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ABSTRACT

Legibility refers to the physical appearance of printed materials: line lengths, type size, style of type face, space between lines and between letters, margins, and physical format are some of the factors that are involved. After the turn of the century, especially after 1925, research became fairly common in this area, but has been meager since 1950. From the 1800s, the best type of serifs, the effects of descenders and ascenders, brightness contrast between paper and ink, and other factors have been the topic of discussion and research. Based on the findings of various studies, speed of reading is the most satisfactory measure of legibility of type face. Most publishers maintain that 10 or 11 point type is the smallest that should be used in books, but there is no agreement on this subject by modern authorities. Research indicates that two-point leading (the space between lines) appears to be optimal. There is great diversity in the application of factors such as size of page, margins, single and multiple columns, paragraph arrangements, and vertical and horizontal printing. Research indicates that black print on a white background is more legible than white print on a black background, and approximately three-fourths of readers prefer it in this manner. Factors affecting legibility typically are not determined by research, but by persons who publish printed material simply according to their own beliefs and opinions. (Contains 24 references.) (RS)

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LEGIBILITY OF PRINT

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Legibility of Print

For well over a century there has been concern with the legibility of print. Many opinions and recommendations were expressed in the earlier years, but they were based on observation, intuition, and the like, rather than on scientific research (Tinker, 1963). Before 1900, there were almost no experimental studies dealing with legibility. After the turn of the century, especially after 1925, research became fairly common in this area, but for some reason, has been rather meager since 1950.

In the past, legibility has had various meanings (Luckiesh and Moss, 1937). Prior to the nineteenth century, for example, the esthetic appearance of print and those factors related to it were the primary concerns. Legibility would have been used in relation to those concepts. Today, legibility refers to the physical appearance of printed materials (Labuz, 1988). Line lengths, type size, style of type face, space between lines and between letters, margins, and physical format are some of the factors that are involved. At one time visibility factors were considered to be closely related to legibility, but today they are considered to be legibility factors by most authorities (West, 1990). The color of print, color of finish of the paper, finish of paper, and contrast between the print and the paper are among the factors that are commonly considered.

Some typographers make a distinction between readability and legibility (Nelson, 1987). To them, legibility has to do with the ease in distinguishing one letter from another while reading. They would consider readability a much broader term having to do with the ease with which the reader takes in the printed material.

Vocabulary

Any study of legibility must deal with the special vocabulary that is common to typographical work. The printing industry has its own special units of measurement. Height, for example, is measured by the point. A point is approximately one seventy second of an inch. The height of any type, regardless of type or design, is always measured in points.

Printers use the pica as their unit of measurement for line width. It is equivalent to twelve typographical points or one sixth of an inch. Pica is also used to designate twelve point type.

The spacing of type has one meaning, but several applications. It can refer to space between letters, lines, words, or even paragraphs, but spacing is always within the framework of the margin. Leading is a specialized form of spacing and it always refers to the space between lines of print. Spacing and leading are dependent on such factors as type size, line lengths, the syllabication of the words, and the means of setting the type.

There are many other terms used in the printing world, but for the most part, they are technical and relate to the mechanics of type rather than to legibility. The exception to this is the name of the type face and the description and characteristics of the type. This paper will use only those type styles that have been researched or discussed in the area of legibility.

Legibility of Letters

Interest in the legibility of letters began in the 1800's with observations and subjective judgements. From that time, the best type

of serifs, the effects of descenders and ascenders, brightness contrast between paper and ink, and other similar factors of legibility has been the topic of discussion among those in the field. This is still an area of much discussion, and opinions continue to be expressed freely. Much research has been done, but it is often ignored in preference to personal opinions (Tinker, 1963).

It is believed that the first controlled research on the subject was done by Cattell in 1885 (Tinker, 1928). Numerous investigations have been done since then, but the period between 1925 and 1938 saw the greatest output of experimental research. Most of the studies were concerned with the relative legibility of the letters of the alphabet.

Until some time ago, most authorities believed the old Roman Capitals, which are made up almost entirely of straight lines and sharp angles, offered the maximum legibility of letters. Ovink (Tinker, 1963) however, discovered many serious faults in the capital letters of most of the different styles of print. By having his subjects view the different capital letters at a distance and fully describing what they saw, he arrived at his conclusions.

The most important principle Ovink found was that of clearly differentiating the letters. For example, the T should have a long horizontal cross at the top. A Q should have a curve at the bottom that is easily noted. There should be an adequate opening in the C. A rather heavy horizontal stroke should be used in the G, and there should be an adequate white opening above it.

The second principle he stressed was to avoid narrowness. The capitals of A, V, X, and Z are especially hard to determine if they are extremely narrow.

