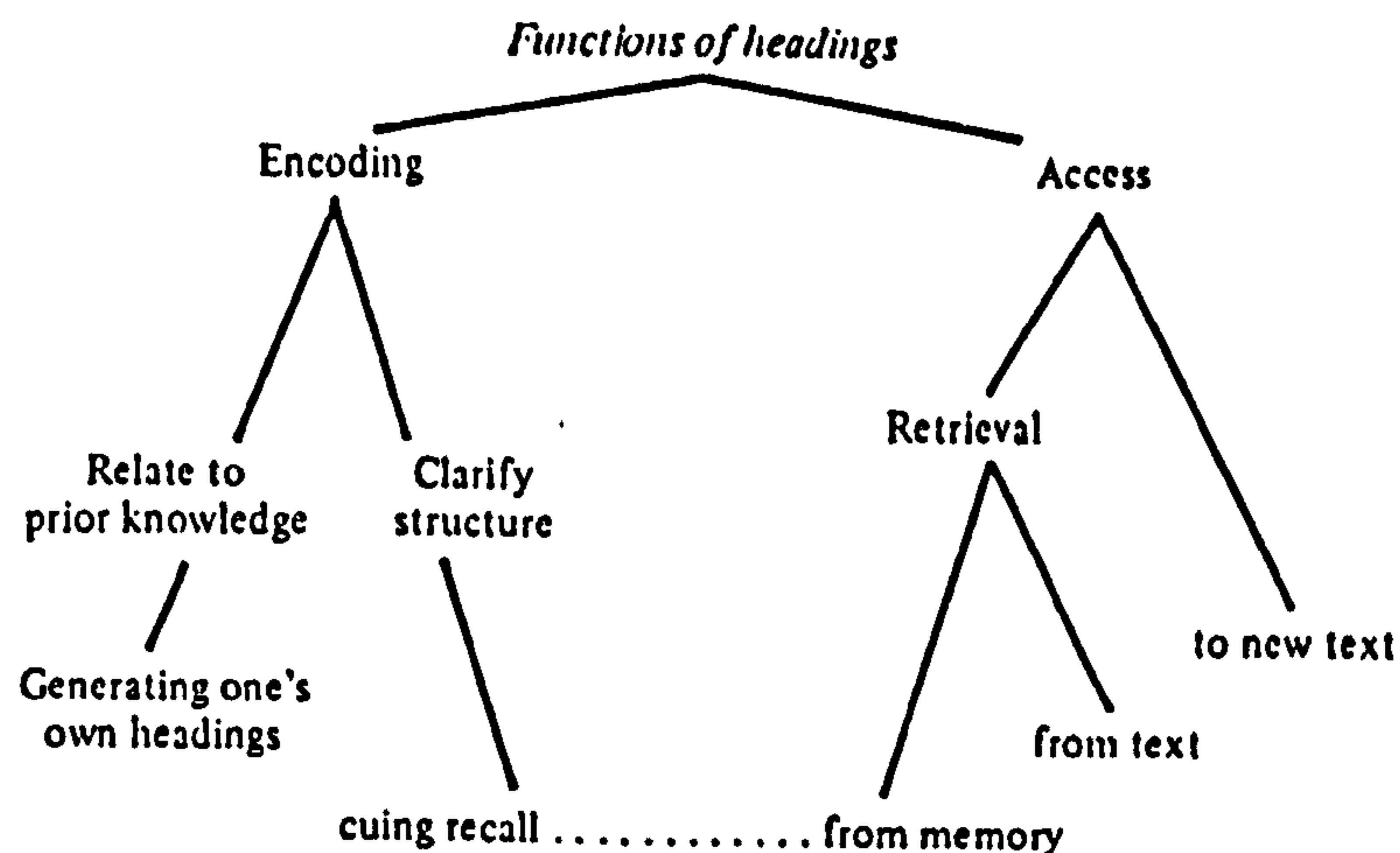


fig 5:15

(Hartley & Jonassen, 1985, p 240)

representation in memory could be other than propositional and could be more memorable. This is much more in line with the concept of 'text as diagram' (Waller, 1982). As Waller (1985) has pointed out, there is a sense in which the physical shape of prose adds something to its meaning. The illustration quoted by Hartley (1985) (fig 5.16) is not only an example of unjustified text with line endings determined by syntactic considerations, it is also an example of text as diagram in that it has a characteristic shape.

In the beginning  
 God created the heaven and the earth.  
 And the earth was without form, and void;  
 and darkness was upon the face of the deep.  
 And the spirit of God  
 moved upon the face of the waters.

(p 5327)

fig 5.16

Waller (1985) argues that the concept of text as diagram requires that typographically-structured pages must be seen in their wholeness and must operate within the artifactual limitations of the print medium in a way that contrasts with the normal view of prose. He claims that typographical and spatial factors can be used to clarify the larger structural relationships in a text thus easing the cognitive burden.

This is the same framework as that within which Stewart (1984) operated



when designing text which would help health professionals cope with conceptual change. The typographical layout allowed for several levels of hierarchic arrangement, so that main headings were above the body of the text, sub-headings were in a smaller point size and at the side of the body of text, and sub-sub headings were in a different typeface, in a smaller point size, and preceded with a ■ symbol (fig 5.17). The whole page thus has a characteristic shape indicative of the structural relationships in the text. On its own, this could be quite effective: it was, however, seen in conjunction with a visual organizer which was, in effect, the topic analysis of the material (fig 5.18). The visual organizer indicated the location of this particular

