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ABSTRACT

Intended for use by both producers and evaluators of textbooks and other print instructional materials, this review of the literature focuses on the effectiveness of illustrations for motivation and for learning, and such typographical variables as readibality, legibility, standard typographical conventions, and format and layout. Areas examined include the effects of the presence or absence of illustrations; the effects of illustrations on recall; readability as a function of visual factors; legibility, including type size and typeface, leading and line width, ink and paper color, and aesthetics; justification; cuing by means of headings, underlining, and questions; paragraphs and column format; vertical typography and segmentation; and format and layout. A bibliography of sources cited is provided. (BBM)

THE DESIGN OF PRINTED INSTRUCTIONAL MATERIALS: RESEARCH ON ILLUSTRATIONS AND TYPOGRAPHY

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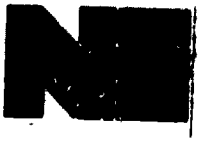

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PREFACE

In a satirical essay comparing print media with electronic technology, Mitchel asks us to "suppose--just for a moment--that the invention of modulated electrical current and of photography had come before the invention of movable type and the printing press by some 200 or so years. What would have happened?" (1976, p. 64). This supposition brings forth visions of educators probing every aspect of the "new" medium called print, assessing its instructional value and devising methods to increase its effectiveness. However, the advent of printing predated "educational assessment" and "instructional design" by a few hundred years, and printed materials became accepted as instructional tools without much of the research that follows the introduction of a new medium today.

This is not meant to imply that researchers have ignored the print medium. An impressive body of literature exists, but we rarely see evidence that it has been drawn upon as a tool for those who use, evaluate, or produce books and other forms of printed materials for instruction. Apparently we have become so comfortable with textual materials that we accept them as they are and give little thought to how they could be improved. A comparison of today's texts with their counterparts of a decade ago will show few changes, and most of those will be cosmetic in nature. Print, possibly because of its long existence, has escaped most of the accountability procedures applied to the newer media.

We believe that diminishing resources will soon force printed materials to be assessed in terms of their cost effectiveness and ability to deliver information. As a result, we believe the design of printed instructional materials will change dramatically in the next ten years. The research identified here is potentially useful to producers of print materials and could result in products that deliver information more effectively. The power to improve information delivery is available to all producers of printed information, whether they are commercial publishers or educators with access only to a mimeograph machine. Either group could adopt many procedures that would produce products superior to those we now use. This document can also serve those who evaluate textbooks by providing information to reassess their current standards. Miller (1957)

suggested that research relating to illustrations should be compiled in a single source to aid publishers of illustrated textbooks. Perhaps this publication will be a step in that direction.

The literature of illustrations and typography relating to the design of printed instructional materials was reviewed. Only English language printed or microform items were considered in an initial computer search of the ERIC database which identified relevant citations, and was the starting point for our research. Our quest for additional materials was greatly aided by Ms. Marykay Hartung, Interlibrary Loan Librarian, University of South Florida Library, and we wish to acknowledge her contribution.

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ILLUSTRATIONS--AN OVERVIEW

A. Introduction

In 1658 the first illustrated text printed with movable type, Orbis Pictus, was published by Comenius. The 150 woodcuts he incorporated in the book helped assure its success and importance in the educational world for nearly 100 years. In spite of this success, illustrations were rarely used in other texts until the 1830's. Even then, nearly two centuries later, only elementary text books were commonly illustrated (Johnson, 1963).

Today, incorporating pictures in texts is the accepted practice. As Travers and Alvarado (1970) observed, we developed the technology for reproducing pictures cheaply long before we began to analyze their role in the instructional process. There is no lack of research data dealing with illustrations in texts, but, as Spaulding (1955) indicates, the results are not always consistent. He found that in some cases illustrations aided retention while in others they resulted in less information being retained. His contradictory results, not substantially different from many of the studies discussed below, are not surprising considering the number of variables incorporated in these studies and the variety of roles ascribed to illustrations.

B. Rationale and Discussion of Variables

Dwyer (1972) cited a number of reasons for using visual material, including clarifying information, and highlighting key parts of a presentation. He also ascribes several other functions to illustrations, noting that visualization of content material can:

1. Facilitate the accuracy and standarization 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. (Dwyer, 1972, p. 1)

The most common variables identified in the studies examined were the mix of verbal and visual information, the variety of pictorial formats ranging from simple line drawings to realistic photographs, color or the lack of color, the placement of illustrations, the presence or absence of instructions to study the pictures, the amount of time allocated to read the text and view the accompanying pictures, and the number of pictures accompanying the text.

C. Early Research

In one of the earliest studies of illustrations, Lewerenz (1929) found that pictures helped learners understand verbal information. This position was supported by Strang (1941) and Halbert (1944). Goodykoontz (1936), however, found that the addition of pictures to printed materials did little or nothing to aid comprehension. MacLean (1930) found pictures aided in defining contrasts but also indicated that pictures were of limited value.

EFFECTIVENESS OF ILLUSTRATIONS

The following section will examine the function of pictures in motivating producers and users of texts and the effects of illustrations on the learning process.

A. Illustrations and Motivation

Illustrations are often included to make books more attractive and increase sales. Legenza and Knafle (1978, p. 170) state that, "It even seems as though publishers use pictures in basal readers as a primary vehicle with which to compete with each other for sales." Dwyer (1972) also discusses the use of pictures as decorations. He concludes that "the basic problem relative to the use of visuals is that visual illustrations are not produced primarily for their instructional value. Usually the production of visual illustrations is based on the subjective feelings of the designer about what is best, . . . the attractiveness of the finished product, and the availability of a ready market" (p. 2).

Even when pictures are included only to make a book more attractive, they may fail to achieve their intended purpose if they do not appeal to children. Working with both young children (from kindergarten through the sixth grade) and with adults, Rudisill (1952) found that the children's preferences varied widely from those of the adults. The adults were instructed to select the illustrations that they felt children would most prefer. Even though her adult population was not representative of those who produce or evaluate children's books, her results do indicate that illustrations used solely as decoration may be counter-productive if they are not carefully selected with children's preferences in mind.

Adults may also interpret pictures differently than children. Higgins (1980) indicates a potentially serious problem that young children ages three to seven encounter when attempting to use pictures for interpretation. Children in this age range appear unable to envision any element of a picture that is not completely visible. A truncated dog, for example, with his hind quarters out of the picture or obscured by another dog in the foreground, appears to be half a dog to a young child. Similarly, a picture of a boy seated in front of a girl standing behind his chair elicits literal responses about the girl's inability to walk. It appears that many young learners receive information that artists or photographers never meant to convey and in doing so receive information that would hinder the interpretation functions.

Myatt and Carter (1979) examined student picture preference in a wide range of grades (K, 1, 2, 3, 5, 9, and 11). They found color photographs were the overwhelming first preference. Full-line drawings in which form and contour were established by color were the second choice. Cartoons were liked least by all grade levels. Another indication of children's preferences may be the degree to which they can articulate their feelings. Legenza and Knafle (1978) found that factors such as action or the number of children in a picture affected the amount of language first and second grade students used when discussing the pictures. Sewell and Moore (1980) found that undergraduate college students enjoyed cartoon-embellished text as opposed to text alone or audiovisual presentations, but there were no significant differences in learning between the forms.

