# Printing for the Visually Handicapped

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One of the surprising conclusions to derive from long experience in typographical research is that individual needs and preferences for type can be as varied as for hats, food, or any other feature of a non-regimented community.

Another finding is that what is scientifically most desirable in a type-style for most efficient reading may not be the most acceptable to a large number of readers.

Another is that type needs among the visually handicapped will not necessarily be the same for children who have never seen well as for adults whose eyesight is failing after a lifetime of active reading. Therein lies the greatest obstacle to standardizing type for the low vision reader. In fact "visual handicap" or "low vision" is an over-simplified term. It covers many unfortunate conditions, most of which have only one thing in common, difficulty in seeing without, or even with, the aid of special devices.

At least seven factors must receive special consideration when preparing books for the visually handicapped reader:

1. Type size
2. Type style and proportions
3. Interletter spacing
4. Interword spacing
5. Interline spacing
6. Line width (or length)
7. Contrast of the type with the paper

All these factors have been given exhaustive attention; some by several researchers, many by ordinary experimenters. The writer's own work, extending over almost 30 years, was finally used for children at the Ohio State School for the Blind, numerous homes for the aged in Ohio, and a hospital clinic, to produce a report for the Library Technology Project of the American Library Association.

*Some Facts Related to Vision and Reading*

When considering aid for visually handicapped readers, many people think primarily of juvenile needs, overlooking the fact that there are more elderly subjects with subnormal vision whose needs may or may not be identical with those of the young. Figures provided by the National Society for the Prevention of Blindness up to July 1, 1959, showed that there were at that time:

96,000 partially-seeing children of school age
40,000 partially-seeing children of pre-school age
14,000 legally blind children under 20 years of age who could nevertheless be classed as ink readers
150,000 *total*
767,000 partially-seeing adults from 20 to 64 years of age
989,000 partially-seeing adults of 65 years of age and over
1,750,000 *total*

There is every reason to believe that this is a low estimate for the present time.

There are two differences between the young and the aged in this situation. The former need visual aid in order to develop their education, while the latter, although most of them will have completed their formal education and maybe enjoyed an active life, have a need to read more and more as the tempo of their physical activity declines. The children have conditions which may or may not be congenital, may be pathological, anatomical, physiological, or due to arrested development, and *may or may not have a promise of improved vision later*. The elderly may be suffering from one or more pathological conditions, and *usually have no hope of improvement with the passage of time, except by cataract removal.*

We still do not fully understand or appreciate the visual experiences of those with subnormal vision. Elderly people of high intelligence have been able to convey some of their sensations, and we have been able to examine autopsy material under the microscope to obtain a picture of what changes take place in many conditions, but children can give us little information because they have no other experience with