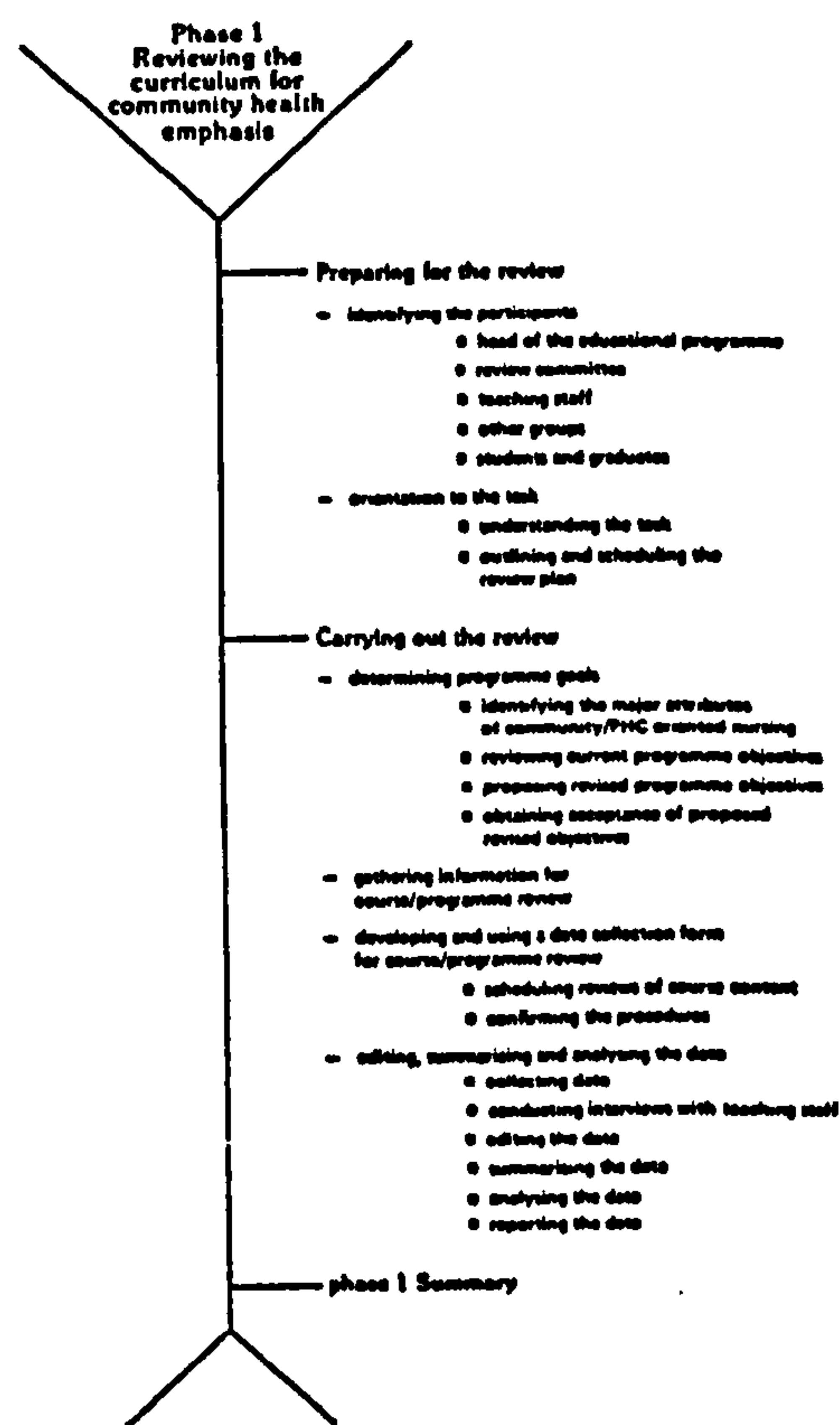


fig 5.18

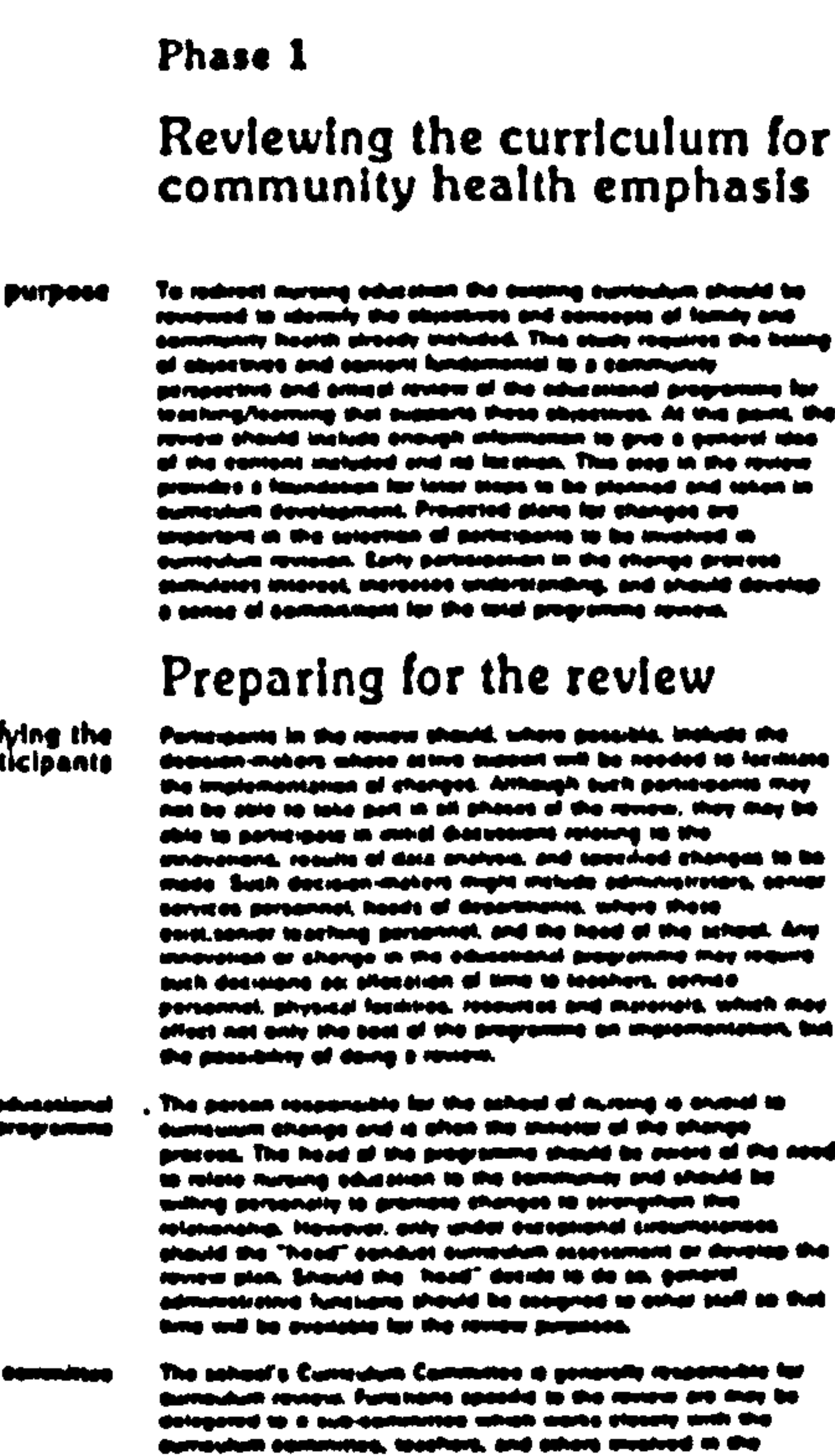
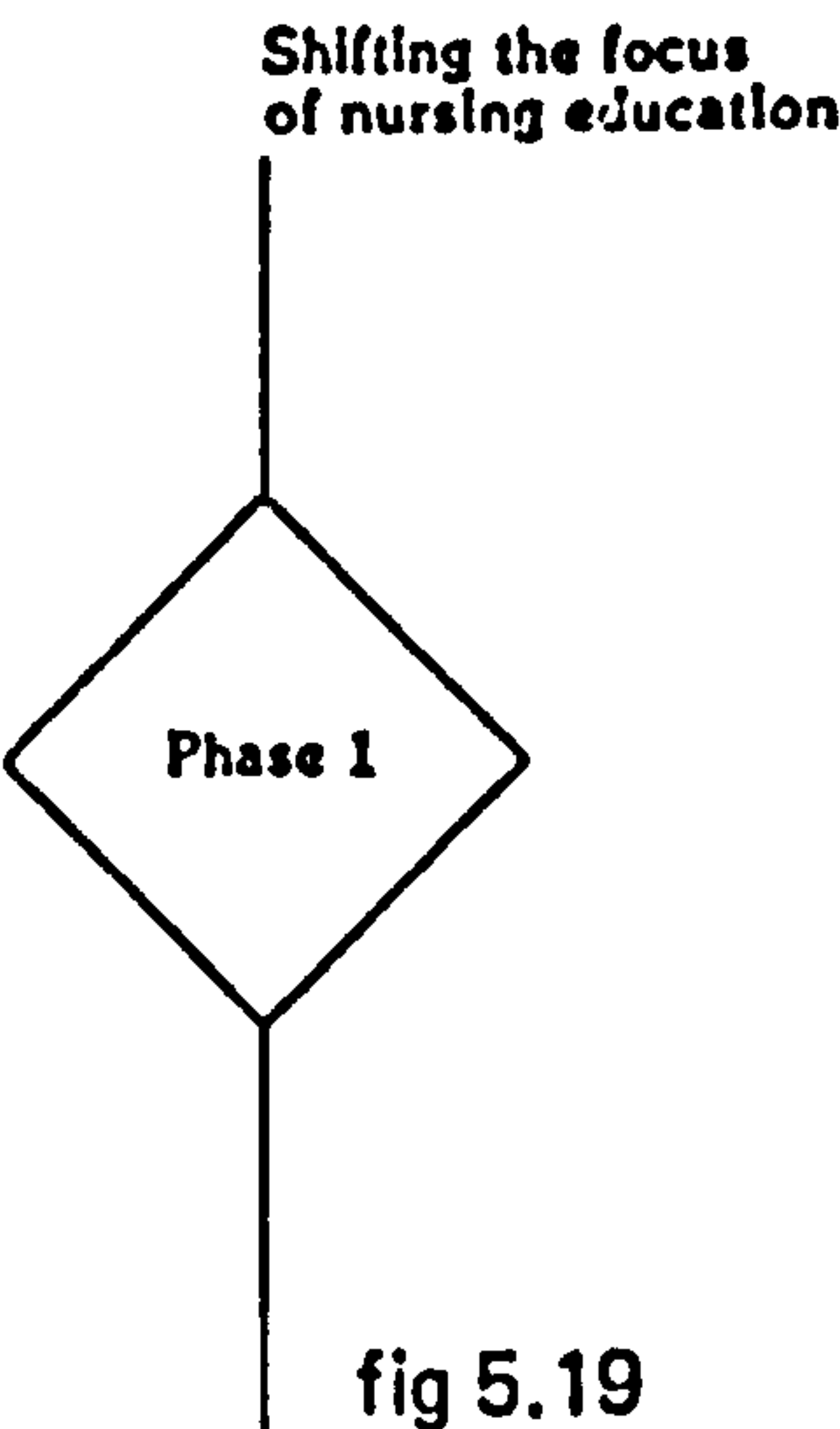


fig 5.17

section within a more global structure, each phase having been indicated as shown in fig 5.19, and indicated the structural relationship of the various levels of argument within the text.





What is being argued is that a spatially and typographically cued text in which the whole page can be regarded within the 'text as diagram' concept, is probably capitalising on all the known theoretical frameworks for the comprehension of text and reducing the cognitive load for the reader.

From the discussion on spatial and typographical cueing, therefore, the following principle is derived

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"If headings in text are chosen and arranged spatially and typographically to reflect the structural relationships in the text, comprehension of both the structure and the content of the text is likely to be enhanced."

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The above principle makes one rather basic assumption, viz. that the wording of the headings accurately reflects the content of the text. There is a fairly widespread tendency to insert headings simply to break up the text, in which case they contribute nothing to the comprehension of the text and may, in fact, mislead as Swarts, Flower, and Hayes (1980) have shown.

## **5.4 Student strategies**

At several points in this discussion, mention has been made of reader strategies, including reader-generated visual post-organizers, reader-generated adjunct questions, reader-generated headings, or metacognitive activities. They have been dealt with briefly and, in the process, have been referred to as generative activities requiring a level of processing beyond that normally expected to accompany constructive cognitive activities. Nevertheless, it has to be acknowledged that the interactive reading process involves not only the text and the reader's prior knowledge and schemata, but the reader's acquired and developed skills in interacting with text. Consequently, there is a need to examine in more detail the nature of these skills.



In a review of the research relating to reader-generated questioning or self-questioning, Wong (1985) approached the topic from three theoretical perspectives: the active processing perspective, metacognitive theory, and schema theory. The active processing theoretical perspective was identified as focusing on comparative investigations of the efficacy of student-generated versus teacher-generated questions on student's prose processing and on the qualitative and quantitative aspects of self-questioning instruction; the metacognitive theory perspective was identified as focusing on self-monitoring instruction; and the schema theory perspective was identified as focusing on activating student's relevant prior knowledge.

It was observed by Wong (1985) from the 27 studies reviewed, that the type of questions on which students were instructed corresponded to instructional implications from the theoretical perspective used by the researchers, so that an investigator using the active processing theoretical perspective would focus on instructing students in generating higher order questions, an investigator using the metacognitive theoretical perspective would focus on instructing students in generating self-monitoring questions to ensure comprehension of important textual elements, and an investigator using the schema theoretical perspective would focus on instructing students in generating questions that would activate relevant prior knowledge to enhance textual understanding. However, despite the different perspectives from which the studies had been carried out, she was able to conclude that self-questioning instructional studies have been efficacious in enhancing students' processing of prose. It has to be noted, therefore, that not only is self-questioning or reader-generated questioning a strategy which can facilitate comprehension of prose, it is a strategy which can be acquired and developed.

Of the 27 studies reviewed by Wong (1985) only four were from the metacognitive perspective and only one from the schema perspective, the reason for which, she suggests, is due to the recency of using these perspectives in self-questioning instructional research. The metacognitive approach in reading comprehension studies is fairly recent. However, as it has been referred to on several occasions without explanation (and avoided on other occasions since mention of it without explanation would have been unhelpful) a brief review of its potential is included here.



Jonassen (1985d) has stated that the cognitive tasks, and the differences in comprehension which they produce, can occur at three general levels of text processing, viz. micro-processing, macro-processing, and meta-processing. At the meta-processing level, differences in comprehension result from a combination of metacognitive processes, cognitive strategies, and executive control processes, terms which, although not synonymous, in common indicate that learners who consciously employ various processing strategies while processing text almost invariably comprehend it better.

Armbruster and Anderson (1985b) have pointed out that the cognitive strategies students use include not only the initial focusing of attention and the subsequent encoding of the information attended to, but also an 'executive level' aspect of these processes called metacognition. Armbruster and Brown (1984) have argued that efficient and effective learning depends on the orchestration of a number of variables, an orchestration which is accomplished by a higher-order process called *metacognition*.

Brown and Palincsar (1982) highlighted the fact that, although the term metacognition has been used very broadly to refer to many aspects of active cognition, two broad categories can be distinguished, namely *knowledge about cognition* and *regulation of cognition*. Knowledge about cognition involves conscious access to the individual's own cognitive operations and reflection about those of others and is usually assumed to be late in developing since it requires that learners can step back and consider their own cognitive processes. Regulation of cognition, often referred to as 'executive control' within information processing models, involves planning activities prior to understanding a problem, monitoring activities during learning, and checking outcomes.

With respect to metacognitive processes in relation to text processing, Armbruster and Brown (1984) describe the specific application as follows.

"The first type of metacognition, knowledge about cognition, refers to knowledge readers have about their own constellation of component variables: their repertoire of abilities and activities and the compatibility between these and the demands of the text and the criterion task.



The second type of metacognition, regulation of cognition, consists of the self-regulatory mechanisms used by an active learner during reading. These mechanisms include planning one's next move, checking the outcomes of any strategies one might use, monitoring the effectiveness of any attempted action, and testing, revising, and evaluating one's strategies for learning."

(p 274)

Brown (1981) notes that knowledge about cognition is the form of knowledge that has traditionally been referred to as "knowing that", whereas regulation of cognition is the form of knowledge often referred to as "knowing how", and that although the term metacognition may be new, the type of knowledge to which it refers has long been recognised.