Research results on the motivation for purchase or selection appear inconclusive. The value of illustrations as motivation for learning is also unclear. Commenting on the ability of illustrations to motivate learners, Levin (1979) says that, in general, they have little effect. Both Samuels (1970) and Duchastel (1980) note a total absence of studies discussing the motivational value of illustrations. Levin (1979) concludes that "there exist no convincing data to relate increased motivation per se to increased prose recall" (p. 15).

B. Illustrations and Learning

1. General Background

Current evidence does not support the proposition that visual repetition of textual information (reiteration) contributes to improved prose learning. One possible reason for this may have been identified by Dwyer (1971a) in a description of color as an instructional variable. He notes that detailed illustrations may distract from essential learning cues and may also require more time for study. Citing Travers (1964), Broadbent (1965), and others, Dwyer cautions that:

> The effectiveness of discrimination learning promoted by the addition of relevant stimuli may be limited by the information processing capacity of the organism. . .The failure of the more realistic illustrations to facilitate achievement may be attributed to the amount of realistic detail they contained which may have had the net effect of distracting students from essential learning cues. (p. 413)

In a series of studies with college age subjects ranging across more than a decade, Dwyer (1972) examined the effects of color and varying pictorial details on the subjects' ability to: (1) draw a diagram of a heart and label specified elements, (2) identify the parts of a heart numbered on a detailed drawing, (3) define related terminology, (4) demonstrate comprehension, and (5) demonstrate total understanding by completing a final 78-item criterial test. Dwyer (1968, 1971b, 1971c, 1971d, 1972) found simple line drawings most effective for improving student's ability to draw and label parts of the heart. Detailed shaded drawings in color were found most effective for the identification task. Print materials without illustrations proved to be as effective as print materials incorporating illustrations on the terminology, comprehension, and total criteria tests. He examined questions as pre- and post-organizers and found that this instructional technique was ineffective when used with illustrations. Readers seeking more detailed information than Dwyer's synopsis (1972) provides will find citations to his earlier publications in the bibliography at the end of this work.

Peterson (1976) concludes from her review of the literature on black and white versus color illustration that color is more effective when younger children (ages two to five), or illiterate, deaf, or immature adults are concerned. Color was most effective when used to emphasize differences, aid in the retention of non-verbal materials, and direct attention to the "information areas" of the text.

Levin (1979) indicates that pictures assist learners in organizing information presented by a combination of text and pictures. He also alludes to the power of illustration to clarify complex concepts. He concludes that pictures contribute a moderate to substantial amount to improved learning of prose materials. Few data other than Levin's were found to support these conclusions, although Weisberg (1970) reported that visualization in the form of a map and a graph proved to be significantly more effective as an advance organizer than did a verbal expository treatment.

2. Presence or Absence of Illustrations

Pictures provide a second modality (pictorial as opposed to verbal) for transmitting information and thereby making the information learners receive more concrete. Levin feels that this dual input can help both cerebral hemispheres acquire information and result in improved prose learning. Smith (1971) and Donald (1979) agree that pictures can provide useful contextual information. Smith claims

that this is an efficient process because only the visual cues that are needed to reduce uncertainty are selected from the redundant information provided. Not all researchers agree with these conclusions. Broadbent (1958, 1965) and Travers (1967) both warn of the possibility of exceeding a learner's capacity for using information. Samuels (1970) cites numerous studies indicating no significant difference or even negative effects when pictures are used with print materials. Among these works are those of Braun (1969) and Baker and Madell (1965). Braun's study dealt with young children while Baker and Madell worked with college students. In spite of the age discrepancy, their results were similar and indicated that pictures were a liability to learning.

Thomas (1978) examined elementary science textbooks and found that including or excluding pictures had no bearing on the comprehension of the material. He concluded that the cost of textbooks could be greatly reduced if illustrations, particularly color photographs, were omitted. Working with a population of first grade students learning to read, Samuels found "no difference in learning between the picture and no-picture condition for better readers. Among the poorer readers, those in the no-picture condition learned significantly more words" (1970, p. 399).

His results were similar to those of an earlier study by Braun (1969), who found kindergarten students learned to read words significantly faster without pictures. Donald (1979) indicates that Samuels' work may be flawed, since he used isolated words not in continuous context. Donald's research sugggests that there is a positive effect when "relevant illustrations," as he refers to them, are incorporated with print material. Samuels concludes that "the bulk of the research findings on the effect of pictures on acquisition of a sight-vocabulary was that pictures interfere with learning to read" (1970, p. 405).

3. Effect of Illustrations on Recall

According to Levin (1979), illustrations can serve as mnemonic prompts. He argues that this "transformation function" is necessary for textual components that are not difficult to understand but are difficult to remember. He concludes that children exposed to story-relevant pictures may be expected to recall at least 40 percent more of the information in comparison to no-picture controls. This would be a useful process for names and dates, and in historical text that must be memorized.

Haring and Fry (1979), working with fourth and sixth grade students, found that when pictures were redundant with the text, the subjects were able to recall the main elements of the story but not less essential elements. Koenke and Otto (1969) found that sixth graders using passages with pictures representing the main ideas of the passages scored higher than did subjects who did not see the pictures. Their similar experiment with third graders did not yield similar results, however. Pictures appeared to be of no value to this population. Koenke (1969) found that when instructions to view pictures were given, emphasized, or omitted, no significant differences occurred between similar test groups.

Vernon's (1953, 1954, 1964) studies showed that pictures probably improved the recall of facts but served to retard the ability of students to describe the overall purpose of the text. It may be that the location of pictures has some effect on different types of learner recall. Brody and Legenza (1980) found that placing pictures after the text led to better comprehension of incidental information.

TYPOGRAPHY--AN OVERVIEW

A. Introduction

While research on typography has been conducted for over 150 years, the advent of printing precedes even the earliest research by several centuries. Whereas a rational case can be made for adding or omitting illustrations from an instructional text, no printed text can exist in the absence of typography. All of the essential elements of the printed page are involved in typography--the nature of the type itself, its size and spacing, the format and layout of the page, the width of the typeset line--all participate in the final product, regardless of whether the type is set by hand or generated from computer memory. Furthermore, these elements interact with one another in subtle and often unpredictable ways.

Before research into typography began, the basic decisions involved in the composition of a printed page were made by tradesmen, artists and craftsmen. Many of their books are undeniably attractive and legible, even masterful, but they worked in the absence of any scientific knowledge about the psychological effects of what they were doing. Their artistic instincts were their sole guide.

Today, we have the benefit of hundreds of studies concerning typographical variables to help us make the necessary decisions that result in printed materials. But, as Macdonald-Ross (1977) points out:

> Educational texts are extremely complex typographically: they contain title, contents, section numbering system, glossary, index, running heads, section headings, page numbers, footnotes, references, tables, photographs, diagrams, captions, questions and answers, instructions, mathematical formulae or other special notation, typeface, type size, work spacing, interlinear spacing, line length, use of space, columns, boxes and rules, cover design, bindings, page size. Also the designer must consider the production system, the conditions of usage and the needs of marketing. Over thirty issues must be resolved by the typographer or book designer. (p. 41)

No one can possibly reach a perfect compromise between the effects of all these variables, and no researcher has successfully predicted their interaction. Concessions must therefore be made for text

production to take place. The end result, as with illustrations, is often merely decorative, and the final decisions are often based less on sound research than on practical financial and marketing considerations.