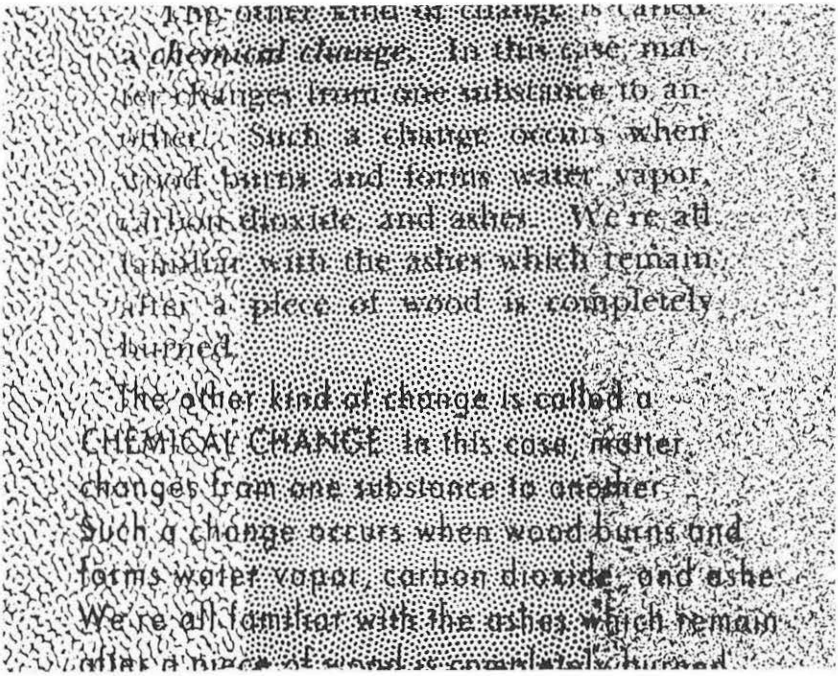



Figure 1.
Baskerville (top) and Spartan are shown in conditions of retinal degeneration. Spartan may be slightly easier to read even though both types are carefully spaced identically.

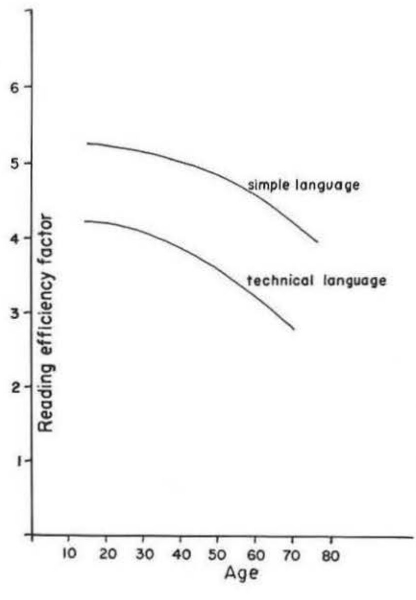



Figure 2.
The curves were made with numerous different sizes and styles of print on a large number of subjects. They show that performance always becomes reduced with age.

which to compare what they see or think they see. Then too, we cannot be sure if all cases of simple uncorrectable defective vision result from congenital ocular defects, or are related to cerebral malfunction. But we do know that in some of the juvenile pathologies the microscopic picture is the same as that in elderly patients with similar diseases.

It is possible to divide the conditions contributing to subnormal vision as follows:

a. *Optical blur*. This is a form of "image-spread" or distortion produced by uncorrectable deformities or anomalies of any of the optical components of the eye.
b. *Functional blur*. This may be the result of faulty transmission of the visual image to the brain.
c. *Functional and anatomical holes*. When groups of light receptors in the retina degenerate or are rendered non-functional by any means whatsoever, one would assume that this would result in gaps or holes in the visual field. Although we know that such holes are seen occasionally by patients, the vast majority of those with non-functional groups of receptors give no such definition to their disability. Our knowledge of the cerebral integration of a retinal image neither supports nor denies that holes in the visual field are possible.
d. *Loss of sensitivity*. This may be general to the entire visual field, or localised centrally in what is known as "Macular degeneration." When the whole visual field is involved, it may be due to autotoxic conditions or to the effects of a drug which may produce a permanent impairment of sensitivity.

Occasionally these conditions may be further complicated by "Nystagmus," a searching quiver of the eyes that makes any form of fixation impossible, but which does bring different parts of the visual field into ever-changing positions on the retina in an effort to provide a complete image.

Magnifying lenses may help subjects with conditions a, b, and c, and so will enlarged print, but those having a blind area in the center of the field of vision due to absence of or severe damage to the receptors are more difficult to help. However, if we enlarge print enough for it to be recognized in the surrounding retina which has a coarser visual acuity, it can be of *some* help, although reading will prove laborious.

A knowledge of retinal and cerebral function, and the magnification factors of the eye, enables us to calculate the best letter size, limb or stroke thickness, and interletter spacing for a given condition. And we can test our calculations with reading-speed tests and visual acuity tests on both normal and subnormal subjects until we achieve optimum results.

Because there are so many levels of subnormal vision and so many possible aberrations in the defective eye, we must produce something that is as acceptable as possible to all of them, and this is no simple task. Our obvious experimental direction is to start with what we know about maximum legibility for normal subjects and proceed from there.