Perhaps the most important aspect of metacognitive skills is that they can be taught. Armbruster and Brown (1984) have observed that research on summarisation and self-questioning indicates that lower-achieving students can benefit from instruction in learning to learn from text that includes training in metacognitive skills. Brown, Campione and Day (1981), recognising that readers can learn how to learn from text, conclude that:

"If learners can be made aware of (1) basic strategies for reading and remembering, (2) simple rules of text construction, (3) differing demands of a variety of texts to which their information may be put, and (4) the importance of activating any background knowledge which they may have, they cannot help but become more effective learners. Such awareness is a pre-requisite for self-regulation, the ability to orchestrate, monitor, and check one's own cognitive activities".

(p 20)

Given that summary of the situation, no principles need to be derived.



## 5.5 Conclusion

The organisation of text can be made explicit through both verbal and typographical cueing systems.

Verbal cueing can be either of a linguistic nature, i.e. concerned with the semantic and syntactic structure of the text, or of an instructional design nature, i.e. verbal support such as advance organizers and adjunct questions which, although an integral part of the text, are not really part of the content. Application of the principles identified in relation to verbal cueing suggests a requirement for an integration of linguistic and instructional design approaches to the design of text or an extending of instructional design practice to include linguistic considerations.

Typographical cueing, which could be considered as including spatial cueing, is very much more than simply the use of headings and can be used to clarify the larger structural relationships in a text, thus easing the cognitive burden. Educational practice with respect to typographical cueing needs to be reconsidered, therefore, within the context of making explicit structural relationships. It is not so much that practice is contrary to principle, but rather that practice is not always grounded in principle.

Student strategies in reading need to include, within a metacognitive context, the ability to monitor not only the linguistic indicators of relative significance in the text but the typographical cues signifying significance and the instructional design adjuncts developed to activate prior knowledge.



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## **6    Integration and summary**

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### **6.1    Introduction**

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### **6.2    Legibility of print**

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#### **6.2.1    Legibility**

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#### **6.2.2    Layout**

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### **6.3    Readability**

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#### **6.3.1    Cognitive aspects**

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#### **6.3.2    Affective aspects**

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### **6.4    Comprehension**

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#### **6.4.1    Psycholinguistics and cognitive psychology**

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#### **6.4.2    Eye-movement research**

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#### **6.4.3    Imagery**

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#### **6.4.4    Depth of processing**

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### **6.5    Visual illustration**

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#### **6.5.1    Visual perception**

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#### **6.5.2    Visuals in learning**

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#### **6.5.3    Visuals in text**

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### **6.6    Structure and organisation**

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#### **6.6.1    Verbal cueing**

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#### **6.6.2    Typographical cueing**

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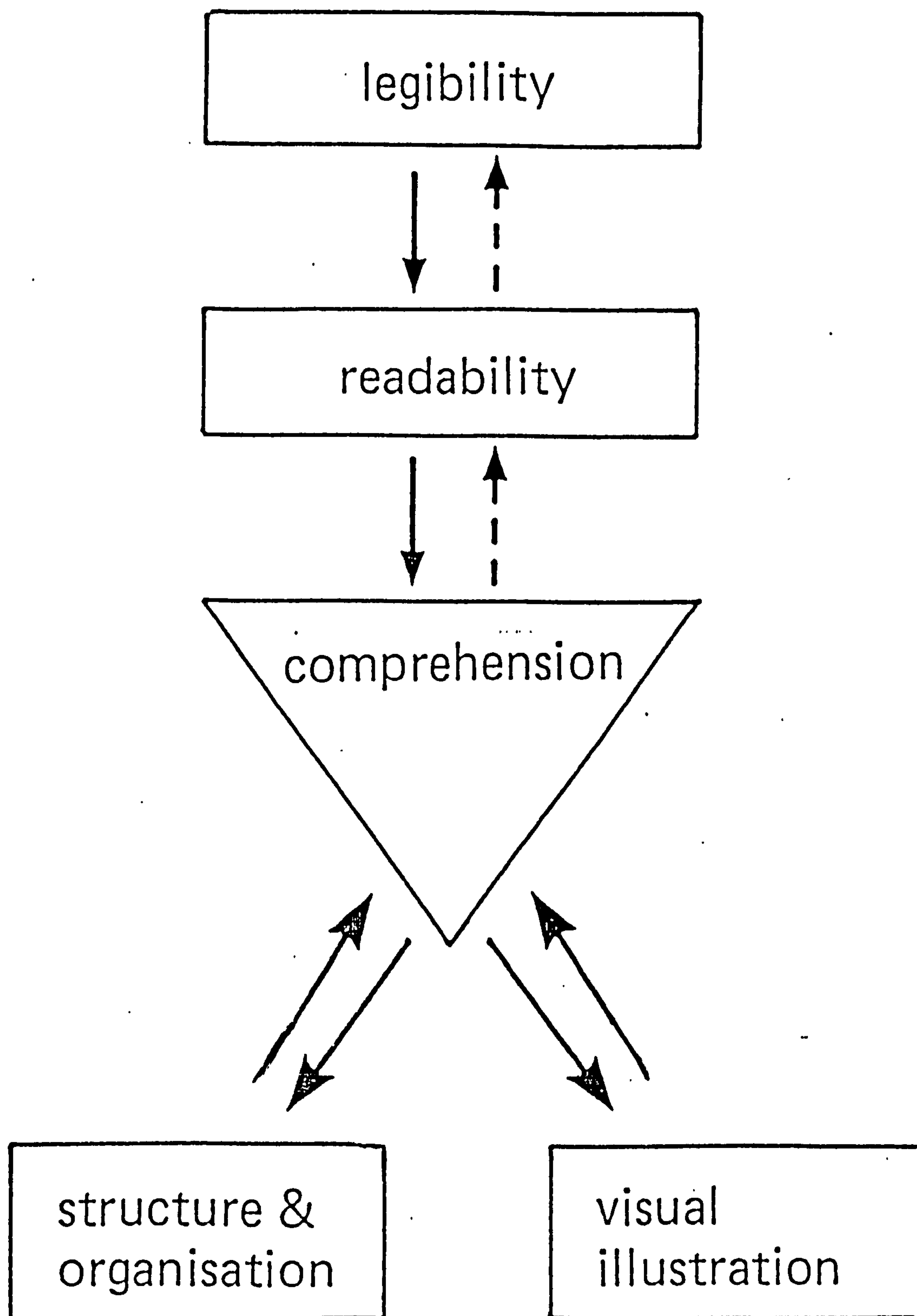
#### **6.6.3    Reader strategies**

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### **6.7    Conclusion**

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## 6 Integration and summary

### 6.1 Introduction

It was noted in the *Introduction* to this thesis that psychological theory and research have failed to be successful in helping students to derive information from text, a failure which was attributed by Goetz (1984) to the traditional sharp distinction between basic research, applied research, and educational practice, and to the tradition within each strand. It was also noted that the failure of psychological research was due, according to Entwistle (1984), to a reliance on research procedures in the physical sciences which he considered inappropriate to the task, as a consequence of which he proposed an alternative paradigm involving approaches to research rooted in phenomenology, an approach which involves a shift not just of methodology, but of perspective.

In reviewing the research associated with the various aspects of learning from print, results from both the traditional 'scientific' approach and the phenomenological approach have been considered without any value judgment as to the relative worth of each. It is recognised that rigorous, quantitative enquiries may yield results which have statistical significance but no educational significance and, equally, that qualitative enquiries may lack rigorous quantitative data from which principles are traditionally inferred. The argument by Howe (1985) that "the rigid epistemological distinctions between quantitative and qualitative methods and between factual and value judgments exemplified in present thinking about educational research methodology are unsupported dogmas held over from logical positivism" (p 10) is in accord with the view taken in this study. There is, in the study, an empathy with the view of Strauss (1963) that "man thinks, not the brain", and the derivation of principles has, therefore, been based upon both quantitative and qualitative research findings as appropriate.

The study has been concerned with an analysis of the research related to three perspectives on instructional text, viz. the 'physical characteristics' research exemplified by the work done on legibility and readability, the 'learning theories' research typified by the work on human memory and



representation of knowledge, and the 'improvement of text' research, characterised by the work on adjunct aids, illustrations, and typographical cueing. At each stage there has been a discussion of the research reviewed in an attempt to identify basic principles which could be applied to the design of text as an instructional medium, and from which a theory of instructional text design might emerge, and to relate these principles to educational practice in order to assess consistency or need for change. As noted in the *Introduction*, the study of reading comprehension became a pivotal focus which resulted in the contribution of visual illustrations, adjunct aids, typographical cueing, and other structural and organisational devices to the reading comprehension process being considered not only in the historical context of their respective developments, but from a new perspective of a cognitive framework for reading comprehension. Similarly, the nature of the contribution of legibility and readability to reading comprehension needs to be re-examined in the context of an understanding of the reading comprehension process.

It is the purpose of this chapter, therefore, to integrate further the discussion of the various issues raised and to summarise the principles derived from the discussion, together with their implications for practice and their possibilities for a theory of instructional text design.

## **6.2 Legibility of print**

Since the first step in reading for understanding must rest on the legibility of the material concerned, the aphorism

“If it isn't legible, it won't be read”

is a statement of a fairly fundamental principle, the implications for practice of which need to be clearly identified. Basically, there are two areas for typographical practice where legibility considerations are important, viz. in the physical aspects related to legibility and in the more psychological aspects related to layout.



### 6.2.1 Legibility

The principles derived in relation to typeface; typestyle; size of type; length of line, and interlinear spacing; and justification are not affected by any of the considerations raised in subsequent chapters. They arise, in the main, from text-based parameters and are affected only marginally by the input from the reader.

It is in relation to their respective parameters that they are now summarised.

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Typeface:	"If a typeface is fully formed, well proportioned, within and between characters, it will have maximum legibility".
Typestyle:	"If normal weight lower-case typestyle is used, there will be maximum legibility".  "If different slant or weight of type is used, there will be an increase in emphasis provided such use of type is not associated conventionally with some other purpose".
Size of type, length of line, and interlinear spacing:	"If text is set in 11 point type, within a line length of 18–32 picas and with 2 pt leading, it will have optimal legibility".
Justification:	"If text is justified without excessive hyphenation and/or increase of inter-word spacing, legibility will be at least as good as unjustified text and may be more readable".

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The principle relating to typeface should, in practice, cause the producers of printed instructional materials to be particularly careful with respect to the output of printers connected to computers. Those relating to typestyle should, in practice prevent the use of upper-case type to any extent and encourage the discriminate use of italics and bold type.

The principle relating size of type with length of line and interlinear spacing should, in practice, be a caution to those who tend to type 'all the way across the page' and should have implications for the layout of the page



since length of line is such a strongly determining factor in layout. The principle relating to justification should, in practice, cause the producers of printed instructional materials to be careful concerning the output from word processing systems and to over-ride the automatic justification features of these systems.