B. Scope and Definition of Variables

A complete treatment of the extensive research on all the variables listed above by Macdonald-Ross is well beyond the scope of this paper. The following review will highlight the significant research in the areas of typeface and type size, leading and line width, ink and paper color, and aesthetics. We will also examine several standard typographical conventions: justification, cuing, and paragraphs and column format. Finally, we will consider format and layout and a non-standard style of typography called vertical typography.

For extensive bibliographies of research involving these variables and others not treated in this review, the reader is referred to Tinker (1966), Macdonald-Ross and Smith (1974, 1977), Hartley, Fraser, and Burnhill (1974), and Spencer's excellent text, The Visible Word (1969). For discussions of the mechanics of book design and modern practices in typography, Morison (1967), Williamson (1966), Rehe (1974), Hartley and Burnhill (1977a), and Hartley (1978) are all useful sources. Watts and Nisbett (1974) provide a review of legibility in children's books with recommendations for standards of legibility.

To better understand and compare the various research studies we will examine, it is first necessary to define certain key terms, and explain how they will be used in this review.

As Foster (1965) notes, a good deal of confusion surrounds the current terminology used in typographical research:

> Three terms have current usage among research workers, these being legibility, visibility, and readability. All are used to signify certain qualities of printed matter, but are used with different meanings in different contexts, sometimes by the same author. (p. 279)

Foster distinguishes between visibility and legibility, claiming that visibility is the "identifiability of a printed character or form," such as the greatest distance at which a given typeface can be identified.

Legibility, on the other hand, is reserved for the "influence of the total format of a printed page on the ability of the reader to understand the text," or the "ease with which running text matter can be understood under normal reading conditions." Readability is defined as the effect of writing styles, such as the length of sentences and sentence structure, on "comprehensibility" (p. 279).

Tinker (1963) also refers to the difference between readability and legibility, adding that prior to 1940, legibility was used to express "factors affecting ease and speed of reading" (p. 4). Since then, the term readability has begun to be used for the same purpose. He continues:

> For a time, it appeared to be a broader term and perhaps more meaningful. However, with the advent of the readability formulas devised to measure the level of mental difficulty of reading material, we have had the same terminology employed with entirely different meanings. Obviously, this has led to confusion. (p. 4)

Zachrisson (1965) concurs, and defines legibility as the speed and accuracy of visually receiving and comprehending meaningful running text, while in general language, legibility refers to contents and is then called readability.

This paper will be concerned primarily with variables affecting legibility, although readability will also be discussed. These terms will be used in the manner described above.

C. Early Research

The first typographical research on record was conducted in 1790 by Anisson in Paris. He experimented with the relative visibility, at increasing distances, of two contemporary typefaces (Wiggins, 1967). His work, as well as that of Hansard in 1825 and Babbage in 1827, is summarized in the classic review by Pyke (1926), Report on the Legibility of Print. In addition to reviewing the earliest research, Pyke also reports on his own experiments, which involved eight different typefaces. He measured their relative legibility in terms of reading speed, and found that there were significant differences between them. He concluded, however, that under normal reading conditions the differences between typefaces would have to be radical in order to affect legibility. His discussion of the specific criteria of legibility is noteworthy for attempting to

define this elusive term. He defined legibility with specific reference to measurable quantities, reading speed and accuracy, and noted that few of the early investigators had made any attempt to define legibility.

Anisson and other early researchers anticipated the work of Emile Javal, the first researcher to perform scientifically controlled experiments in typography. Working at the University of Paris in 1878, Javal studied eye movements, the relative visibility of letters, and the effects of variables such as lighting and paper color on the eyes of the reader (1878).

Javal also mentions an earlier study by Cohn, in 1865, in which 10,060 children were examined. Javal credits Cohn's investigation of myopia in these school children as being the starting point for subsequent studies of lighting, text, type, and other variables that affect reading (Cohn, 1886).

One methodological criticism that Spencer (1969) levels against these early researchers is that they utilized the distance method, measuring the visibility of printed characters at increasing distances. He claims that the results of such studies can be misleading when applied to normal reading conditions, and are more appropriate for road signs, street lettering, and car number plates.

Spencer's review of the history of typographical research is recommended for the reader wishing a more detailed historical survey, as are Pyke (1926) and Zachrisson (1965).

EFFECTS OF TYPOGRAPHICAL VARIABLES

A. Readability

Readability refers to the content and grammatical style of a text rather than to its format or legibility. For a general review of experimental studies, the reader should consult Coleman (1968).

Some of the "stimulus dimensions" Coleman discuses include: word length, word frequency, phonics regularity, phoneme selection, phonics blending, content words, clause structure, and grammatical transformations.

"Readability formulas," as developed by Flesch (1958), have greatly influenced later work in this field. By applying these formulas to text materials, the readability of a text passage can be measured. Klare, Mabry and Gustafson (1955) tested the formulas of Flesch (1948) and Dale and Chall (1948) on 989 Air Force trainees. They found that an "easier style of writing" in technical material (as measured by these formulas), led to higher retention, more rapid reading, and more "acceptable" preference judgements by the subjects. Kare et al. found a "high relationship between judgements of material as easier to read and more pleasant to read" (p. 295).

True tests of readability, however, must measure content as well as the number of syllables and the average number of words per sentence in a 100-word text sample (the Flesch formula). One criticism of Flesch's work can be found in McLaughlin's Temptations of the Flesch (1974).

Rothkopf (1972) concludes that "clear experimental tests of the hypothesis that learning and reading ease are related are scarce." One reason he gives for the inadequacy of many readability and learning studies is that they "have confounded subject matter difficulty or information content with readability". Pointing out that it is extremely difficult to control verbal content in readability experiments, he adds that "it is hard to find studies in which content is held constant while readability, or the factors that determine it, are varied" (p. 318).

Furthermore, the level of integration we most need to study to make readability research more useful, is precisely the most difficult one to examine. Coleman (1968) points out that:

> There is not much of an experimental nature to say here. Surely most of us believe that the major determiners of readability for adults lie at this level--lie in the associations between clauses and paragraphs, in the overall organization--but psychologists have not yet refined the experimental techniques to investigate this level and linguists are not yet able to describe it." (p. 177)

B. Legibility

1. Type Size and Typeface

The practice often followed in experiments that compared typefaces and/or type sizes has been to base comparisons on point size. Spencer (1969) cautioned about a potential for error with this practice. He cited Cohn and Rubencamp (1903), who drew attention to the importance of measuring type in visual, not body, size in order to make valid comparisons. The problem with using point size as a comparative measure is explained by Zachrisson (1965):

> This measure does not give exact information about the actual height or width of the letters. It is merely a measure of the body of the type, not its design. There are instances where the heights of type faces having the same body, or point, size vary as much as 25%. (p. 42)

Typeface differences and their effect on the legibility of text material have been investigated by Paterson and Tinker (1940), Burt, Cooper, and Martin (1955), Tinker (1963), and Salcedo, Read, Evans, and Kong (1972).