To produce maximum legibility of letters for normal subjects it is essential that the image in the eye will consist of strokes which are never closer together than their own thickness. This minimum amount of white between the black strokes is imperative no matter what the style of print, otherwise the strokes will overlap each other in the visual image when this is small enough to be considered a "threshold" image. Any deviation from this ratio must be in the direction of more white and less black, and for some handicapped subjects this is essential.

This overlapping of parts of an image can be called "blur" for simplicity, and besides overlapping it involves a reduction in blackness of the letters if these are not perfectly in focus. As contrast between print and its background is essential to legibility, this compounds a reader's problems. There must be a combination of good focus, correct stroke thickness, and illumination. The last factor must be considered in all tests, and also in any subjects's reading habits. In fact lighting recommendations should always accompany those for reading, even though individual preferences may make this difficult.

In evaluating some of the types used in legibility experiments, many other factors have been considered: all kinds of eye defects of a wide range of severity, the intelligence of the subjects, their age groups, their professions, and the physical qualities of print such as the relative areas of the letters, their reflectance data, their degrees of familiarity to the readers, and their numerical occurence in standard literature.

Some of the investigations undertaken were designed to establish

1. Individual legibility factors for each individual upper-case letter both for normal vision and all kinds of refractive errors.
2. The same factors for all lower-case letters.

3. Legibility factors for all letters when placed against all other letters in nonsense syllables.
4. Legibility factors for all letters when placed against all other letters in known words in both standard and specially designed types.

For a normal subject, the most legible dimensions of letters which are in focus are likely to be those in which the letter width is 80 per cent of its height, and the thickness of each stroke is not more than 20 per cent of the height. In letters such as "m" and "w," the width must be equal to the height to obtain appropriate stroke thickness and interstroke spacing. We really do not have to be exacting for subjects with normal vision, and although such dimensions are theoretically ideal, unfortunately what is effective for normal subjects is not always best for those with subnormal vision.

Once letters are formed into words, the familiarity of the latter influences legibility, but in unfamiliar words, the positions of the various letters and their proximity to certain other letters also influences their legibility. This change in the legibilities of letters when they are in groups was measured both in words and nonsense syllables. Because the latter can give us information on words an observer has never seen before, it also helps us to understand better the performance of uneducated readers, especially those with visual handicap.

What follows reports the findings of the final phase of an extensive project designed to ascertain the best type and other criteria for the visually handicapped. The findings did not conform to what had been expected on the basis of earlier experiments, and an explanation for this is attempted.

Once a number of criteria for optimum legibility of print were devised and proved individually in the laboratory, and it was found that when used for testing visual acuity they were outstanding in the degree to which they were recognisable above conventional types, it seemed natural to combine all of these together to produce the ideal print.

These criteria were found to be

1. Letters without serifs, and having a width of not less than 80 per cent of their height, using the lower case "o" as the base dimension.
2. A stroke thickness of 17.5 per cent of the height of the lower case "o."
3. Spaces between the strokes of not less than 24 per cent of the height of the letter "o."

4. Interletter spacing of 40 per cent of the height of the letter "o."
5. Interword spacing of 200 per cent of the height of the letter "o."
6. Interline spacing of 140 per cent of the height of the letter "o."
7. Line length of a minimum 30 picas; 36 picas is preferable, however.

The dimensions suggested several paragraphs above are not invalidated by these now given. These are the result of tests on a wide range of abnormal conditions as well as on normal subjects.

Even among conventional type styles, when sans-serif letters such as Spartan are used in non-sentence legibility tests in the laboratory against serif letters such as Baskerville, they are much more effective than the latter. But when letters are combined into familiar words, and these make up sentences, each word forms a picture which, in older people at least, has been imprinted on the mind in conventional types over a long period of time, and the advantages of special criteria are then greatly reduced. The difference in legibility between the styles diminishes also as the size of the print is increased; and conversely as print is made smaller, the serif type becomes more illegible.