### **6.2.2 Layout**

The use of typographical characteristics to affect layout is determined, in part, by the physical parameters referred to earlier, but also by the potential contribution which typographic features can make to reading comprehension in their cueing capacity. The highlighting of key words and phrases by typographic means (e.g. through italic or bold face) is a comparatively elementary use of typographic cueing, despite its effectiveness. The use of typographic cueing to reflect the structure of textual content is a much more sophisticated application, and the discussion in chapter 5 regarding this organisational role for typography provides a psychological dimension to what was initially regarded as only a physical consideration. In this sense, legibility and layout cannot be considered as an a-theoretical study. From the perspective of instructional text design, layout and typographical cueing assume a new importance and can justify, in addition to the principle already derived relating to layout, an additional principle relating to typographical cueing.

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Layout:	“If the layout of a page is determined by the empirical evidence regarding typographic characteristics, the page will be more legible than if these characteristics are ignored”.
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Typographic cueing:	“If the typographic arrangement reflects the key features of the content of the text, comprehension of the structure of the text will be facilitated”.
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The implications for educational practice of the application of this latter principle are substantial. It is not uncommon for typographic matters to be left to the typesetter or printer, yet it is unreasonable to expect these



persons to be able to analyse content and identify key features. Typographic cueing needs to be determined, therefore, by the author or the designer of the instructional text. It is important, then, that such persons need to be familiar with typography and its manner of specification.

## 6.3 Readability

Klare (1984a) has observed that analysis of comprehension promises to be one of the more active areas of research in the future and predicts that

“It should be interesting to look at the  
question of readability and comprehension  
again 25 years from now”. (p 493)

The problems associated with the cognitive aspects of readability are certainly real, but without waiting for 25 years, it is possible to reconsider the issues raised in chapter 2 in the light of the understanding of the comprehension process reviewed in chapter 3.

### 6.3.1 Cognitive aspects

Huckin (1983) compared the cognitive-psychological approach to readability with the readability formula approach and concluded that they could be integrated. He distinguished between the approaches by noting that cognitive psychology is, by definition, a *process-oriented* science, seeking to understand how people interpret, store, retrieve, and otherwise manipulate lightly abstract entities in their minds, whereas readability formulae are inherently *product-oriented* since they are used properly only when they are applied to finished products. The major differences in approach, as identified by Huckin (1983) are as follows:

- (a) the cognitive psychology approach attributes importance to the reader's familiarity with the material while the readability formula approach ignores this factor;
- (b) the cognitive psychology approach is concerned with reading style and how it relates to readability, but readability formula developers have no interest in this variable; and



- (c) the cognitive psychology approach searches for the factors which actually cause readability to increase or decrease, from which can be derived guidelines for readability, whereas the readability formula approach is concerned not with causal factors but with quantitative factors that are concerned with overall readability. The guidelines which can be developed from readability formulae may change the readability score but not necessarily the comprehensibility of a text.

Kintsch and Miller (1984) have also viewed readability from a cognitive psychology standpoint. They indict the a-theoretical orientation that has dominated readability research since its beginning, arguing that readability is not a fixed property of a text but, rather, the result of the interaction between a reader and a text. In their judgment, readability is best interpreted from the perspective of the more general process of prose comprehension.

“It is now clear that comprehension, and therefore readability, is a complex, multi-level process, and that, correspondingly, no single indicator will be adequate. Instead, a battery of tests will be necessary to explore how well a text and a particular reader are matched”.

(p 231)

Amiran and Jones (1982) have proposed a taxonomic analysis of three variables that define difficulty of text, viz. structure, texture (or explicitness), and informational density of text, but they have also identified reader variables of world knowledge and ability to use learning strategies as giving rise to important interactions with textual variables.

The review of research relating to comprehension highlights the need for readability to be considered within a much broader framework than hitherto so that the textual variables can be extended to include higher-level characteristics such as ‘idea density’, and ‘organisation’, and the wide range of reader-based variables can be included. Perhaps the summary by Chall (1984) is helpfully balanced.



**“The new research in prose comprehension has, potentially, much to offer to readability measurement. Its major contribution will be, I believe, to the measurement of the more qualitative, elusive factors that have been tried by readability researchers, but which were not fully satisfactory. Generally, although the basis for some of the ideas may stem from a different theoretical tradition — cognitive psychology, linguistics — than that of traditional readability studies, they are contiguous with it”. (p 246)**

Within a cognitive psychology approach to readability, Huckin (1983) offers the following tentative guidelines.

- 1. State your purpose explicitly, in such a way that your reader can anticipate the approach you are taking to the subject. Make it clear to the reader what issue or conflict you’re addressing.**
- 2. Make the topic of each section and paragraph *visually prominent* — by using headings and subheadings, and by placing topic sentences at the beginning of paragraphs.**
- 3. Keep the topic in the reader’s mind by referring to it frequently, preferably in the grammatical subject position of sentences.**
- 4. Try to anticipate what reading style the reader is likely to use. If it’s just skim-reading, concentrate on formatting, headings, topic sentences, visual aids, and other general guides to the informational hierarchy of the text. But if the reader will need to read for detailed comprehension or evaluation, employ techniques that help the reader in the step-by-step processing of information in short-term memory; the remaining guidelines describe some of these techniques.**
- 5. Structure the text according to the nature of the information you want the reader to pay most attention to. If it’s main ideas, use a hierarchical (general-to-particular) structure; if details, use a listing (coordinate) structure.**



6. Once you've started referring to something by a particular name, *continue* referring to it that way. Don't vary your terminology just for the sake of variation.
7. When writing for nonspecialists, be sure to explicate the most important concepts in your text by using examples, operational definitions, analogies, or other forms of illustration. In other words, use familiar concepts to explain unfamiliar ones.
8. When writing for specialists, on the other hand, do not *overexplain*. That is, do not use lengthy examples, operational definitions, analogies, and so on for concepts the reader is likely to already be familiar with. Instead, rely on the standard terminology of the field, even when such terminology is long and complicated.

(p 101)

The aphorism stated earlier,

"If a text is readable, it is more likely to be understandable"

is not affected by the reinterpretation of readability within a cognitive psychology framework.

The more detailed principle derived earlier,

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"If the semantic and syntactic structure of the text is matched to the vocabulary and reading ability of the reader, there is more likely to be meaningful interaction between reader and text".

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is also valid, despite its roots in the traditional surface-level readability formula approach. The cognitive psychology framework for an understanding of the comprehension process and, thus, for readability, emphasises the psycholinguistic aspects of text as well as the reader-based sources of variance. However, those same emphases from cognitive psychology probably require the derivation of an additional principle which reflects more explicitly the cognitive orientation of readability.



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“If the content and the psycholinguistic organisation of a text are related to the prior knowledge and the cognitive ability of the reader, the readability of the text will be enhanced”.

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These two principles raise problems for educational practice due to the connection of content and style with reader ability and prior knowledge. While it is an ideal of instructional design to develop learning experiences matched to the requirements of the individual, individualised learning does not normally imply such fine tuning of ‘individualising’ as would be required in the application of these principles, nor is the production of printed materials normally associated with design for the individual learner. Print is essentially a mass medium, yet these principles demand a considerable measure of individualisation. It is unrealistic to prepare print materials for an individual reader, and the application of these principles is probably best carried out by careful consideration of the group of readers for whom the material is being prepared, assessing as accurately as possible the abilities and prior knowledge which they have.

### **6.3.2 Affective aspects**

Reconsideration of readability within a cognitive/information-processing framework has no effect upon the affective aspects dealt with in chapter 2. In fact, a criticism of the cognitive/information-processing approach could be that it makes insufficient allowance for non-cognitive factors which affect comprehension. Noddings and Shore (1984) have argued that ‘understanding’ involves a fulfilled complementarity of intellect and intuition in an individual; have emphasised the relationship between the ‘will’ and intuition; and have highlighted the importance of appeal to the senses in intuitive arrangements where the material is, by its nature, affect laden.

The affective dimension of readability is one which is deserving of further research. Whether such research is likely in a climate of cognitive research influenced by the metaphor of the computer and its processing procedures



is another matter. Thus, the already derived principle relating to the affective dimension of readability remains.

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“If a text is designed to generate optimal readability, reader motivation will be enhanced”.

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As noted earlier, such a principle emphasises the text-induced aspect of readability and the interactive nature of readability. Its implications for practice are important since it posits that whatever initial motivation exists can be increased through the enhancement of the affective dimension of the text’s readability and that this improvement in readability will, through increased motivation, bring about greater comprehension. In practice, therefore, considerable attention needs to be directed to those aspects of a text’s design which contribute to its affect.

## 6.4 Comprehension

As noted in the *Introduction* to this thesis, the issue of comprehension is the pivotal focus of the study since,

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“If it isn’t comprehensible, it won’t result in meaningful learning”.

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Legibility and readability studies made inadequate assumptions about comprehension: the practices of adjunct and organisational aids in text were developed in a less than defensible theoretical framework; and the use of illustrations was often conducted in a theoretical vacuum. An understanding of the comprehension process has required, as already discussed, the development of a more credible framework for legibility and readability. Equally, it has required a reorientation of the theoretical framework within which adjunct aids and visual illustrations are considered, and the research in each of these fields has, in turn, contributed to a richer understanding of the comprehension process.

Criticism of the information-processing/cognitive psychology approach to an understanding of the comprehension process could be levelled at the over-



dependence on computer analogy concepts. The reference earlier to Strauss' (1963) phrase that "man thinks, not the brain" highlights the need for the totality of experience being involved in the comprehension process. Similarly the evidence of Zajonc (1980) that affect is not only separate from cognition but is a pre-cognitive process, emphasises the totality of man's experience, as does the reference earlier to intuition and cognition (Noddings & Shore, 1984). The limitations of the computer analogy must be recognised, because there is a sense in which the present direction of cognitive research is allowing the computer to "create man in its own image".

#### **6.4.1 Psycholinguistics and Cognitive Psychology**

The research discussed in relation to psycholinguistics and cognitive psychology, and the principles derived from the work done in these areas are fundamental to the design of instructional text. From both psycholinguistics and cognitive psychology has come the notion of 'ideas' in text — a notion which is in marked contrast with the more surface aspects highlighted in the earlier readability studies — and the principles derived in relation to this concept are reiterated as follows.

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"If the comprehension of text is concerned with the construction of ideas, then the text needs to be designed so that ideas are emphasised".

"If the ideas in discourse are emphasised and indicated in the organisation of the text, the reader is likely to form representations and networks of representations in keeping with the organisational plan".

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The information/cognitive psychology approach to comprehension has tended to regard the 'representations' as being propositional in nature, and again caution must be expressed because the evidence from imagery suggests that representations can certainly be non-propositional. In similar vein Noddings and Shore (1984) have suggested that intuition is the mental



capacity that receives and creates representations and that if intuition is neglected, affective connections are not made and material is quickly forgotten.

The highlighting of ideas can, of course, be done by other than linguistic techniques, and the implications for typographical cueing arising from these principles are important. Equally, the possibility of using typographical cues in concert with linguistic cues is, potentially, of considerable importance to the designer of instructional text.

Perhaps the most important contribution to the conceptual framework of reading comprehension has come from the work done on schema theory and prior knowledge since it provides such a useful foundation, particularly when combined with the work on psycholinguistics representation, for the practical design of instructional text. The principle derived from schema theory is, therefore, of fundamental importance.