The results from these and earlier studies were well summarized by Burt, Cooper, and Martin (1955), who stated that "with adult readers enjoying normal vision, wide variations in design... seem permissible without greatly affecting efficiency of reading" (p. 45). Working with students in grades one and four in Sweden, Zachrisson (1965) found that changing typeface under various conditions made no significant difference in either legibility or visibility. His study therefore confirms for children what Burt and others found for adults.

Poulton (1959), in a study with scientists, did claim that one typeface (11 point Modern Extended No. 1) was superior to others for the main body of a scientific paper. Poulton's focus on special reader groups has been recommended by Salcedo et al. (1972). They conclude that "the human variable in legibility studies invites further inquiry . . ." and that "subject type might be manipulated as part of the research design" (p. 295).

As noted earlier, when typefaces are compared, point size does not necessarily equate to an equivalent actual size. This has been taken into account by careful investigators of "ideal" type size. Thus Paterson and Tinker (1940) and Tinker (1963) have defined the most legible type sizes to be either 9, 10, 11, or 12 point depending on the typeface in question. Burt et al. (1955) recommend "type having an x-height of about .060 inch, e.g., 10-point Times New Roman or 11-point Inprint or Modern 7" (p. 45).

As summarized by Rehe (1974), the consensus of research findings is that "for text matter a type size of 9, 10, 11 or 12 point should be selected. For type faces of a small x-height, 11 or 12 point should be used, while for type faces of a large x-height, a 9 or 10 point size might be most appropriate" (p. 29).

2. Leading and Line Width

Hartley, Burnhill, and Davis (1978) had grade school children read four pages from MacLean's Master of Morgana. The text was set up as a single column about 7½" wide or in double columns, each about 3 3/8" wide, with variations in leading to indicate new paragraphs. The amount read in ten minutes was measured, then subjects were asked to "scan" for another ten minutes. Scanning (Poulton, 1967) involves giving subjects phrases taken from their reading, each with a missing word, and asking that they scan quickly, find, and write down as many missing words as they can.

Neither line-width nor leading variations caused significant differences in reading speed. Hartley et al. point out that since the students did not experience great difficulty with the single-column layout, "if it is necessary to use this extreme line-length (because of the nature of the text) then this can be done without placing undue strain on the reader" (p. 194).

Earlier research on line length (Burt, Cooper, and Martin, 1955; Paterson and Tinker, 1940a, 1940b, 1942; Tinker and Paterson, 1949) confirms that a line length of 3 to 5 inches with about 60 to 70 characters is optimal for type sizes in the 9 to 12 point range, with narrower line widths for smaller type sizes. Thus line widths may vary considerably without creating problems. Paterson and Tinker (1940a, 1943) found, however, that very short lines slowed perception and increased the number of fixation pauses. Very long lines greatly increased the number of regressions and caused inaccuracy in locating the beginning of each new line.

If type is set solid, without interlinear spacing, the printed lines will be too close together for effective reading because the descenders in one line interfere with the ascenders in the next line. Leading between the lines solves the problem. The measure used is the point, where 1/72 of an inch is one point (Burtt, 1949, p. 216).

Paterson and Tinker began checking the effect of leading on the legibility of type in the early 1930's. This task seemed to be a relatively simple job at first, but they found that "one experiment led to another until 11 studies were completed in which over 11,000 readers served as subjects" (Tinker, 1963, p. 90). For the commoner type sizes (9 to 12 point) the most effective amount of leading ranged from one to four points, depending on the type face and line width (Tinker, 1963).

Luckiesh and Moss (1938) found the optimum for 10 point type was 3 points of leading, but Burt et al. (1955, p. 35) reported that 2 points of leading "appreciably increased the ease of reading (8 and 9 point type). . . but little seemed to be gained by 3 point leading. Four point leading usually diminished legibility."

3. Ink and Paper Color

Tinker (1963) reviews the work of earlier investigators who compared the legibility and readability of conventional black print on a white background with the same test using white letters on a black background. Taylor (1934), Paterson and Tinker (1931), and Starch (1923) all found that black print on white paper was significantly more readable then white print on black paper. A review of experiments with colored inks led Tinker (1963) to conclude that "the brightness contrast between letter and background appeared to be one factor determining the perceptibility of the letters" (p. 143).

Prince (1957) reinforces this observation, indicating that maximum paper reflectance promotes maximum reading efficiency because it provides the greatest contrast between background and image. Comparative studies of black print on papers of various tints by Luckiesch and Moss (1938) and Stanton and Burtt (1935) showed no significant difference in speed of reading due to paper tints.

The effect on reading speed of colored print on colored paper in various combinations has also been studied. Tinker and Paterson (1931) used black ink on white paper as a norm and tested the readability of 10 ink/paper combinations. Black on white was most readable, and the remaining combinations in order of legibility were: (1) green on white, (2) blue on white, (3) black on yellow, (4) red on yellow, (5) red on white, (6) green on red, (7) orange on black, (8) orange on white, (9) red on green, and (10) black on purple. Paterson and Tinker conclude that combinations 7 through 10 are very illegible and should not be used. Combinations 5 and 6 should not be used where speed of reading is important.

4. Aesthetics

Tinker and Paterson (1942) carried out a comprehensive study of the "pleasingness" of various typographical arrangements. "Pleasingness" is their term for reader preference. As they stated, "We are now in a position to determine the extent to which judged legibility and judged pleasingness agree or disagree with one another" (p. 39). They compared ordinary printing with bold face, lower case versus caps, styles of typefaces, and numerous other arrangements. Their conclusions are quite definite: "In all cases judged legibility and pleasingness showed remarkable agreement. We are warranted in concluding that judged legibility may be accepted as pleasingness" (p. 40).

Burt, Cooper, and Martin (1955) conducted a study of typography which included aesthetic preferences. One part of their study correlated legibility and reader preference in much the same way as Tinker and Paterson had done in 1942. Although Burt et al. make no reference to this earlier work, the conclusions they draw are remarkably similar. According to Burt, "we obtained a partial correlation between ease of reading and preference amounting to .33--fully significant with the number tested" (p. 44).

Zachrisson (1965) reviewed several earlier studies related to aesthetics as a background for his experiment on the "congeniality" of types and typography. He identifies Ovink (1938) as:

> The pioneer in scientific work on congeniality. Ovink . . . elicited judgments on the appropriateness of 30 book and display types for 8 literary subjects and 8 ideas. The analysis brought forward clusters of type faces which were judged to express the atmosphere within three categories: luxury-refinement, economy-precision, and strength. (p. 82)

With respect to his own experiment on congeniality, Zachrisson concludes that:

> In studies of aesthetic appreciation, the perceptual and artistic ability of the subject should be of interest. We have failed to take this into full consideration in our congeniality experiments. Only by separating our subjects into interest groups have we to some extent been able to relate the indivIdual to the task in a meaningful way. (p. 84)

It appears that most of the research on aesthetics has been exploratory and inconclusive. The observations of Rehe (1974) seem especially germane:

> By and large research into the congeniality of type face is in an initial stage. Results of investigations have only shown the value of certain methods of investigation. Eventually, however, results from careful investigations into the congeniality of type face may become an important determinant in the selection of type faces for typographic design. (p. 55)

C. Standard Typographical Conventions

1. Justification

All typed pages normally have irregular margins. When they are typeset for production, the unevenness is often eliminated by a process called justification. This process involves changing the

spacing between letters or words so that every line is the same length, with a minimum number of words being hyphenated into syllable fragments. Justification was first used for purely aesthetic reasons.