The Chinese language has no alphabet. Each word is a separate picture, and it is possible for people to memorize thousands of these pictures. It is now obvious that even though we use an alphabet, we do much the same thing, and we have been ignoring this fact when searching for greater legibility in type. The criteria for more legible type do not conform to the memorized pictures, and therefore such new criteria would have to be introduced at the grade-school level where the word pictures are learned in order to be effective at later ages when greater legibility is needed. That they would provide better performance in later life is without question.

Now we find ourselves confronted by the paradox of special sans-serif type being more readable in individual letters and syllables but not in familiar words, and conventional serif type being more readable in words and sentences (because of the picture image), but not in individual letters.

This explains also why the long-familiar serif letters lose little, if anything, in competition with the sans-serif letters among educated readers, but often do among young handicapped students who have no long-established word-picture pattern developed. When any low-vision reader encounters new or unfamiliar words, serif print does present more of a problem, for the memorized word picture is not available to them to compensate for the low legibility of the actual letters compared with what this would be in sans-serif type.

Some unexpected facets of different reading habits have become obvious in all the experiments carried out in recent years.

1. Stated preferences for particular typefaces over others seldom accord with the performance data on these typefaces, so efficiency and preference are not always related.
2. Type that is produced to criteria that theoretically should aid the efficiency of readers with subnormal vision will frequently reduce the performance of normal readers quite drastically.
3. There is no absolute preference or performance uniformity within the group of normal readers, or within the group of subnormal readers. There are types which will please or aid a majority in either group, but the remainder will be as highly diversified as their personalities. This means that there is no type size or interletter spacing which will give optimum performance to all members of all groups. There is in fact no set of criteria that is entirely acceptable to everyone in either group.
4. *There are some factors common to all readers, and these can be given attention by print manufacturers without fear of interfering with the efficiency or comfort of any one group.* These are:

*Punctuation.* Periods and commas need to be enlarged beyond present sizes in all types so far tested. *This is not just reflected in the data and observations in scientific tests, but is voluntarily and persistently commented upon by large numbers of both normal- and subnormal-vision subjects used in reading tests.* The period should be approximately 30 per cent of the height of the lower case "o." The comma should be approximately 55 per cent of the height of the lower case "o." This is quite essential for subnormal-vision readers.

*Line length.* Line length could in any case be more standardized than it has been in the past. It should be not less than 30 picas, and 36 picas is usually even more efficient *and* more economical in many sizes of print. The short-line, double-column style adopted in some scientific books is exceedingly inefficient. It takes longer to read a given amount of material; it demands more eye excursions; it produces more hyphenation which confuses the less efficient reader, and in some instances it demands more paper.

*Paper.* Although maximum paper reflectance produces maximum reading efficiency through its contrast with the print, paper reflectance is no more important than paper opacity or weight. This is because while a high reflectance factor is desirable and attainable for maximum contrast, this is reduced by the presence of print on the reverse side of the page. For instance, 80-pound paper stacked can have a reflectance of 82 per cent, but this can be reduced to 76 per cent when printed on both sides of a sheet. Much depends upon the kind of type used, and the closeness of the lines to each other; and this can be considered an above-average reflectance. So *a dense or opaque white paper is desirable*. But so also is a light-weight paper, because the size of large-type books can make them very fatiguing to hold if no consideration is given to this factor.

*Reader Groups*

There are three main reader groups with whom we are concerned in any comparative study of typeface and typesize in relation to visual performance:

1. All readers with normal vision.
2. a. Children with subnormal vision, but with some focussing ability.
   b. Children with subnormal vision and no focussing ability.
3. Elderly subjects with subnormal vision due to congenital, pathological, or surgically induced conditions. Women outnumber men by almost ten to one in this group in the writer's experience, but this may have no significance for the investigation under consideration. It is purely a factor of survival, perhaps related to the fact also that women remain more active and more optimistic than men when they do survive to great age. They take better care of themselves.