Extreme contrasting hairlines were another source of trouble at a distance. Ovink's study indicated that these hairlines in obliques, horizontals, and verticals should be avoided. Specific examples are Y, N, and F.

Similarly, he found that heavy or too long serifs on horizontals and verticals should be avoided. For example, the F and the top of the U are difficult to read when heavy serifs are used.

Orvak's study, while dated in that it was undertaken years ago, is current in that it is factually timeless, and his findings are used in the most current literature and textbooks in the field.

Tinker (1963) discounts the value of any study of the comparative legibility of capital letters. In ordinary printing they are not that important because most of it is in the lower-case letters except for a few words such as proper names and the initial word in a sentence. He contends this is fortunate because lower-case printing is much more legible than all-capital printing due to the fact that lower-case letters have more character in terms of variation in shape and the contrasting of ascenders and descenders with short letters. And letter character is extremely important because research has shown that readers look most closely at the top half of letters (Labuz, 1988). Thus words formed from lower case letters have unique outline patterns, and familiar words can be read as a whole, while all-capital words have no distinctive pattern and slow down readers (Beach, et al, 1986).

Kinds of Type

Tradition, rules of printing, and artistic appearance often dictate typographical arrangements. For example, most book and magazine

material is printed in Roman capital and lower case. Occasionally, a phrase, sentence, paragraph or even a page may be printed in italics, all capitals, or boldface for emphasis (Burt,1959).

Any printing for effective communication must attempt to employ type forms that will enhance legibility of the print (Hymes, 1958). In order to choose the proper type form, those that enhance legibility must be known. And when this is known, one would assume the printing industry would follow suit.

In a study to determine what extent present and past publications have followed recommendations on type, Soar (1951) surveyed the printing practices in eighteen different psychological journals. He examined issues published in 1920 and 1950. All these journals were following optimal practices in the use of italics and boldface in 1920 and 1950. But by 1950, there was a widespread use of all-capital type. All research has indicated this to be a non-optimal form of print, yet it appears to continue to be on the increase.

A somewhat similar study was conducted by Nelson (1949). She appraised the typograph in thirty six employee handbooks. The use of all-capital printing was dominant in twenty six of the handbooks. In attempting to prepare an attractive handbook, the authors and printers had overlooked or perhaps were unaware that they had employed non-optimal type form. Nelson also pointed out that all-capitals, all lower-case, all italics, and all boldface were randomly introduced throughout the majority of the handbooks.

It is apparent that editors, advisors, and publishers believe that styles of type are more important than other typographical factors. Books on typography devote more space to type description

than to other factors (Hymes, 1958). Despite this knowledge, publishers have tended to use the type of their choice without too much concern for legibility (Burt, 1959).

In a 1932 study, Paterson and Tinker selected the seven most frequently used type. The types were: (1) Scotch Roman, (2) Garamond, (3) Antique, (4) Bodoni, (5) Old Style, (6) Caslon Old Style, and (7) Cheltenham. Three radically different types, Kabel Light, American Typewriter, and Cloister Black (Old English) were added for a better comparative effect. The material was printed in ten-point, using a nineteen pica line width. Using nine hundred college students, the speed of reading the ten types were compared, using Scotch Roman as the standard. There was little or no significant difference in eight of the type faces. Only the American Typewriter and Cloister Black were found to be significantly different. The Garamond type was read somewhat faster than the Scotch Roman control type. This is especially interesting in view of the fact that Garamond was designed in France in 1615 by Jean Jannon (Craig, 1980). Other authorities have also concluded that research has not discovered much that the early type designers did not know (Labuz 1988).

Interestingly, before the advent of phototypesetting, there was a relatively small number of typeface because of the labor involved in producing it (Bann, 1985). Today there are about five thousand published typefaces, but only about four dozen are commonly used (Beach et al, 1986). It is also interesting to note that Communication Arts magazine asked leading designers which type families they would retain if all others vanished (Beach, 1986). Times Roman, Helvetica, Caslon, Goudy Oldstyle, and Garamond were the winners.

This indicates another area to be considered is the reader's pre-

ference with regard to print. Tinker (1963) polled two hundred ten college students in an attempt to determine their personal preference of the ten type faces used in the 1932 study. Their only point of agreement with the 1932 study was that Cloister Black was at the bottom of the list. Thus, legibility and personal choice of type are not necessarily identical. A heavy or darker type was the favorite of all the students. The study seems to indicate that where there is little difference in legibility, the reader will choose the type most pleasing to him. If, however, it is difficult to read, fewer will choose that particular type face, regardless of its physical appearance.