The technique is of more than theoretical interest. Justifying typeset lines is a very expensive and time consuming process. If it has no effect on reading rate or comprehension, it may be desirable to produce unjustified texts at a significantly lower cost. Macdonald-Ross and Waller (1975, p. 20) found that corrections required at the proof stage for Open University texts ran to 30 percent in some cases. To correct justified text required 6.3 percent of the total print cost in one year, or 22,000 pounds sterling. Justification is often done solely for cosmetic purposes, and there is some disagreement in the literature over whether it has any positive effect on legibility.

Fabrizio, Kaplan, and Teal (1967) concluded from their study of 216 Navy personnel that irregular margins, irregular margins with a printed guideline, and straight (justified) margins all gave "essentially equal scores" on reading speed, level of comprehension, and speed of comprehension.

Gregory and Poulton (1970) on the other hand, found significant differences in the rate of comprehension between justified and unjustified text, but discovered that the length of the line and the subjects' level of reading ability were a major factor in the effects of justification. Their study found that when line lengths averaged seven words, poorer readers did significantly worse on comprehension tests on justified texts. Good readers did equally well on either margin format. When line length was increased to 12 words, this disadvantage of poorer readers using justified texts disappeared. They concluded that the "variation in interverbal spacing" was most critical for shorter lines, and that when line length was increased, the "variation in spacing is barely noticeable and so it is not surprising that the disadvantages of justification should disappear" (p. 433). They also criticized the experiments by Fabrizio et al. (1967), claiming that the reason no differences were found between the two styles of margins was that their subjects were mostly high school graduates and therefore presumably good readers. Fabrizio et al. made no attempt to divide their subjects into groups of good or bad readers (p. 428).

Gregory and Poulton's results confirmed earlier studies by Powers (1962) and Zachrisson (1965). Powers, using newspaper text of four to five words per line, found that an unjustified style was an advantage for slow readers (although he performed no statistical tests to establish the significance of this result). He found that justification slowed the reading rate but led to better comprehension overall.

Zachrisson measured reading time, comprehension, eye fixations, and regressions. He recorded eye movements using a text with a line width of about nine words (10 cm). He also discovered that poor readers read significantly faster with the typical unjustified style. No significant differences were found between texts with even or uneven left hand margins. For right hand margins, poor readers required longer reading times for justified text. Gill (1954, p. 88), as quoted in Wiggins (1967, p. 8), concluded that "even spacing is of more importance typographically than even line length. Even spacing is a great assistance to easy reading."

Hartley and Burnhill (1971), using volunteers from psychology classes, tested three formats: standard unjustified text versus text with line endings determined by syntactic or grammatical considerations, standard unjustified versus unjustified text with about 33 percent of the lines hyphenated, and unjustified one column versus two column texts of varying lengths. No significant differences were found for any of these comparisons. They concluded that: "These experiments taken together would seem to indicate that unjustified text is robust; that is, it can be quite markedly manipulated without affecting reading speed or comprehension" (p. 277). Since their subjects were college students and probably relatively skilled readers, this experiment may have overlooked the negative effects of justification on poor readers that other researchers have found.

Davenport and Smith (1965) conducted a study with 408 adult subjects. About half of them were high school graduates, and the other half had at least some college level education. They stated: "Hyphenation, justification, and type size do not affect how much, how quickly, or how accurately newspapers are read" (p. 388).

Wiggins (1967) found that: "The use of space bands to give even right margins and constant spacing by the use of thin spaces to provide uneven right margins was not significant" (p. 17). He

cautions that test specimens should be set "line for line" to prevent introducing other variables, such as hyphenation and differences between texts in the total number of lines.

As Hartley and Burnhill (1971) summarize: "There is, in fact, little--apart from tradition--to justify justified text" (p. 265). The empirical evidence would indicate that for beginning readers, and poor readers in general, the use of unjustified text format is recommended.

2. Cuing--Headings, Underlining, and Questions

The process in which format and layout assist the reader is often referred to in the literature as "cuing." Such variables as headings and underlining, typesize, indentation, and paragraph structure all act to cue the reader on where he is in relation to the overall organization of the text, and what is of greatest importance on that page.

The use of headings and underlining serves to accentuate selected elements in printed text with the expectation of improving learner acquisition and retention. Both are used to draw a learner's attention to information an author considers important for the learning task at hand.

Bransford and Johnson (1973) found that headings (which they call "titles") influenced a subject's interpretation of the subsequent text and resulted in increased comprehension and recall. They concluded that improved test scores were due to the organizational schemata provided by headings. Their findings also indicated the need for careful consideration when constructing headings because they influence a reader's perception of the text that follows. They note that their subjects could not correctly interpret a sentence when they found a discontinuity between it and the preceding heading. In addition, subjects wasted time in "creative attempts" to rationalize this incongruity. The converse proved equally true; presenting a context cue tended to make difficult textual material more comprehensible. Many subjects in groups that were given material without headings "attempted to find or generate information that would make sense of the materials" (p. 409). These findings are consistent with those of Fowler and Barker (1974) who examined used college textbooks and found that over 90 percent of the students had used some form of self produced typographical cuing.

Swarts, Flower, and Hayes (1980) tend to support Bransford and Johnson (1973) with the observation that headings can mislead readers and seriously impair their understanding. However, their findings also suggest that clearly written text can substantially overcome this problem when used with adult learners conversant with the content of the printed material.

Holley (1980) suggests that headings may be more valuable as aids for retrieval than for retention. He examined:

> The utility of intact (i.e., appropriately positioned within the text) headings as processing aids with non-narrative text . . . . The major result of this investigation was that students provided with text containing intact and embedded headings significantly out-performed students whose text did not contain these processing aids . . . the text-with-headings students recalled approximately 11% more information at immediate testing and 44% more information at delayed testing than the text-without-heading students. (p. 4)

Underlining is a traditional practice used by many authors to call attention to important concepts. It may not achieve the desired effect or, if successful in aiding retention, it may, in some cases, do so by creating a condition where non-underlined information is not recalled. Wendt and Wecherle (1972) found that underlining "keywords" in reference work did not aid recognition with 10- to 12-year-old pupils. Cashien and Leicht (1970) found that underlined material increased the scores of college freshmen but not at the expense of information that was not underlined. In a summation of the literature related to underlining, Glynn (1978) states that:

> The research reviewed suggests that experimenter-provided underlining has little or no effect on overall retention of text propositions. Apparently, learners were unable to exceed the overall capacity limitations of their information-processing systems. However, the provision of underlining did affect learner's allocation of attention to certain subsets of text propositions. Underlined (intentional) propositions were best recalled albeit at the expense of nonunderlined (incidental) propositions. Underlining provided nonverbal cues which readers used to

> help define their decision criteria. In this way, the typographical cue exerted control over which items in the text were encoded, rehearsed, and thereby, learned. (p. 9)

Schnell and Rocchio (1974) concluded that a structured method of preparing students proved beneficial. As with other forms of cuing, the amount of instruction given to the student about the underlining may affect the results.