After several experiments with students at the Ohio State School for the Blind, the final tests were devised to be offered to them in conjunction with other subjects having subnormal vision, handicapped elderly subjects, and normal ones. The following seven tests were designed to be consecutive, and constitute a continuous story. Each page consisted of three paragraphs, each of 70 words (210 words per page). The criteria were

1. *14-point Spartan Medium* 36B Linofilm (Mergenthaler Linotype Company); interletter spacing of 2 points, 30-pica line, interword spacing of 6 points minimum, 4-point interline leading, 10-

point paragraph spacing. This produced 23.25 lines, a total of 697.5 picas, and a total area of print of 31.25 square inches.

2. *18-point Spartan Medium* 38B Linofilm, with interletter spacing of 3 points, 36-pica lines, 8-point interword spacing, 5-point interline leading, and 11-point paragraph spacing. This resulted in 26.5 lines with a total of 954 picas, and a print area of 55 square inches.
3. *14-point Baskerville* Linofilm reduced 10 per cent photographically to give the same height to the lower case "o" as in the 14-point Spartan (No. 1), and a 30-pica line length. Conventional spacing and 4-point leading with 10-point paragraph spacing resulted in 19.25 lines, 577 picas, and 27.5 square inches of print. This size is comparable to Harris Intertype Baskerville 14 point.
4. *18-point Baskerville* reduced 10 per cent to give the same height to the lower case "o" as in the 18-point Spartan (No. 2), had also a 36-pica line, conventional spacing and leading, 11-point paragraph spacing, a total of 20 lines, 720 picas, and 39.6 square inches of print area. This is comparable to Harris Intertype Baskerville 18 point.
5. *Same as No. 1* except that hyphenated words were eliminated and interword spacing fixed at 6 point at the cost of an even right margin. This produced very roughly 24.5 lines and a total print area of 40 square inches.
6. *14-point Spartan Medium* Linofilm ALL CAPITALS; same criteria as No. 1. This made up 28 lines, or 840 picas, and a print area of 40 square inches.
7. *Same as No. 1.* except that the line length was 36 picas. There were 18.5 lines with a total of 666 picas, and a print area of 30 square inches.

Although the conventional 14-point type in No. 3 test occupies the smallest area of print, No. 7 demands very little more space in spite of its wide interletter spacing and careful leading, and it will be seen later that No. 7 proved to be the more effective of the two.

*Procedure*

Reading speed tests were run first on 43 subjects with normal vision, all between the ages of 20 and 60 years, as these could be drawn into the testing laboratory without any warning or preparation. Then, all the available ink readers at the Ohio State School for the Blind were tested. After this, all useful and available residents of those homes for the aged in Columbus and Cleveland, Ohio, who would co-operate were tested. Finally a number of subjects seeking large-type books from the Cleveland Libraries were tested, and suitable subjects visiting the out-patient clinic in the Department of Ophthalmology at University Hospital, Columbus, were persuaded to participate.

Although earlier it was suggested that there are only three main reader groups, the subject data was finally assembled and divided into

1. Normal-vision readers, aged 20 to 60 years
2. Residents of homes for the aged, from 65 to 100 years old
3. Library subscribers with visual problems
4. Children at the Ohio State School for the Blind, aged 11 to 20 years
5. Subjects seen in a hospital out-patient eye clinic
6. Subjects over 80 years of age
7. Subjects with vision of 20/100 or less, regardless of age or other factors. 20/200 is the measure for legal blindness, so 20/100 can be considered as a 20 per cent level of vision when 20/20 is normal.

These groups covered all ages from 11 to 100 years, all visual acuities from 20/20 (100 per cent) to 20/1600 (1.25 per cent), and many pathological conditions including cataract, glaucoma, macular degeneration, diabetes, etc. Some of the groups were later combined for statistical purposes. For instance, elderly library subscribers were considered to be different from residents of homes for the aged only in their living circumstances, and were therefore included in their group. This applied also to patients of similar age in the hospital outpatient clinic, for it was found that their pathologies were equally prevalent among the residents of the homes. The only difference was that the latter were cared for privately instead of at the clinic.