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“If reading comprehension is an interactive process between text-based ideas and reader-based schemata then the greater the correspondence between the text and the prior knowledge of the reader, the more efficient will be the comprehension”.

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Such a principle has implications not only for organisation and structure of text in relation to the facilitation of comprehension. It would, *ergo propter hoc*, contribute to the readability of the text.

The emphasis in the research on variables in the reading comprehension process being either text-based or reader-based brings together the crucial criteria for both readability and comprehensibility, and the general principle derived from that perspective is of considerable relevance for the designer of instructional text, viz.

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“If the design of text takes into consideration the process of comprehension involved in reading to learn with respect to text-based and reader-based variables, comprehension will be optimised”.

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As noted in the discussion section of chapter 3, the above principles from psycholinguistics and cognitive psychology have implications in relation to the nature of the text since they require that idea units in the text be emphasised by semantic, syntactic, or typographic means. Highlighting of idea units by typographical means requires the sort of skills on the part of the author, instructional designer, or instructional materials developer as were identified in relation to readability, but highlighting by semantic or syntactic means requires a linguistic ability not normally expected of an instructional designer. The instructional developer already needs many skills, but he/she is unlikely to be the complete instructional designer until able to demonstrate linguistic ability in the highlighting of idea units in text.

However, these principles are concerned not only with text-based variables but also with reader-based variables, particularly those concerned with prior knowledge and with schemata. As noted earlier, printed materials are not produced for individuals, they are produced for groups of individuals and, usually, for very large groups. The instructional designer, in trying to find correspondence between text-based ideas and reader-based knowledge has to have a clearly defined target population and has to know as much about that population's prior knowledge as possible, but in the end, the correspondence is bound to be more general than specific.

#### **6.4.2 Eye-movement research**

The contribution of eye-movement research has been noted in this thesis in relation to studies of legibility, readability, comprehension, illustrations, and structure. Clearly it is an important methodology and one which is not necessarily tied to any one theoretical position. Although the evidence is less than clear cut, it seems reasonable to assume that the duration of eye-fixations is related in some way to cognitive processing. The methodology of eye-movement research does, therefore, offer considerable scope for re-examination of existing evidence and the carrying out of further investigations with respect to structure, organisation, and layout. For example, although it was noted in the relevant discussion that eye-movement research suggested an initial extracting of 'gist' prior to more specific examination of



detail, it is possible that the initial, over-all, visual examination is not only for gist, but, perhaps primarily, in relation to the affect of the material and, thus, of immediate consequence for motivation and readability as well as for comprehensibility. Also, there does not appear to have been a great deal of interest in conducting eye-movement research in relation to typographical, structural, and organisational aspects of text design. Would eye-movements indicate increased processing of headings and sub-headings either through increased fixations or more frequent fixations? Would regressive fixations to headings be indicative of mental manipulation and attempts to construct meaning within a larger framework? Perhaps this is an area where further work is justified, utilising, perhaps, the macro eye-movement procedures identified by Schumacher and Waller (1985).

However, regardless of the need for additional enquiry, the principle derived, relating as it does the linguistic and typographic aspects of textual design, is of considerable importance to the designer of instructional text.

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“If the structure and content of text are made clear semantically, syntactically, and typographically, the reader will devote cognitive processing time selectively to these issues”.

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Devoting cognitive processing time to structure and content as a result of semantic, syntactic and typographical cueing provided by the instructional developer, while a desired outcome of the design process, is not easily achieved. As has already been noted, the typographic ability may be readily acquired, but the linguistic ability less readily. Nevertheless, as this principle again emphasises, instructional developers certainly need such ability in relation to the design of text.

### **6.4.3 Imagery**

It is clear from the review of research that the issue of imagery has been given less than justifiable consideration by the information-processing/ cognitive psychology movement with respect to reading comprehension. The



notion of dual coding, common coding, or non-propositional representation is, on the surface, a weakening of the information-processing/cognitive psychology approach. However, it has been made clear in this study that there is no reliance on any single approach and that coexistence of approaches is judged to be necessary. There appears to be evidence which leads to the inescapable conclusion that there are different and distinct ways of processing information. Church (1983) has provided further evidence that picture encoding and word encoding are mediated by processes unique to each other, and Cohen (1983) has found distinctive electro-myographic patterns associated with cognition and affect. The significance of the separate means of processing is of particular relevance in relation to the use of illustrations, but it is also of relevance for purely verbal presentations in that readers can generate images and can inspect these images if encouraged so to do. In this study there has been no attempt to explore in any detail the effectiveness of instruction to the reader to generate images since that was considered to be part of the 'generative' strategy which was not the purpose of the study. Nevertheless, it has to be acknowledged that the linguistic style of the text could readily lead the reader to adopt an imagery approach within comprehension. The derived principle relating to imagery is, therefore, worthy of consideration.

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"If the content of the text is related to spatial, creative, or problem-solving applications, the eliciting of imagery processes in its comprehension will be helpful".

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The principle, however, would require, in its application, guidance being given to the reader to adopt imagery processes. If the reader has high imagery comprehension could be assisted, but if the reader is a low imager, the guidance may not be of much assistance. Whether the reader is a higher imager or a low imager is just another reader variable which needs to be taken into consideration, and from the standpoint of the instructional developer, application of this principle in practice must assume that at least a proportion of the the readers will have imagery abilities and that guidance to employ imagery processes can only be helpful.



#### 6.4.4 Depth of Processing

The point made by Saljo (1984) that reading cannot be reduced to a single, basic model of information processing characteristics of individuals is fundamental to the understanding of the comprehension process, because it highlights the significance of purpose and intention. The significance of dialogue as opposed to interaction in reading also comes from this work and is consistent with the view of Goodman (1984) that reading is transactional. As noted in the discussion, the real challenge to the designer of instructional text is really to be able, through the design characteristics of the text, to induce in the learner the will to adopt a deep approach to the reading experience. The principle derived from the analysis of research in relation to deep processing, viz.

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“If a text is to be read for understanding, then the reader must approach the text with that goal in mind”

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is certainly valid, but it begs the question of how this is to be achieved.

Reference above to the need to design text in order to induce in the reader the will to adopt a deep approach emphasises again the broader nature of the reading process than that involved in a purely information-processing/cognitive psychology approach. Mention of the ‘will’ implicates motivation and other affective aspects of the comprehension process to which repeated reference has been made in this chapter. The affective aspects of deep processing, however, go beyond those associated with the readability of the material. What is required is an affective outcome coupled with a cognitive outcome. The reader needs to be motivated, not in a general sense, but in a very specific sense, viz. to adopt a particular approach to the reading task, the guidance for which will, inevitably, have to be presented verbally. Perhaps there are implications here for the ‘pre-instructional strategies’ which were reviewed in chapter 5. There could well be a combined affective/cognitive role for advance organizers in preparing the reader not only for the material that lies ahead but also for the nature of the interaction or transaction that will ensue. Perhaps an additional principle would be appropriate.



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**“If a deep processing approach is to be induced, the use of a suitably designed advance organizer will activate the necessary cognitive and affective responses in the reader”.**

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Such a principle, however, suggests the need for further research by both quantitative and qualitative methods to determine how such advance organizers would be developed. Putting the principle into practice in the meantime can probably be done best through the provision of guidance to the reader to adopt a learning orientation to the task at hand. This is not dissimilar to the identified need of orientation with respect to learning from other media. The main difference is that with other media, such as film, the guidance is provided by the teacher prior to the viewing of the film. In the case of print, this guidance can be provided only on the printed page, since the reader may encounter the material at times when no teacher is available.

## **6.5 Visual illustration**

Twyman (1985), concerned about the comparative neglect of pictorial language in the area of graphic communication, tried to suggest how pictorial language could be considered in relation to other branches of language. He noted that

**“Seen from the point of view of the linguistic scientist, language divides into two major areas: spoken and written. Seen from the point of view of the typographer and graphic designer, the primary breakdown of language tends to be between verbal and pictorial language. These two approaches . . . appear to be incompatible and certainly lead to difficulties when it comes to studying issues of common concern”.** (p 245)

As already noted, verbal graphic language has been extensively examined by those concerned with effective communication, but pictorial language has been much less extensively and, certainly, less critically examined. This, coupled with the alleged incompatibility, has resulted in very little research relating to the interaction of visual illustration with text, and the review of research in chapter 4, together with its discussion, reflects that situation. It



is unfortunate, but necessary, that the issue of visual illustration had to be examined, first in the context of visual perception and visual information processing, then in relation to the facilitating of learning and, finally, in the particular setting of learning from text.

### **6.5.1 Visual perception**

The evidence suggesting that picture encoding and word encoding are mediated by processes unique to each other raises interesting possibilities regarding verbal and visual literacy. The evidence reviewed in chapter 3 concerning the processes by which a reader comprehends written verbal messages leaves no doubt that the reader has to acquire an ability to decode verbal language and to carry out semantic and syntactic processing. If reading and writing are, in a broad sense, regarded as decoding and encoding messages, the visual analogue of verbal literacy could be considered as a matter of being able to interpret visual messages produced by others and being able to compose meaningful visual messages.

However, since visual processing is distinct from verbal processing, comparison between the two may not be so straightforward, and the range of theories for visual processing reflects the partial correspondence with verbal processing and the independence of visual processing. The visual information processing approach is similar to the verbal information processing approach, but the idea of direct perception is totally at odds with the information processing approach. But it is not dissimilar from the view noted earlier regarding affect being pre-cognitive, holistic, and rapid. There is, thus, a sense in which perception is more related to affect than to cognition, to an affectively effected impression than an analytically derived percept. There is no sense in which a glance at a page of words can convey the intended message, but a glance at an illustration may well do so, and a glance at a page of words, if it is typographically arranged to reflect content as discussed in chapter 5, could quite readily provide an impression which could not be conveyed by normal cognitive processing.

The Gestalt perspective is, in a sense, somewhere between the two extremes discussed above. There is no doubt that the grouping processes of the Gestalt



approach can provide a grammar of the visual world, but it has to be acknowledged that the tendency to group perceptually is not an acquired skill. The viewer is able, to some extent, to 'read' the visual information without having to learn either the vocabulary or the syntax. The problem is that the designer of information has to master both the vocabulary and the syntax to be able to 'write' visually. What is being suggested is that lack of understanding of the visual communication process is resulting in the designers of the visual components of printed instructional messages underestimating the extent to which visual communication is a more text-based variable than is verbal communication.

It may appear to be the adoption of a 'sitting-on-the-fence' position not to identify one or other of the visual information processing theories as the best or most appropriate one, but it has been argued, and is still argued, that the research evidence available does not lead to the adoption of a single approach, and that a substantial research effort is required to determine what is involved in visual thinking. In these circumstances, the two relevant principles derived are reiterated.

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"If information is visually organised and contextually congruent, the perceptual processes of the viewer will accommodate it to maximise cognition".