Another form of cuing treated in the literature is the form and placement of questions in the text, and their use as "organizers" of text content. Lack of space precludes a discussion of the issue, but the interested reader will find Morasky and Wilcox (1970), Svenson and Kulhavy (1973), Sagaria and DiVesta (1978), Grotelueschen and McGraw (1973), and Allen (1970) a useful introduction to the problem of questions.

3. Paragraphs and Column Format

Educational texts are usually set in a one or two column format with various styles of paragraph denotation. The use of paragraphs in written or printed materials is an invention of the Middle Ages. Spencer (1969, p. 42) says that: "In the late Middle Ages it became the practice to begin a new paragraph on a new line." Prior to this, a paragraph mark was used to designate paragraphs in a continuously written or typeset text. Now, of course, it is a universal convention to separate paragraphs, which Paterson and Tinker (1940b) call "thought units," by indenting the first line of each new paragraph, or by separating paragraphs by one of more lines of blank space. The invention of this new paragraph format may owe something to the prevailing artistic tastes of the late Middle Ages. Printers were letting light and space into printed text, as the architects and craftsmen were letting it into the gothic cathedrals.

Little research has been done on the usefulness of paragraph structure. It originated as an artistic convention and became accepted as the basic textual format with no accompanying empirical evidence to support it.

The best experiments in this area are those of Paterson and Tinker (1940b) and Hartley, Burnhill, and Davis (1978). Paterson and Tinker used 30 paragraphs with 30 words per paragraph. They called

these 30-word paragraphs "thought units." They made up an alternate version of the same text, typeset as six paragraphs of five "thought units" each. Using 180 college students as subjects, they found that the 6-paragraph page was read 7.3 percen. more slowly. They also claimed that: "The equivalence of the two test forms was maintained in the 6-paragraph arrangement and that the reliability remained consistently high" (Tinker, 1963, p. 122).

Spencer (1969), however, criticizes their interpretation of the experimental results. He avers that: "It would, perhaps, be more reasonable to regard this result simply as confirming what one would expect--that unrelated 'thought units' are more difficult to read if strung together in a single paragraph than if set out separately, as logic demands" (p. 44).

Hartley, Burnhill and Davis (1978) set paragraphs in one of four ways:

1. New line of text after a one line space, with no indent;
2. New line plus indent, but no line space (the traditional method);
3. New line, but no ident and no line space;
4. No indentation: (i.e., the text was set as a solid 'slab'). (p. 184)

Five-hundred school children, grades six and seven, were randomly assigned to one of eight conditions, i.e., each of the four paragraph formats above set in either one or two column layout. The "scanning" technique (Poulton, 1967) was used to test layout legibility. The average scores were very close together. The only significant differences between paragraph formats were between system (1) and either (3) or (4). System (1) was superior to these two, but not to system (2).

In the same experiment, they found that there was a significant difference in favor of a two column layout. The difference was very small, however, and they report that "our readers did not seem to experience any great difficulty in handling the single-column layout" (p. 194).

Foster (1970) reported similar results from his study of the British Psychological Society Bulletin. Using the one column layout that the Bulletin's supplement is printed in, he compared it to the two column layout of the Bulletin itself. Both use the same page size, typeface and type size. He found that "The single-column layout significantly diminished legibility" (p. 114). Poulton (1959) found that single-column layouts were read more rapidly than double-column, but he varied the type size, typeface, and leading to produce the experimental texts.

Burnhill, Hartley and Young (1976) conducted a study with 340 school children who used text that was complicated by tables and diagrams. They concluded that, at least where paragraphs are separated by a line of space, "a single-column structure. . . . is probably better than a two-column structure for text which is continually broken by tables, diagrams, graphs, etc." (p. 69). They maintain however, that "a two-column layout is probably preferable to a single-column one for the setting of straightforward prose, although the actual data suggests that the differences are very small" (Hartley 1980a, p. 141).

Tinker (1963) claims that: "The problem reduces itself to one involving legibility of particular sizes of type with optimal line widths and leading. In addition, printing practice and reader preferences are involved" (p. 116).

Hartley (1980a, p. 141) cautions that, given the complexity of instructional text, "decisions concerning the column structure of a page should not be decided by a simple concern for line length alone but should also take into account the structural requirements of the text and its non-textual components."

Differences between one and two column layout are much more pronounced when examined in terms of reader preference. Paterson and Tinker (1940b) report on a study with 241 college students, using both single- and double-column formats of Psychological Abstracts. They found that 60.5 percent preferred the two column arrangement. They repeated the study with 38 typography experts and printers, and, once again 60.5 percent preferred the double-column arrangement.

Perhaps the preference for double-column format, and its implied effect on the motivation of readers, is sufficient to override the small experimental differences between one and two column prose text. More complex text may require a single-column format to be most effective. The decision to use one or two column format should probably be based on reader preferences and the cost of production, except where complex interrupted text or relatively poor readers are concerned.

D. Vertical Typography and Segmentation

Two current experimental variations of standard text arrangements are vertical spacing and segmentation, or "chunking." Vertical spacing refers to the arrangement of text matter from the top down:

It looks
like this.
    Sometimes with indentations,
sometimes with justified
left margins,
and sometimes

(e.g., see Hartley, 1978)

with vertical space separations

to group items hierarchically.

Segmentation, or chunking, in typography refers to the spatial separation of textual content into meaningful segments. The following example shows standard text from a technical manual and segmentation of that text (Frase and Schwartz, 1979, p. 199).

Standard text version:

> The carrier facility may be developed from single or mixed gauge, PIC or pulp (paper) insulated, copper or aluminum conductor cables with standard sheaths. The cable may be air-core or waterproof design; however, in the case of buried air-core PIC cables, the double sheath types are recommended.

Typographically segmented version without identation:

The carrier facility may be developed from
single or mixed gauge
PIC or pulp (paper) insulated,
copper or aluminum
conductor cables with standard sheaths.
The cable may be
air-core or
waterproof design;
however, in the case of
buried air-core PIC cables
the double sheath types are recommended.

A variant of vertical typography suggested by Andrews (1949) and studied by Nahinsky (1956) is called "square span." It arranges material in double-line blocks as follows:

This is	of the	style of
an example	square-span	presentation. (p. 37)

The preceding example shows segmentation arranged in vertical typography. Segmentation has also been studied in horizontal format, which is similar to standard format except additional spacing has been placed between each segment as shown here. This format is often referred to as "spaced units."

While there is considerable support (as will be shown later) for segmentation as an aid to reading, understanding, and remembering text material, there is no general agreement on how segmentation should best be accomplished. Several approaches appear in the literature. Klare, Nichols, and Shufford (1957) suggest that when creating segments one should: (1) place modifiers with words they modify, (2) separate clauses and phrases from the rest of the sentence, (3) ignore the right hand margin insofar as justification is concerned, and (4) never use existing punctuation within a thought unit (p. 42).