This multiple grouping revealed nothing that was not obvious in the three groups originally suggested, and so three similar groups were ultimately settled on for the final data analysis. These were titled

1. Normal-vision readers
2. Subjects with visual acuity of 20/100 or less (20 per cent or less)
3. Students at a school for the blind

*Results*

In submitting the seven tests to the various subjects examined, it was found that a number of them could not complete all seven, and these subjects were excluded from the final scoring; but what is significant is that almost all of them were able to complete tests Nos. 2, 4, & 6, demonstrating effectively enough that the larger type does help a great number of readers, and this was supported by the average reading times of the seven tests both within the groups of subjects and in the totals of all groups.

Because of the wide range of reading times (speeds) encountered, averaging these does not reveal the true picture. Counts of the numbers of subjects putting up *best performances* with the individual tests was much more revealing.

A surprising result was the great advantage No. 7 (a 14-point Spartan type) has over the other 14-point Spartan tests, and even over No. 2, an 18-point Spartan, especially among normal-vision readers. This can only be related to the line length of 36 picas and the consequent absence of hyphenation.

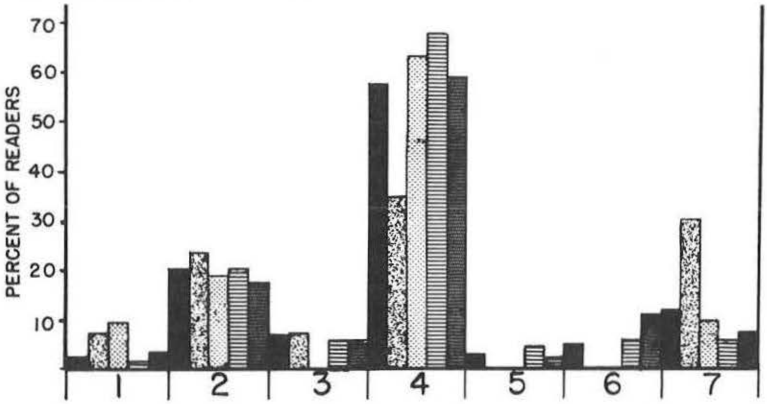
A less surprising result, because it had been tested well before this project, was the progressive reduction in reading speed with advancing age, and still further with retardation and low visual acuity.

The blind-school students were the only group which found test No. 6 (all capitals) useful, and it was a previous test on these same students which had made the idea of such a test in other groups seem worthwhile. There were subjects in this group who could just see No. 6 but nothing else. Other subjects showed progressively lower performances with No. 6 as they demonstrated better visual acuity. But the importance of large type to this group could never be in doubt.

*The importance of large-type books to blind-school students is emphasized by the number of ink-print readers among them who are turning to Braille because it is less fatiguing to them in spite of the slowness with which it is read.*

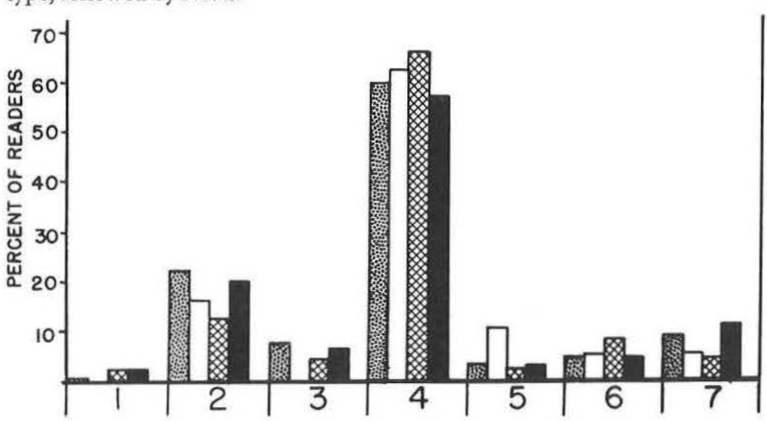
The group which included those in homes for the aged represented a very wide range of backgrounds, culture, intelligence, education, etc., but the attitudes of the subjects almost always reflected the extent to which they are encouraged to take part in activities and interests, and also their general social and educational levels. Probably not more than 10 per cent of all the residents could be involved in the tests, because of the different characters of both the homes and their residents, and the very low level of vision of many of the residents.