"If visuals are designed to convey a finite number of idea units, the viewer's perceptual processes, influenced by the design of the visual and the available schemata of the viewer, will extract the gist and, subsequently, the detail of the visual information"

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The application of these principles in educational practice has serious implications for the designer of instructional text. There is a requirement for the instructional designer or instructional materials developer to have a sufficient understanding of the visual communication process to be able either to construct visual material within the framework of the identified principles or to instruct a graphics artist to do so. Given that few people other than



trained graphics artists have the ability to work with graphics materials, or have the design dexterity needed to exploit the use of such materials, the former option is not really viable. However, since few graphics artists seem to receive within their training explicit elucidation of the framework epitomised by the principles, the latter option requires the instructional developer to be sufficiently *au fait* with both the theoretical framework and the graphical possibilities to be able to instruct the graphics artist as to what is required and to be able to critically appraise the work of the graphics artist, providing feedback for modification as required. Perhaps the best solution is to have more graphics artists undertaking formal courses in instructional design, but until that happens, the onus is on the instructional developer to broaden his/her skill base.

### **6.5.2 Visuals in learning**

Despite what has been said above regarding the visual-based variables, recognition does have to be given to the constructive nature of visual communication in learning. The kind of problem which is encountered in readability studies is whether to help learners to be better readers or authors to be better writers. In the context of this discussion on visuals in learning the same problem arises. Should learners be trained in how to interpret visual information (i.e. increase their visual literacy) or should the designers of learning material be encouraged to be better visual designers?

In the present circumstances, where visual material is used indiscriminately in the mistaken belief that visuals automatically enhance learning, it is clear that the area for immediate attention is the designers of instructional materials. As already observed, even the graduates of colleges of art are unfamiliar with the available (albeit inadequate) research relating to visual communication and learning. There is urgent need to extend the visual literacy level of all those who are involved, or intend to become involved, in the development of learning materials in which visual elements will be incorporated, not so that they can 'read' but, rather, that they can 'write', and with the same degree of fluency as they are expected to be able to exhibit with respect to verbal materials.



The principles derived from an analysis of the available research viz.

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“If a visual is designed in accordance with visual perception organisational principles to be an integral part of an identified cognitive process the activation of that cognitive process is more likely to take place.”

“If a diagram represents spatially the logical organisation of concepts, their comprehension will be facilitated.”

---

depend for their implementation on the acquiring of appropriate skills by those involved in the design of visual instructional materials.

### **6.5.3 Visuals in text**

It is encouraging to note not so much the level as the nature of the interest among researchers in the area of visuals in text. While there has been a lot of very nebulous thinking in relation to visuals in learning in general, with respect to visuals in text the research has been much more specific, more theoretically oriented, and more applicable. It is especially encouraging to note the trend toward examination of the interaction and inter-relationship between visual and text.

Nevertheless, there is still a need for additional research to be conducted. As noted in the discussion, eye-movement research could helpfully be employed to determine the nature of initial encounter with visuals in text, and qualitative investigations with readers would be helpful in exploring the ‘text as diagram’ concept and its relationship to congeniality and perception of textual organisation. The research that is needed is not so much concerned with the nature of the illustrations in text as with their purpose.

The principles derived from an analysis of the available research adequately summarise the main features of recent research.



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“If illustrations are developed as an integral part of the text design they will perform a motivational or attention getting function”.

“If illustrations are designed to support organisational or conceptual aspects of a topic in text, they will facilitate comprehension”.

“If illustrations are developed to support the verbal argument of text, the integrity of the text will be enhanced if the illustrations are appropriately embedded and alluded to, in the text”.

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Their implementation in practice requires the instructional developer to integrate text and visual development and to justify to printers or publishers why particular visual images not only need to be presented in a specified way but be included adjacent to identified parts of text. The instructional developer also needs to be able to justify the exclusion of visuals which do not contribute to the text within the framework of the principles outlined above. The relationship between words and pictures within the context of the structure and organisation of the text is what is at issue and the use of visuals in text cannot, therefore, be left to the discretion of editors, illustrators, or anyone other than the person with overall control of the text design process.

## **6.6 Structure and organisation**

In a recent paper Frase, Macdonald, and Keenan (1985) have proposed a form of computer-aided, cognitively based, text design.

“Computers can make design decisions regarding the format of a text. To do this, the computer needs two models: first, a cognitive model of the information-processing demands of different linguistic features; second, a model of text features that can be changed. Using these models, it is possible to develop computer-based projections of the demands that a document will make on a reader when it is designed in different ways”.

(p 100)



The parameters which are incorporated within the computer programme go far beyond the surface characteristics associated with computerised readability formulae and, although language analysis programs are limited by the text features they can recognise (and, of course, by the present understanding of the relation of text features to reading difficulty), the authors believe that, through technology, designers and researchers will inevitably draw closer together since a science of text design depends on putting complex assumptions into algorithms.

Without any thought of computerised text design, it was a similar concern with the integration of cognitive psychology, psycholinguistics and typography for the purpose of highlighting organisation and structure in text that characterised chapter 5 and its discussion.

It was noted in the discussion of chapter 5 that the organisation of text could be made explicit through both verbal and typographical cueing systems and that reader strategies were related to these systems. Anderson and Armbruster (1985) have argued that the design of text can affect how effectively students are able to read and comprehend, a conclusion they reached when they merged their ideas about how effective studying should proceed with their understanding of the properties of text which seemed to facilitate or impede comprehension.

#### **6.6.1 Verbal cueing**

As noted in the discussion of chapter 5, although the main purpose of this study is not a concern with the detailed linguistic aspects of verbal cueing, these factors are intimately associated with comprehension and do need to be taken into consideration in the design of text. One of the most important aspects of linguistic structure, as observed in the discussion, is cohesion, and it is interesting to note that Anderson and Armbruster (1985) have suggested three guidelines concerning cohesion, viz.

- (a) relationships among ideas should be explicitly stated;
- (b) referents should be clear; and



- (c) in temporal sequences/processes and in explanations, the order of events should proceed in one direction only.

The emphasis on cohesion, together with the emphasis by Meyer (1985a) on content structure, amply justifies the derivation of the principle quoted earlier, viz.

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"If the critical information to be communicated is appropriately emphasised as part of an overall text structure, comprehension will be facilitated".

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However, it is the instructional design aspect of verbal cueing which is of more interest in this study, particularly because of the extensive literature, and equally extensive lack of understanding concerning the use of adjuncts to text.

The discussion in chapter 5, coming as it did after the discussion on legibility, readability, comprehension, and visual illustration, integrated structural and organisational factors with, in particular, comprehension issues, but also issues raised in earlier chapters. With respect to verbal cueing, the discussion established a cognitive framework for the operation of adjunct aids and the restatement of the principles derived provides a useful summary of the issues involved.

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advance organizers	"If the reader is oriented by a brief verbal organizer toward the application of existing knowledge to the assimilation of the main features of new knowledge in text, then comprehension of that new knowledge will be facilitated".
graphic organizers	"If a graphic organizer is used to convey isomorphically the structure of ideas in text, then comprehension of the structure will be facilitated".
adjunct questions	"If higher-level questions are inserted in text they are likely to induce a deeper level of processing on the part of the reader".
learning objectives	"If a high-level learning outcome is stated as an objective in advance of reading, the learner is likely to adopt a deep approach to reading of the passage".

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These are practical issues and the principles must provide the guidance for practice. If current practice is not consistent with the principles then modification of practice will be necessary.

The principle concerning advance organizers, when put into practice, requires an approach to the design of advance organizers which is significantly different from current practice in that there is an overt emphasis on the activation of existing knowledge which, within a traditional approach, might have occurred only because it happened to be part of the way in which advance organizers operate. Making explicit a need to activate prior knowledge is really guidance to the reader, as is the linking of this to the main features of new knowledge in the text. The organizer with respect to the new knowledge is, however, more in line with the traditional approach to advance organizers. Conceivably, it would be possible to separate the 'guidance' from the 'organizer', but an integrated approach would probably be better and what is required is really an extension or broadening of the concept of advance organizer to include the element of guidance implicit in the identified principle.

Application of the principle concerning graphic organizers would require change in present practice for the obvious reason that the use of graphic organizers is a relatively rare occurrence. The development of a graphic organizer is a useful exercise when analysing already written text and can readily show up weaknesses and inconsistencies in the structure of the text but it is much more appropriate to try to develop the organizer based on the ideas and their relationships prior to their being put together in the text. The development of a graphic organizer is also a very useful stage in the development of typographical cueing devices since it can identify levels of headings and sub-headings. It really is surprising that graphic organizers are not more commonly found in instructional text considering that they may well have formed part of the author's working out of the ideas to be included in the text. It is because a graphic organizer can depict the structure of ideas in text, in the way that the author intended them to be related, that the graphic organizer is worthwhile adopting in practice.

The key features of the principle relating to adjunct questions, as they affect educational practice, are the emphasis on questions being 'higher-level' and the outcome of their inclusion being a deeper level of processing. While the



practice of including questions within text is not uncommon, such questions are often of a factual recall nature and not of the higher-level implied in the principle. No doubt there are times when factual questions are appropriate but where deeper levels of processing are intended, higher level questions need to be included. There is a strong relationship between the implications in practice of this principle and those associated with the principle concerning learning objectives. In both cases a deep approach is expected, but in the case of the latter principle due to the statement of a high-level learning outcome. In practice it would be appropriate to implement both principles together by stating the high-level learning outcome in advance of the passage of text and including within the text high-level questions related to the stated learning outcome. Hopefully the combined effect of both objective and question would be more certain than either independently and would, in fact, result in deeper processing.

### **6.6.2 Typographical cueing**

The relevance of typographical cueing within a cognitive framework was explored in the discussion of chapter 5, and the principle derived, viz.

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“If headings in text are chosen and arranged spatially and typographically to reflect the structural relationship in the text, comprehension of both the structure and the content of the text is likely to be enhanced”.

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summarises the main features of the discussion.

In fact, it is in the implied integration between typographical and linguistic cueing that the strength of the principle lies. It is significant that, in guidelines suggested in relation to structure, Anderson and Armbruster (1985) include the following:

- “1. The author’s topic, purpose or question, and structure should be readily apparent to the reader from titles, headings, and/or topic sentences.



2. The actual structure of the text should match the author's purpose as implied by titles, headings, and topic sentences" (p 165/166)

The integration of typographical and verbal cueing systems (including the linguistics aspects of verbal cueing) is an area where further research would be valuable, particularly where such integration was considered within an instructional design framework relating topic analysis to design of material and the criteria for achievement assessment.

Nevertheless, within the available research on which the principle is based and the framework of the earlier discussion, implications for practice can be drawn.

It is not often in an instructional text that the headings are arranged either spatially or typographically to reflect the structural relationship of ideas in the text. As noted earlier, the development of a visual organizer can help to establish the conceptual relationship in the text and, because of the visual aspect, the spatial relationship. What is needed in practice is a much greater correspondence between the 'conceptual map' and the typographical organisation of headings. Such integration does not require any new skills on the part of the instructional developer – it requires only that consideration be given to the application of a principle that brings together notions of verbal and visual cueing allied with typography to help the reader comprehend both the structure and the content of the text.