Those types used in the 1932 study are not commonly used today, but the same conclusions hold true. Esthetic values are stressed by the publishers (Hymes, 1958). They are accepted by the reader if legibility is not retarded too much. This fact was demonstrated by Tinker and Paterson (1942) in another study. They found that readers place a higher value on the printing arrangements that appear most legible, regardless of the esthetic values that may be present.

Italics type is considered far less legible than Roman lower-case by printing authorities. In the first controlled experiment, Tinker and Paterson (1928) found italic print to be significantly more difficult to read. They also found that readers did not like italics, especially when it was combined with other type.

As stated earlier, Roman lower-case is easier to read than Roman capital type. This was first demonstrated by Starch in 1914, but Tinker and Paterson conducted the first controlled experiment in this area (1928). A significant difference of 13.4 per cent was found in

favor of the lower-case.

There are many other reasons for the above difference. Total word form is more important in perceiving words in the lower-case than in all-capitals where perception occurs largely by letter (Tinker, 1963, Beach, et al, 1986). This conclusion is supported by the fact that words in lower-case yield more misreadings than words set in capitals. Almost always, the incorrect word has a configuration or form similar to that of the correct word.

Also, the printing surface required for all-capital text is thirty five per cent greater than that for the same material set in lower-case. This factor alone would increase the number of fixation pauses required to read any given material set in capitals, and as a result would slow down reading (Beach, et al, 1986). This was demonstrated in Tinker and Paterson's (1939) eye movement study. Fixation frequency and perception time were significantly greater for reading all-capital print.

Frequently, in order to emphasize phrases, etc., boldface type is used (Hymes, 1958). It is also used to denote titles of books, chapters, section headings, and the like. Although the visibility of boldface is greater than lower-case print, Patterson and Tinker (1940) found no difference in speed of reading boldface and lower-case print. It would appear that boldface is an excellent means of emphasizing without any significant loss of legibility.

For readers who are hypermetropic or astigmatic, legibility is often improved by using boldface type (Burt, 1959). But there is an optimal thickening, and beyond that, there is an adverse effect. However a moderately boldface type is preferable in books for the very young.

While there is still much discussion concerning serifs and there are popular sans serif fonts being used today, we know that serif faces tend to move the eye along the horizontal direction of reading (Binns, 1989). Because of this, serifs make type more readable, thus more legible, and reduces eye fatigue during long periods of reading (Beach, et al, 1986).

Based on the findings of various studies, it would seem that speed of reading is the most satisfactory measure of legibility of type face. Letters should never require study or even a second glance (West, 1990). Therefore it can be concluded that a legible type is one that can be read rapidly and easily. and if it offers a form of pleasingness to the reader because of its physical appearance, then it is all the more legible.

Size of Type

There has always been an interest in the size of type in relation to the legibility of print (Tinker, 1963). Most publishers maintain that ten or eleven-point type is the smallest that should be used in books. There is no real agreement on this subject by modern authorities. What is amazing, however, is the uniformity of printing practices where there is no uniformity of opinion. An exception is children's books. In producing books for children, printers and publishers use a wide variety of type faces and sizes (Burt, 1959).

Numerous studies have been done in this area and the division point seems to be about the fifth grade. Fifth graders read 10 and 12-point type as well as type set in larger points (Labuz, 1988).

Based on his controlled research, Burt (1959) established optimum

size type for children's books. Using a semi-boldface type, his conclusions were:

Age	Type (Points)	Width (In.)
Under 7	24	5
7-8	18	4
8-9	16	3 1/2
9-10	14	3 3/4
10-11	12	4
Over 12	11	4 1/2

Paterson and Tinker (1940) have established 11-point type as the favorite of adult readers. In order of preference, 10, 12, 9, and 8-point types were next in popularity. And while it may be coincidental, the majority of books are printed in 11-point type. Most magazines and journals range from 9 to 11-points, but 11 is more common. Studies have revealed that very small and very large type size were read more slowly than those in the 9 to 11-point range (Paterson & Tinker, 1940).

It has been observed by numerous authorities that as the size of type is increased or decreased, more eye fixations per line are required (Smith & Dechant, 1961). As the fixation pause becomes longer, the reading rate declines. One explanation for this is that larger type is less readable because fewer characters can be seen during each fixation, and that smaller type is less readable because of the reduced visibility (Luckiesh & Moss, 1937).

Width of Lines

The length of the printed line has always aroused interest and concern among those dealing with it. Beginning in 1881, there have been numerous reports published, but these were based on casual observations and opinions. As a group, they suggested lines of approximately 22 picas, but they were contradictory in many ways (Tinker, 1963).