Figure 3. *Best reading times.* The percentage of total readers making their best scores with the seven tests as numbered. It will be seen that normal vision readers made almost as many top scores with No. 7 as with No. 4—No. 4 is 18-point Baskerville; No. 7 is 14-point Spartan, but with a 36-pica line. In some groups, therefore, the longer line compensates for smaller size.




All readers Normal readers 20–60 years old Blind-school students Over 80 years old Vision 20/100 or less

Figure 4. *Best reading times.* When normal vision readers are not included in the columns, No. 7 shows no particular advantages. No. 4 remains the outstanding type, followed by No. 2.




All readers Homes-for-aged residents Large-print seekers and other library subscribers Hospital clinic patients

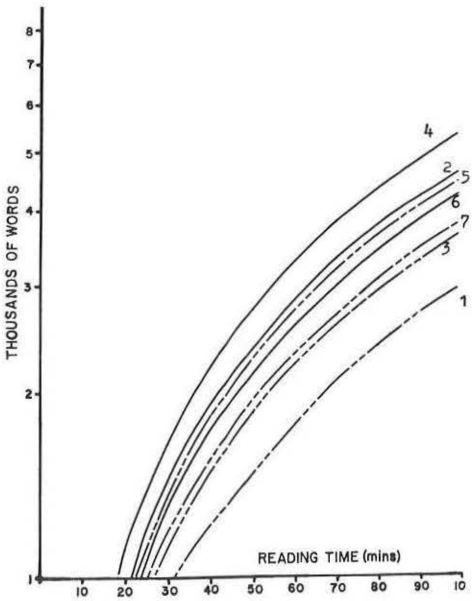



Figure 5. *Blind-school students.*
An expression of reading efficiency showing that in a given time, this group of subjects could read 5,000 words of No. 4, but only 4,000 words of No. 6, and so on.

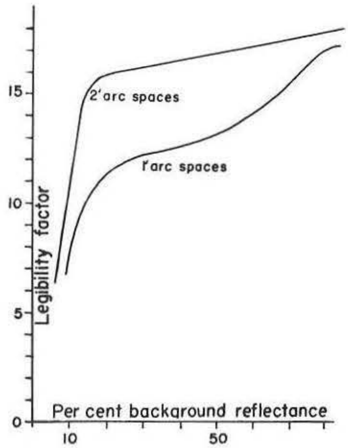



Figure 6. Curves represent legibility; not reading speed or any other performance factor. Carefully spaced type (test No. 1) gives much better legibility at levels of poor contrast than will type which is less carefully spaced.

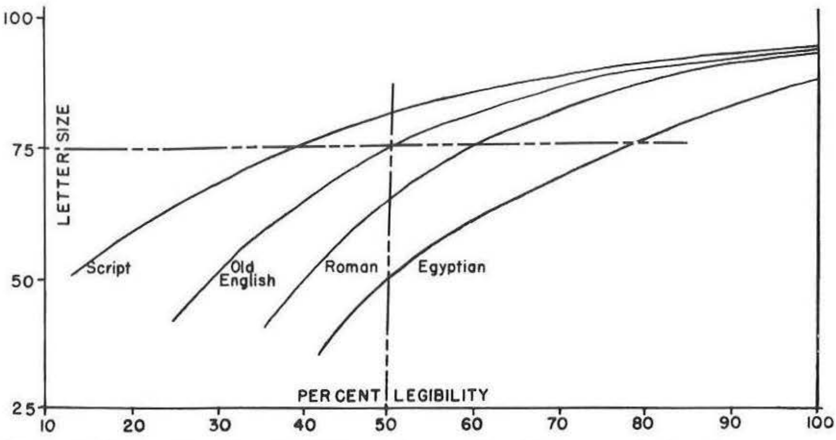



Figure 7. Curves show how legibility varies greatly with letter style, but that the great difference in legibility diminishes as size of print increases.