The approach used by Johnson (1970) was to have college students divide prose into "pause acceptability units." The 23 students were told that pause units might be for taking a breath, giving emphasis, or enhancing meaning. The locations in the story

which were considered acceptable for pausing by a majority of the students were hypothesized to be the functional boundaries used in encoding and decoding the narrative (p. 13).

Frase and Schwartz (1979) produced units by segmenting sentences into major phrases, with noun phrases and modified noun phrases used to begin different lines. They did not eliminate punctuation marks or make any other changes from the original text. Hartley (1980b), in an extended commentary on the paper by Frase and Schwartz, advocates an alternative that he and Peter Burnhill had developed earlier. As Hartley puts it, they found a "different and (in our view) simpler way of organizing text which is structually complex." They proposed that line endings be determined by "syntactic boundaries" and that space "be used systematically not only to separate items from one another, but also to group the items hierarchically by employing one, two or four units of line-space between groups as the content of information dictates" (Hartley, 1978, p. 23-24). For a further discussion, see Hartley's (1980a) presentation of his ideas on vertical segmentation and total layout with several case study illustrations.

As reviewed by Carver (1970), research on recall showed that there was an improvement in short-term memory when information was grouped into meaningful units, or "chunked." In that case, why not pre-organize textual material to facilitate comprehension and retention? This question has been studied under varying conditions with mixed results.

Favorable studies include those by North and Jenkins (1951), who found spaced-units superior to both square-pan and standard typography in terms of reading speed and comprehension. Nahinsky (1956), on the other hand, found that "the square-pan style yielded comprehension spans significantly superior to both of the other styles (i.e., conventional and spaced units) investigated" (p. 39). Coleman and Kim (1961) studied the effects of vertical, square-span, spaced units, and conventional arrangement presented on paper and via a tachistoscope. In the tachistoscope series three experimental styles--vertical, spaced, and square span--were all significantly superior, vertical being most superior. Frase and Schwartz (1970, p. 203) found that technical documents with meaningfully segmented text resulted in 14 to 18 percent faster response time than standard text. Hartley and Burnhill (1976, 1977) recommended segmentation

to reduce errors in finding information in documents published by the British Psychological Society. Johnson (1970) tested the recall of a prose passage by various samples of learners immediately after reading and at intervals of up to 63 days. He found that "the structual importance of the linguistic units was shown to be related to their recall" (p. 17).

Two studies found no significant difference between learners using segmented text and standard text. Klare, Nichols, and Shuford (1957) used standard text, square span, and horizontally segmented "thought units" to test retention, efficiency of reading, and the acceptability of technical material by adults. They concluded that while the experimental typographic arrangements "may possess certain advantages over the usual arrangement. . . the advantages. . . are best described as potential, since they interfere with strongly developed reading habits" (p. 45). Carver (1970) tested the effect of chunked typography on the reading rate and comprehension of college students. He concluded that "the spatial separation of reading material (e.g., textbooks) into meaningful related groups of words will probably not improve the reading efficiency of mature readers, reading at their normal rate, no matter what method [i.e., vertical or horizontal segmentation] is used to separate the material" (p. 296).

Kinross (1979), in a critical review of Hartley's Design of Instructional Text, points out some important practical and philosophical problems concerning Hartley's proposals for a vertical typography. Coleman and Hahn (1966) compared the reading speed of second and third graders when reading standard text with their speed when reading vertical text presented one word at a time. They found that "conventional typography was read significantly faster than vertical" (p. 435).

E. Format and Layout

All of the variables we have discussed, both pictorial and typographical, are involved in the format and layout of instructional text. In addition, the designers or evaluators of such texts must consider many other factors such as page size and paper composition,

size of margins, and the manner in which the text, pictures, charts, figures, questions, and other elements are "laid out" on the page. The juxtaposition of these various elements is known as "layout." The overall organization and arrangement of the text, including its physical form and layout, is referred to as "format."

It is difficult to experimentally measure the effectiveness of format and layout. As Poulton (1959) reminds us: "The few experiments in which two or more variables were manipulated simultaneously show that the variables interact with each other" (p. 3).

Generally, there are no well-determined rules to follow in textbook design or evaluation. As we have seen, the empirical evidence is often contradictory. It frequently suggests guidelines and rarely offers established rules. Some useful general discussions of such guidelines are Hartley and Burnhill (1977c), Hartley (1978), Spencer (1969), LeMay (1978), and Rehe (1974). Examples of criticism of printed text, which illustrate some basic shortcomings of poor design, can be found in Hartley (1978) and Macdonald-Ross and Waller (1975a). A brief and useful discussion of some of the major factors affecting format and layout, together with recommendations for their use, is found in Hartley and Burnhill's "Fifty Guidelines for Improving Instructional Text" (1977b).

Naturally, we would not want to have instructional text designers slavishly following a set formula for determining format and layout. As Cheetham, Poulton, and Grimbly (1965) remind us:

> Again, it must be emphasized that the last thing that is wanted is a rigid set of rules which would make every page of every book, magazine or paper look the same; what is needed is a guide to the way in which readers search for their information, and a guide to the more effective ways in which such searches could be most readily assisted. (p. 50)

Hartley (1978) and most other researchers recommend the use of a "reference grid." A "basic" grid resembles a sheet of unnumbered graph paper. From this, a "master" grid, or set of grids, can be drawn up for a particular text, to insure consistency in text layout. Hartley claims that:

> The principal weakness in the typography of many instructional materials is a lack of consistency in the positioning of functionally related parts .... This indicates that layout decisions have been made during the process of assembling the image (type and illustrations) prior to the process of its multiplication by printing. In the world of building this would be equivalent to erecting a house without reference to a formal specification or plan. When it is considered that the cost of producing a book may equal that of erecting a building, then some idea may be gained of the wastage and cost of muddling through in this way. (p. 13)

Macdonald-Ross and Waller (1975a) take issue with the use of inflexible reference grids. They state that:

> Our view is that the grid is a useful tool, but no substitute for the taste, skill, intuition, and creative judgement of the designer. A grid which is too strict or inflexible can discourage the designer from taking personal responsibility for a job .... It must allow the designer to use his judgement and skill within a disciplined framework. (p. 3)

The generous use of space in instructional texts is an absolute necessity for aiding comprehension as Hartley and Burnhill have repeatedly stated. Logic would tell us that increased use of space would also increase the size and, therefore, the cost of the text. However, as Hartley and Burnhill (1976, 1977d) demonstrated with documents published by the British Psychological Society, such re-design can often save money in the long run by making the document more comprehensible and its important features more obvious. Hartley (1980a) also reminds us that "it is difficult to measure the costs to the user of badly designed documents" (p. 137).

Burnhill, Hartley, Fraser, and Young (1975) suggest some ways in which the increased cost of the correct use of space in texts can be minimized through modern printing methods and the simplification of various typographic procedures.

Designers should also avoid what Hartley and Burnhill (1977c) call the:

> Tendency to apply the bilateral mode of symmetry to layout; that is, to 'balance' the parts about the central axis of the page. . . . It could justifiably be termed 'illiterate' for, clearly, the component parts of a text are not mere objects of varying shapes and sizes to be displayed like ornaments on a mantel shelf or pictures on a wall. In addition, this approach is uneconomical from the point of view of print production. (p. 237)

One other common pitfall in text design is the excessive use of varying type sizes and typefaces to convey meaning, emphasis, and structure. Macdonald-Ross and Waller (1975a) examined one Open University tex which contained no less than 18 different type variations. Ha y and Burnhill (1977c) also criticize the "excessive variety in the sizes, styles, and weights of typeface chosen to code heading levels" (p. 237).