### **6.6.3 Reader strategies**

The nature of the structure and organisation of text as signified by verbal and typographical cueing has implications for the strategies to be adopted by readers. Anderson and Armbruster (1985) suggest that high quality text will assist students in studying since, *inter alia*,

- "1. Criteria for studying will be clearer to students because . . . the titles, headings and topic sentences help the student identify the questions that the text is answering.



2. Focusing attention will be easier because . . . each idea unit in the regular text is important . . . nonessential [idea units] are clearly marked as such . . . [and] the hierarchical structure of the text . . . makes it easy and efficient for students to locate a specific text unit.
3. Encoding activities will be more efficient because . . . the high degree of coherence, structure, and unity will enable the students to . . . engage in a variety of activities to promote encoding . . . [and] the hierarchical structure of the text encourages students to use a top-down, higher-level perspective when reading and organizing ideas from the text". (p 175)

Anderson and Armbruster (1985) contrast this perspective with a bottom-up one in which the students are not sure where the author is going, and must put the puzzle together in an inefficient, piecemeal fashion.

The purpose of this study has been to find ways of designing text so that comprehension can be facilitated. Nevertheless, many of the ways which have been identified as being potentially useful have implications for the reader. Student strategies in reading need to include, within a metacognitive context, the ability to monitor both the linguistic and typographical indicators of relative significance in the text and to assimilate the instructional design adjuncts developed to activate prior knowledge. These abilities should form part of a 'learning to learn' or 'learning to study' module within a course of instruction.

## **6.7 Conclusion**

As this study has progressed through legibility, readability, comprehension, visual illustration, and structure and organisation, there has developed an increasingly complex image of the reading comprehension process and the role of these various parameters within it. The first major recognition, and the one which most fundamentally affects all the areas of study, must be



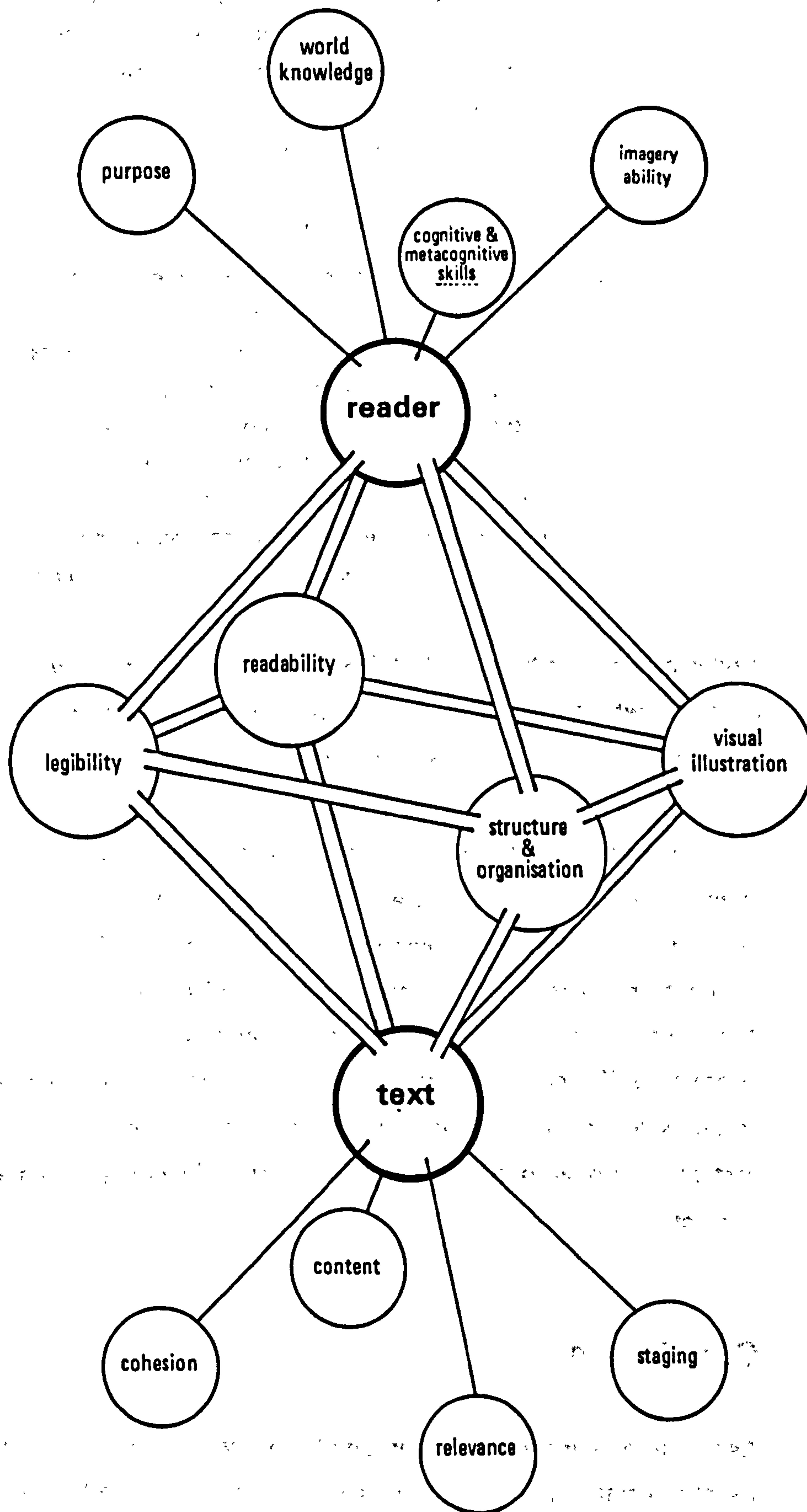


fig 6.1

— characteristic of  
 == interaction with



that concerning the interactive nature of reading. It is on the cornerstone of reading as an interactive process that this study has built, because it has examined and re-examined where necessary, the nature of that interaction and the way in which the numerous variables, whether text-based or reader-based, affected the interactive reading process.

From the initial concept of legibility and readability being intervening variables between the reader and the text, there has evolved a complex structure reflecting not only the numerous text-based and reader-based variables but the many possible interactions which can take place between them.

In approaching the design of text as an instructional medium, the instructional designer or instructional materials developer has to have a clear mental picture of the process of reading comprehension and the variables in both the reader and the text which can affect that process. The instructional designer/developer also needs to have a sufficient understanding of the ways in which those aspects of text over which there can be design control can be manipulated within the framework of identified principles to facilitate comprehension. That understanding should enable the instructional designer/developer either to work from first principles to develop acceptable practice or to examine current practice against the criteria of identified principles and the theory of instructional text design to which they contribute.

Figure 6.1 is a useful visualisation of the conceptual framework of the ways in which the characteristics of the reader and the text interact with the major areas of design concern and of the ways in which these areas relate to each other.

#### **6.7.1 Text characteristics**

Of the text characteristics, the most important in relation to the areas of design concern are those of cohesion and staging and these are related most strongly to the areas of readability and structure & organisation. All four reader characteristics are probably equally important and influence all four areas of design concern, although not necessarily in equal measure.



The text characteristics of cohesion and staging can affect readability and determine, to some extent, what has to be done about structure & organisation and the verbal/typographical cueing necessary for them to be made explicit. The abilities to write textual material in a cohesive way and to write in a way which emphasises key points are skills which are not necessarily always associated with instructional design/development activities. The evidence from this study makes it clear that text cannot be designed for optimal readability or for explicit structure & organisation unless these skills can be performed. It behoves the instructional designer or instructional materials developer, therefore, to develop his/her own writing skills so as to be able to maximise all these aspects of text design.

Content does, of course, determine to some extent, in association with cohesion and staging, the structure & organisation of text simply because content analysis (or topic analysis) is indicative of the hierarchical arrangements within the content. This area is much more firmly within the instructional design field, and the instructional designer/developer should have little difficulty in incorporating content analysis in the text design process. That being said, however, current practice in text design unfortunately, and frequently, does not reflect content analysis.

Relevance is a characteristic of text which, potentially, affects the readability of a text but does so because of its strong relationship to characteristics of the reader such as purpose and world knowledge.

### **6.7.2 Reader characteristics**

Purpose, world knowledge, cognitive & metacognitive skills, and imagery ability are inherent characteristics of the reader which have to be exploited through the various areas of design concern in order to elicit interaction between reader and text and, thus, facilitate comprehension. To some extent the text and its adjuncts are explicitly encouraging the reader to employ or resort to these characteristics, but there is a sense in which the encouragement is more implicit and is achieved through the total effect of the design of the text.



Purpose in reading is related to readability in that it is associated with motivation which is closely involved in readability; it is linked with visual illustration in that, depending on purpose, illustrations may be interpreted as either attentional, explicative, or retentional irrespective of their intended purpose; but most significantly, it is closely related to structure & organisation in terms of both adjunct and main content text. The notion of depth of processing is closely allied to that of approach to learning which, in turn, is reflective of purpose in reading. Adjuncts to the text may be used to exhort the adoption of a deep approach to learning and the subsequent verbal and typographical cueing of the content may facilitate assimilation into organised memory. Pre-reading purpose may determine a particular use of the organisation & structure as indicated by verbal and typographical cueing to meet the reader's perceived needs at that time.

World knowledge on the part of the reader is deeply implicated in the reading comprehension process and is a relevant factor in relation to each of the four areas of design concern. Legibility of text is, to some extent, determined by the reader's knowledge of the use of typefaces for particular purposes and in particular contexts. Readability is similarly determined by the reader's knowledge of typeface connotation contributing to the text's congeniality and by the reader's knowledge of both vocabulary used and the grammatical structures used to express the ideas in the text. Visual illustrations depend for their effectiveness, in part, on the reader's knowledge of visual communication (on his/her visual literacy). The structure & organisation assigned to a text are dependent for their effectiveness upon the reader's knowledge with respect to syntactic relationships, types of argument, the subject matter concerned and typographical convention.

The imagery ability of the reader is of significance in relation to visual illustration, and structure organisation. The high imager is likely to be able to utilise imagery to facilitate comprehension, and, apart from the obvious relevance of visual images in this process, the physical layout of the page is of particular relevance in helping such a person not only to remember material but to establish spatial relationships in the construction of knowledge. Imagery ability is not something which can readily be taught, and exploitation of imagery by the instructional designer/developer really needs



to be confined to those readers who already possess such ability and who can be encouraged to utilise it in their reading.

Such is not the case, however, with either cognitive skills or metacognitive skills. Evidence that these skills can be developed and enhanced and then utilised in the reading comprehension process is encouraging for the instructional designer/developer because it is clear that such skills are of considerable relevance, particularly to the design area of structure & organisation. The reader with highly developed cognitive and metacognitive skills is in a much stronger position to be able to learn from text, irrespective of how well it is designed, but the student with less developed skills needs the support of well designed text.

### **6.7.3 Areas of design concern**

Bearing in mind the characteristics of any reader and the characteristics of text in general, the instructional designer or instructional materials developer, in developing instructional text, needs to give consideration to the four areas of design concern, viz. legibility, readability, visual illustration, and structure & organisation, each of which has been discussed extensively in earlier parts of this study. Consideration needs to be given to the applicability of the principles identified either by working out design practice which is consistent with the principles or by examining current practice against the criteria implied by the identified principles.