The many subjects who could not be used were either bedridden, confined to darkened rooms, illiterate, mentally retarded, degenerate, disinterested, imbued with hopelessness, or virtually blind. Many had glaucoma. Many subjects with glaucoma were, however, used in the tests, the criterion being their standard of remaining vision.

A surprising number of the subjects over 80 years of age are found to have better vision than younger age groups. One of the most important factors in this is the successful removal of cataracts and the consequent restoration of useful vision. This means that many subjects who may have subnormal vision at one period of their life may later be considered almost normal, and sometimes quite normal because of successful surgery. But those who have had useful vision restored by successful cataract surgery may later deteriorate again with other senile or pathological conditions for which surgery or any other treatment is as yet of no avail, and so this group is not simple to evaluate. While it revealed some useful information of a general nature, only the three groups listed under Procedure were ultimately utilised for full analysis.

Apart from the blind-school students, all the low-vision subjects had a long and mentally well-established word picture pattern before the deterioration of their vision. Conventional type, although not necessarily clearly seen, was therefore to their advantage, and this is reflected in their performances with tests 2 and 4, and the uniformity of results in tests 3, 5, 6, and 7. The data all suggest again that *familiar style* is as important as *size* to these subjects. Indisputably, test No. 4 was the most desirable of all, followed by No. 2.

*Conclusions*

While all this work produced considerable new knowledge, it can be concluded that the special criteria devised in laboratory tests may not be as necessary as was formerly thought to be the case. This is one situation where the needs of people do not necessarily conform with what appears to be scientifically desirable for them. This is because strong behaviour or preference patterns have become well established earlier in life.

The problems attached to aiding the visually handicapped in their reading needs can best be attacked at this time by paying most attention to the following factors:

1. The print may be of conventional style such as Baskerville—*but*

2. It must have clean edges, i.e., be free from microscopic ink-spread or other blurring characteristics dependent upon the quality of the products used.
3. It must be of such a size that the lower case "o" will be approximately 2.7 millimeters in the vertical direction, or more. The strokes should not be too bold, i.e., not more than 17.5 per cent of the letter height. These dimensions favour 16- to 18-point type.
4. The paper must have high contrast and opacity. It must also be light in weight.
5. The line length should be not less than 36 picas.
6. Periods and commas *must* be larger than those traditionally in use. Sizes have been suggested in the Introduction.
7. Hyphenation must be kept to a minimum, preferably eliminated entirely.

Several workers have decided on the basis of extensive experiments that 18-point type need never be exceeded in size in order to produce the greatest benefit for visually handicapped readers. It may be well to recapitulate the reasons for this. The larger a type, the fewer words to a line unless the length of the line is extended far beyond that which is convenient to the making of the book, or the holding of it by the reader. When there are fewer words on a line, the number of excursions from the end of one line to the beginning of the next is vastly increased in any book. The number of hyphenations is also increased unreasonably. Both of these factors slow the reader and reduce his efficiency, and even though there may be no problem of letter legibility, there does arise a problem of word legibility, because the eye can accept only so much area of print at a time, and this means that words of more than three or four letters must be given greater attention by assembling them from the parts that can be accepted by the eye in each scanning pause. There is general agreement that this problem arises very definitely in type over 18-point size.

Finally then, conventional 18-point Baskerville to the specifications outlined will help visually handicapped readers very considerably, more so if they have an established reading pattern and well implanted word images in the brain. Young people who are learning to read, however, benefit more from sans-serif type such as Spartan Medium. This produces a better visual image, which will not conflict in their case with an established one in conventional serif type. To produce books of this kind for these readers alone would be impracticable. It would be imperative to print *all* books this way so that the establishment of word images in this type would be well consolidated in all people approaching old age and consequent visual deterioration. Spartan type *is* and would be better for all people if they could start and continue through life with this best form of type, but unless it is used universally, its advantages are hardly worth considering.