In order to determine what was common to the publishing world,

Paterson and Tinker (1940) surveyed 1500 journals and books. American magazines and journals used both single and double-column printing. A wide range of 14 to 22 picas were found in the double-column printing, but the single-column printing demonstrated a greater uniformity. The journals ranged from from 23 to 28 pica line widths, while the text-books were between 19 and 24 pica lines.

Like type face, line widths have optimal size. In an early study, Tinker and Paterson (1929) compared speed of reading material set in 19 pica with material set in 14, 23, 27, 32, 36, 40, and 44 pica. All the material was set in 10-point type. The difference can be best shown in the following table. As with other tables used in this paper, A minus sign indicates less legibility than the control material.

Line Width	Differences (%)
14 pica	- 4.1
19 pica (Control)	0.0
23 pica	0.0
27 pica	- 2.5
32 pica	- 2.3
36 pica	- 3.4
40 pica	- 5.1
44 pica	- 7.5

Tinker and Paterson (1940) conducted two other studies similar to the above. In one they used 935 college students as subjects. Ten point type was used and the line width ranged from 17 through 27 picas. The results indicated no significant difference in any of the widths. In their third study, using 500 students as subjects, 10-point type was used, but 9, 14, 19, 31, and 43 picas were used. The results are indicated in the table below.

Line Width	Differences (%)
9 pica	- 6.7
14 pica	- 4.2
19 pica (Control)	0.0
31 pica	- 6.8
43 pica	- 6.0

Tinker and Paterson conducted many other studies using various type sizes and pica, but the results were similar to those listed above. They also analyzed the eye movement pattern of their readers in the ten-point type studies (1942). They demonstrated that more fixations pauses of greater duration were used in reading the short lines. Eye-movement measures revealed less efficient reading with the long lines. Regressions were particularly obvious following the back-sweep to the beginning of a new line. Long lines make it more difficult to make the correct return sweep. Short lines, on the other hand, require more return sweeps and lead to choppy reading. This is due in part to the fact that the eye is unable to make effective use of peripheral vision (Smith & Dechant, 1961).

Psychologists have found that we read in a series of eye fixations (Binns, 1989). The reader observes one group of words with one eye span, and then shifts the eyes to the next group. The normal span is 12 to 15 picas wide, and any more than two eye spans per printed line requires the movement of the head as well as the eyes. This becomes tiring and inefficient and affects legibility. Thus the upper limit for a line if it is to be truly effective is 27 picas.

This means that the average reader takes in three to four words per eye movement and comprehends best when making two eye movements per line. The ideal line length would be seven or eight words, averaging about six character per word. This would be approximately 45 to 55 characters per line and would be ideal for the average reader.

Leading

Leading deals with the space between lines of print and like

everything thing else in printing that deals with height is measured in points. Simply stated, it moves line farther apart. Set solid means there is no leading between the lines.

Like other areas of printing, there is no uniform opinion of the best use of leading. In an early English study, Pyke (Tinker, 1963) found that at least twenty five per cent of those in the field believed that leading was unimportant. This was not a true research, but rather an opinion survey. Before 1932, there was almost no discussion of leading. It was more or less decided by the printer without any regard to legibility. A good physical appearance was the standard by which the printed material was judged (Hymes, 1958).

There is no doubt that leading greatly enhances the legibility of small type. This is particularly true for children. By widening the space between the printed lines, the eyes are better able to pick up the correct lines as they move back and from the end of one line and begin another. Children are especially prone to doubling and skipping lines. If the lead is not a proper one, then the problem is expanded rather than corrected (Burt, 1959).

The proper lead has been an area of much study. As in other areas of legibility, Tinker and Paterson are the prime sources of authority. Overall, they conducted eleven experimental studies, involving well over 11,000 readers as their subjects (Tinker, 1963).

Their first study (1932) investigated the effects of leading on legibility using 10-point type in a 19 pica line width. Their conclusions indicated that 1-point leading did not add to legibility. Two-point leading improved legibility by over five per cent. And surprisingly, 4-point leading was not as effective as the 2-point. Thus, for 10-point type in a 19 pica line width, it would appear that

2-point leading is ideal.

Space does not permit a review of all of Tinker and Patterson's work dealing with leading, but overall, they found leading to be an important aspect of legibility. Their collective findings conclude that little is to be gained by 3-point leading, and 4-point and larger tends to diminish legibility. Two-point leading seems to be the optimal.

While some type is set solid, it should be noted that sans serif typeface should always be leaded because there is no serif to aid the horizontal flow that is necessary for comfortable reading (West, 1990). Also, the longer the line of type, the more critical is the need for leading to insure legibility. Long lines are difficult to read, but when set solid they can become very troublesome.