- (a) The first area of design concern is, inevitably, that of structure & organisation. This arises because the first stage of an instructional design approach must be an analysis stage, in this case a topic analysis. The topic analysis provides information which clarifies the hierarchic relationships within the topic and the desired learning outcomes or objectives.

Clarification of the objectives enables the instructional designer/developer to decide what kind of verbal cueing or pre-instructional strategy can be used to help the reader to recognise the desired outcome and adopt an appropriate approach to the reading task. It also allows



the instructional designer/developer to give consideration to the formulation of in-text questions of an appropriate type and level.

Clarification of the hierarchic relationship also enables the instructional designer/developer to consider the kind of verbal cueing necessary, particularly in relation to any advance organizer which must reflect the structure and organisation of the text and alert the reader to relevant schema-activation. The verbal cueing arising from the topic analysis thus allows an integration of learning outcome and overview of structure together with schema activation and establishment of a deep-approach set to learn. But clarification of the hierarchic relationship provides, additionally, the basis for the determination of the structure of the text and from that can be developed the typographical cueing necessary to make explicit the structure. The typographical cueing is, at least, indicative of the legibility and layout issues which need to be considered, and readability is determined, to some extent, by the identified structure. Several areas of design concern are clearly brought together through consideration of the topic analysis as illustrated in fig 6.2.

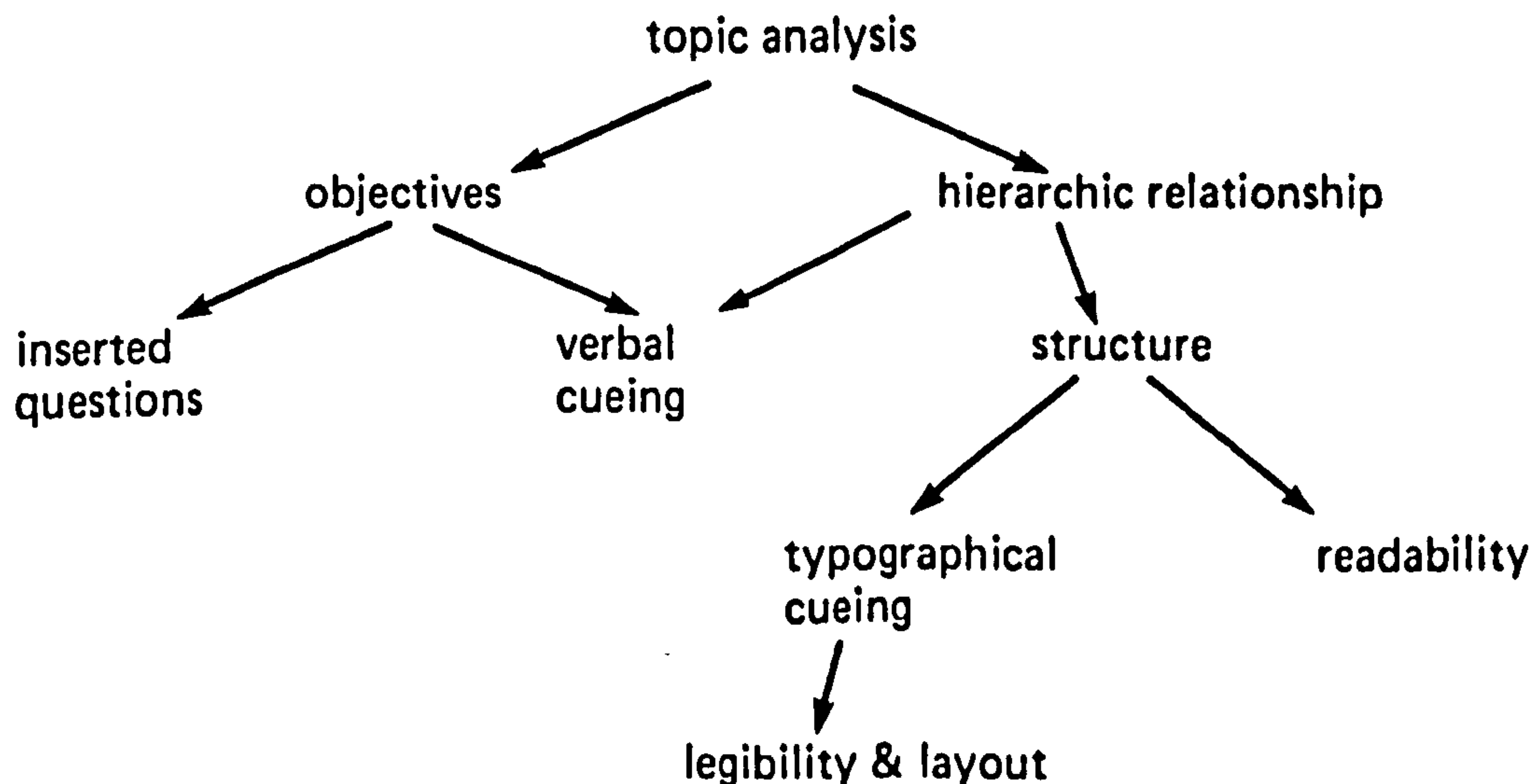


fig 6.2. design concerns arising from the topic analysis

Consideration of structure & organisation issues also raises the questions of whether graphic organizers should be used and whether encouragement to the reader to utilise imagery abilities is appropriate.



- (b) In considering whether visual illustrations should be used, the instructional designer/developer needs to ascertain whether illustrations are required for motivational, explicative, or retentional purposes and whether it is possible to develop visuals relevant to these purposes. The instructional designer/developer needs to bear in mind the possibility that visuals may contribute to the readability of the material in that they may affect the congeniality through influencing motivation. It is also possible that visuals may relate to spatial aspects of topic relationship and be an influencing factor in the typography. The possibility of 'text as diagram' also needs to be borne in mind. Thus visual illustrations are not an independent area of design concern. Their use is related to legibility and readability but, primarily, to structure & organisation in that their main purpose must be to facilitate comprehension.
- (c) Having taken into consideration the structure & organisation aspects, together with the aspects associated with visual illustration, the instructional designer/developer then has to write the material for the text and, in so doing, has to take into consideration not only those linguistic aspects of text which enable idea units to be highlighted within the overall indication of structure, but the linguistic aspects which influence the affective and cognitive dimensions of readability. The designer/developer has to ensure that the adopted style and the overall appearance of the material arising from the legibility and layout considerations are conducive to the cultivation of motivation and, thus, comprehension. Specific criteria of legibility becomes the final check with respect to physical parameters of the text to ensure that in the denoting of structure the typographical cueing is consistent with the other aspects of typography which, together, contribute to a well designed text.

#### **6.7.4 Practice, principles, and theory**

The instructional designer/developer, in approaching the design of text, would normally develop the material in accordance with accepted instructional design procedures consistent with, for example, an



educational technology approach to the design of instruction. As noted in the *preface* to this thesis, the principles of educational technology are not always explicit and there is a tendency for instructional designers or instructional media developers to adopt established procedures and practices without, necessarily, being able to justify these practices from more fundamental principles of educational technology. It is therefore likely that, in the development of instructional text, the same approach will normally be adopted due, mainly, to there not being explicitly stated principles for the design of text readily available.

By examining the research in a range of relatively disparate disciplines this thesis has argued that reasonably fundamental principles relevant to the design of text can be derived and that these principles can either provide theoretical justification for many of the practices commonly accepted as 'good' practice in text design or indicate areas where current practice needs to be modified.

But these principles have been derived in relation to the individual areas of design concern with only the occasional additional principle having been derived because of the inter-relationships between the different areas of design concern. In other words, these principles are derived from a range of disparate theories each of which relates to only one or two aspects of a possible theory of instructional text design. To what extent has the study contributed towards a theory of instructional text design?

Although a theory of instruction can best be based on a theory of learning, there is no single theory of learning from text which would enable the outlining of a theory of instructional text design. What exists is a number of theories relating to how people learn from text, the most fundamental of which are those emanating from cognitive psychology regarding the interactive nature of the reading process and the structured and organised nature of knowledge in memory. These, of themselves, do not constitute a theory of instructional text design but they do provide a focus on which such a theory can be built.

This study has identified four areas of design concern, related to which principles have been derived and associated with which various theories were



examined. In pursuing the development of principles for the design of instructional text, these areas were considered in relation to the fundamental theories mentioned above in an attempt to identify ways in which they could contribute to the structured and organised nature of knowledge acquisition within a framework of the interactive nature of the reading process. Each area of design concern was, therefore, contributing either to the 'interactivity' of the process or to the structure and organisation aspect of acquired knowledge in memory. A unifying theory was developing in which it was clear that, since reading was an interactive process between reader and text, that the process was contributed to by characteristics of both the text and the reader, and that knowledge in memory was highly structured and organised, design elements of the text could be manipulated to ensure that existing knowledge in the reader could be activated so that new knowledge presented in the text in a structured and organised way and appropriately highlighted through verbal and typographic cueing supported, as required, by visual illustration and organisation could be assimilated in a manner facilitative of comprehension.

The emerging theory of instructional text design involves

- (a) a topic analysis to determine the hierarchic relationship of ideas within the topic and the desired learning outcomes or objectives, from which can be determined
  - (i) the kind of verbal cueing or pre-instructional strategy necessary to enable the reader to recognise the desired outcome and adopt an appropriate approach to the reading task;
  - (ii) the kind of verbal cueing, reflective of the structure and organisation of the text, necessary for relevant schema activation;
  - (iii) the basis for the structure of the text and, thus, the typographical cueing necessary to make the structure explicit; and
  - (iv) the kind of questions which can be inserted in the text;
- (b) a consideration of the linguistic aspects of text which
  - (i) enable idea units to be highlighted within the overall indication of structure;
  - (ii) influence the affective and cognitive dimensions of readability;



- (c) a consideration of the role of visual illustrations as to whether they are
  - (i) motivational, explicative, or retentional in intent;
  - (ii) indicative of spatial relationships in the text; and
- (d) a consideration of the physical parameters of the text to ensure that in the denoting of structure the typographical cueing is consistent with the other aspects of typography.

These areas (a) — (d) are, respectively, the design areas of structure & organisation, readability, visual illustration, and legibility, and the acronym SORVIL might usefully denote this approach to a theory of instructional text design.

It is not argued that this is a complete theory of instructional text design, but it is certainly a contribution to such a theory. There are other inter-relationships between the areas of design concern which need to be explored and there may well be other design areas which need to be taken into consideration. What is certain is that the principles derived are valid and that, together, they provide the basis of a theory of instructional text design.

Carter (1985) has observed that

“... the problem of producing usable written materials may have less to do with discovering a host of new principles than with learning to routinely apply those we already know”. (p. 156)

This study has made explicit principles which are fundamental to the design of instructional text and in doing so has contributed towards a theory of instructional text design. In the application of that theory, practice needs to be measured against principle and principle must determine practice.



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