If either format or layout is poorly done or too complex, it can actually distract the reader from the most important information on a given page. Hershberger and Terry (1965) discovered this to be the case in a study using 118 eighth grade students. They manipulated ink color, upper or lower case type, and underlining, to create both typographically simple and typographically complex formats for a lesson plan. The texts distinguished five levels of importance of content (core versus enrichment), and each was set in three typographical formats. The text formats differed in the number of levels of importance highlighted by "heterogeneous typography." They conclude that:

> Simple typographical cuing, distinguishing core from enrichment lesson content, significantly enhances the ratio of important to unimportant content learned without reducing the total amount learned. . . .On the other hand, complex typographical cuing distinguishing five categories of lesson content does not appear to benefit the reader in the least. In the latter case, it seems likely that the complexity of the typography may befuddle the reader sufficiently to offset any advantage derived from the cuing. (p. 59)

Hershberger and Terry (1963), Hershberger (1964), and Tinker and Paterson (1946) reach similar conclusions.

Clearly, it is necessary to choose from among a multitude of typographical variables in order to produce a final layout and format. Most text contains a mixture of both acceptable and unacceptable practices in typography. Any text designer will need to find an optimal solution to the problem of balancing the effects of these variables. The experimental literature usually considers these variables singly, or in small groups, yet all instructional texts contain several such variables, and no one can presently predict their total interaction. One experiment, however, indicates that this interaction can produce some unanticipated results. Tinker and Paterson (1948) studied the interaction of illumination intensity, type form, and type size on reading. They found that although their three conditions were only marginally deleterious when considered separately, when operating together they produced a statistically detectable difference, a "nonoptimal" condition.

From this, and other experiments discussed in Tinker (1963), Tinker concludes that "the printer should never combine either nonoptimal typographical arrangements or marginal arrangements. Such practice will only diminish to a striking degree the legibility of print" (p. 169).

CONCLUSIONS

A. Illustrations

For over fifty years, researchers have examined the of illustrations in textual materials and arrived at widely vergent conclusions. This lack of consistency, while not surprising considering the number of variables involved, indicates a need for further research before illustrations can be used with any predictable degree of success. In general, however, it appears that illustrations can improve learning and retention if they are properly designed for the intended population.

Duchastel (1978) indicates that illustrations may not achieve their intended purpose because we are more concerned with how they look than how well they contribute to the learning purpose. He states that illustrations are most useful when their role is clearly defined and they are carefully designed to fulfill that role. The appropriate roles he assigns to illustrations are the attention role, where illustrations are designed to attract and motivate the learner to read and, as such, have no other purpose; the explicative role where pictures are used to explain some element of the topic which cannot be clearly described in the text; and the retentional role, in which a picture that the student is able to recall helps him remember some essential element of the textual material (p. 36-39).

Dwyer concludes from his numerous studies that the following generalizations should be considered when incorporating visual material in texts for college level students:

1. For specific learning objectives the addition of color in certain types of visuals appears to be an important instructional variable in improving student achievement.
2. The use of visualization to illustrate verbal instruction does not automatically improve student achievement of all types of learning objectives.
3. Different types of colored illustrations differ in the effectiveness with which they facilitate student achievement of identical educational objectives.

4. Increase in realism in a visual does not always cause a significant increase in learning. There are practical limits beyond which increased realism will not result in increased learning. (1972, p. 73)

One wonders whether Dwyer's conclusions could apply to materials used by elementary and secondary school students as well. Future studies using Dwyer's experimental procedures could prove profitable in this area. It is becoming abundantly apparent that educators will soon have to justify every expense. Since illustrations add greatly to the cost of texts, we will have to justify their use.

B. Typography

We have reviewed many significant studies of the variables affecting the finished product of typographical design--the printed page. Many of the research studies have indicated possible guidelines for those who must design and evaluate instructional texts. This research, however, will be of little use if significant results are not translated by practitioners into actual production methods. As Spencer states, in The Visible Word:

> Despite the fact that in many respects they share a common objective, there has until now been remarkably little collaboration between the researchers and the producers of print. Many designers and printers remain ignorant of the results of research or view the whole notion of legibility research with suspicion. The problems of methodology, and definition, which have greatly exercised researchers, have tended to obscure the significance for the designer of many results. (1969, p. 6)

It is obvious that some solution to this dichotomy between theory and practice must be reached if the research results are to serve any purpose other than merely academic curiosity. It is not at all obvious how this can best be accomplished. Macdonald-Ross and Waller (1975b) acknowledge this problem, and conclude that:

> We can, perhaps, speak of a modern consensus between researchers and typographers. Both groups have come to see the defects of the older literature, and would like to

> remedy these defects. All are agreed (though maybe only in a vague kind of way) that research should--indeed must--in the future be of value to the practical designer and typographer. The issue is, how to achieve this? (p. 77)

They suggest that, as a preliminary measure, two readjustments are necessary. First, researchers must realize that "the purpose of legibility research should be to improve the quality of practical decisions." Second, researchers should learn to "value the personal skills of typographers and designers, and take them as the starting point for more fruitful typographic research" (p. 77). As we mentioned in our introduction, artistic skills were the sole guide for producers of texts for many centuries. Researchers have been too reluctant to recognize the value of experience and sound artistic judgement, preferring to limit themselves to the results of empirical research and "book learning."

C. General Conclusions

Spencer (1969) states that future research into typography must begin to address the effects of the new computer information explosion if typographical research is to remain relevant.

> If future legibility research is to be of real significance it must, then, concern itself with the realities of the later twentieth century since no amount of legibility research is alone going to enable our society to digest the current vast outpouring of printed information .... This means that legibility research must be concerned with the requirements of machine reading, cathode-ray tube composition, microfilming, electrostatic printing, and electronic video recording as well as with the needs of the human reader and conventional printing processes. (p. 9)

Many of the areas of research we have reviewed have yielded conflicting results. The processes of perception, integration, and comprehension that are involved in reading are extremely difficult to isolate and control. Kinross (1979), in her excellent review of Hartley's Designing Instructional Text, suggests that perhaps we should not become too concerned with consistent experimental results:

> One hopes in the future for research that produces not so much 'findings' as possibilities that stimulate designers of texts by suggesting alternatives. Rather than attempt to pass on certainties, one hopes that research work will foster a critical attitude in designers and producers of texts. And one would like to see a theory of typography that shows what is common and basic to all visual typographic languages--independent of particular composing and printing systems, and passing by the old allegiances to 'traditional' and to 'modern' typography. There is certainly a place, and much work ahead, for typographic research. (p. 289)

We hope that future researchers, as well as textbook designers and evaluators, will find this review a useful point of departure for their own investigations. As Hartley, Branthwaite and Cook (1980) caution:

> The final review, of course, will still be like a portrait--painted at one point in time and from one particular perspective. And, like all portraits, it will be perceived differently by different people. (p. 261)

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