Spatial Arrangements

The spacial arrangements involve such factors as size of the page, margins, single and multiple-columns, paragraph arrangements, and vertical and horizontal printing. Again, like everything else dealing with legibility, there is great diversity in the application of these factors.

There is great variance in the page size of books, textbooks, journals, and magazines. While some may appear to be the same size, a close examination will reveal they be different only slightly, perhaps as much as only one sixteenth of an inch. There is no standard anywhere that is observed by the majority of the publishers.

The margin is another area of confusion. Margins are accepted by most readers because they tend to believe they are important for

legibility and for their esthetic value. The correct or optimal margin is probably never thought of unless a student is involved in some formal paper that requires a specific margin.

Numerous studies have been done in this area, but the most thorough ones were done by Paterson and Tinker (1940). They concluded that for adults, margins as such do not promote greater legibility, but can possibly be justified for esthetics. But children's books are different. Narrow margins are likely to produce visual fatigue. When the lines are extended and the margins narrowed, Burt (1959) has found that young readers are apt to read off the page.

In the 1930's, single column printing was extremely common in textbooks, but not in magazines and journals, for they had established a trend toward double-column printing that is still with us today. As a result, more and more material, even textbooks, are printed in double or multiple-columns. And for most magazines and newspapers designed for quick reading, a column of type a single eye span wide, about 13 picas, has become the standard (Binns, 1989).

However when double or multiple-column printing is used, other problems arise. It must be decided whether to use a space, a rule (lines), or both between the columns, and the appropriate space, regardless of the configuration, between the columns. Some newspapers and books use intercolumnar rules, while most magazines and journals use space without rules.

Research by Paterson and Tinker (1940) revealed there was little difference in legibility of any particular intercolumnar arrangement. There was, however, considerable difference as to personal preference. The most popular arrangement with the subjects was one using rules with

one-half pica space on either side. Interestingly, this arrangement is rarely found in print today.

Background and Print Color

Another factor affecting the legibility of reading material is the relation of color of print to the color of the background. As in other areas of legibility, there have been numerous observations and opinions presently rather freely. Disagreement was the common factor for most of the viewpoints expressed.

Drawing from the numerous research studies conducted by Tinker and Paterson (1963), several conclusions can be drawn. Black print on a white background is more legible than white print on a black background, and approximately three fourths of readers prefer it in this manner. At a distance, words in sentences and paragraphs, isolated words, isolated capitals, and forms such as ll, li, and ii are more perceptible when printed in black on white. White on black is best only when it is used to attract attention, and should be set in a sans serif type of 10 to 14-point size. And the visibility of black print on tinted paper varies. When type as large as 10-point is used, there is no real loss of legibility with the use of tinted paper.

The use of colored ink and colored paper and its relationship to legibility depends on the combinations used. The most legible combinations are those with greater brightness contrast between print and paper. Dark ink and lightly tinted paper usually are best. But regardless of the combination, the use of color should not distract the reader's eye from the message. It should also be remembered that not only the color, but the paper's surface can also enhance or distract (West, 1990).

Conclusions

This paper has presented some of the problems that are related to legibility. It would be impossible for a complete study to be undertaken in a paper of this size. Rather, an attempt has been made to take those factors that cause the greatest problems with legibility and present an in-dept study of the available research on them. Paterson and Tinker have been used heavily because in many cases they are the sole authorities. Their work is timeless and their findings are just as valid and applicable today as they were when they were done. Many believe their studies, even today, to be the ultimate authority in legibility. Dr. Tinker's Legibility of Print is still used widely by publishers (Robeck, 1990).

There are many other factors that were not considered in this paper. Perhaps the most glaring is kerning -- the spacing between letters and words. West (1990) and others have indicated this is probably the most overlooked factor in legibility. This is an area that needs to be thoroughly researed in the manner of Paterson and Tinker. Those factors not considered does not mean they are not important, but the ones presented here are the more common ones that have been researed by authorities in the field.

No phase of reading is simple. It is altogether possible that legibility is the most complex area of reading. It would take a lifetime to study the effects of the various factors of legibility. This study has pointed out the effects of the various factors of legibility and how they retard reading speed. If one factor has this effect, one can only guess the effects when several of the factors are

combined. They offer an unending list of possible combinations for future research.

All of the factors of legibility are interacting. Any one factor may depend on another. Color of type, for example, depends on color of paper, size of type, spacing, and many other factors. When this is considered, one must also consider the fact that all too often these factors are not determined by research, but by persons who publish printed material simply according to their own beliefs and opinions.

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