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Relative Legibility of Leroy and Lincoln/MITRE Fonts on Television

Donald Shurtleff

The legibility of standard Leroy alphanumeric symbols was compared with that of a new font, the Lincoln/MITRE, on a television monitor at resolutions of 8, 10, 12, and 14 lines per symbol height. The new font was not superior in legibility to the Leroy font at any of the values of resolutions tested. While the findings for the new font were negative, insights were gained about how to improve symbol design for more legible television displays. It was recommended that these new design techniques be evaluated in future work on television displays.

Television is a valuable display device for systems use because of its versatility, ease of signal transmission, reliability of image reproduction, ease of maintenance, and comparatively low cost. In addition, the ability of television to combine different data inputs into a single composite display is well known. Nevertheless, the acceptability of television for many military and industrial systems applications depends upon its ability to display symbols which can be accurately and quickly identified by the viewer.

This ability has seldom been determined through objective performance tests that provide estimates of accuracy and speed (legibility) of symbol identification. Even though television is widely used for entertainment, education, and communication, the research which might have solved some of the legibility problems has been directed elsewhere instead. Commercial TV studies lean to such problems as picture quality, flicker, color quality, and in educational TV, to evaluations of television as an instructional device. When television is used as a means of communication in system settings, symbol legibility is often determined by subjective opinions, preferences, or even guesses.

There is a need to conduct comparative studies of different fonts for developing standards to guide the designer and manufacturer of

display equipment to select the most legible symbols. The present study tried to select a better font for television use by studying the relative legibility of standard Leroy symbols and a set of improved symbols (Lincoln/MITRE) on a television monitor. An improved symbol font may be expected to aid television legibility in either one of two ways (or both) by lowering the minimum number of scan lines per symbol height required for a high accuracy of identification, or to produce faster identification times at previously established minimal values of symbol resolution (10 to 12 lines per symbol height, see references 2, 3, 8, and 9).

A set of alphanumerics which might best serve as a standard would retain good legibility when displayed on any display such as a shaped-beam or slewed-beam cathode ray tube, a high speed printer, an office typewriter, a television monitor, and so on. Work on the development of a universally legible font was started several years ago and, in part, continued some earlier work at Lincoln Laboratory. Essentially, this work involved refining a set of symbols originally designed by Mackworth. The history of the development of this font is described in more detail elsewhere.⁵

The latest version of this font called Lincoln/MITRE (L/M) is shown in Figure 1. In a recent study⁴ the L/M font was compared with the Leroy font (Fig. 1) which is a standard lettering style used extensively in commercial art and advertising. The results of the study showed that subjects made fewer errors identifying tachistoscopically presented L/M symbols than identifying Leroy symbols at each of several values of brightness contrast ratios, ranging from 4:1 to 10:1.

While the work to date with the L/M font is encouraging, there is a need to conduct additional evaluations of this font before it may be recommended as a standard for use in other display applications. Furthermore, the tachistoscope study indicated that some additional improvements might be made in the legibility of L/M symbols by changes in the geometry of those symbols which the subjects misidentified most frequently. However, before any additional changes in symbol design were made, it seemed desirable to collect more data on inter-symbol confusions when the L/M font is tested in other kinds of displays.

Since the legibility of televised symbols has been a major and con-

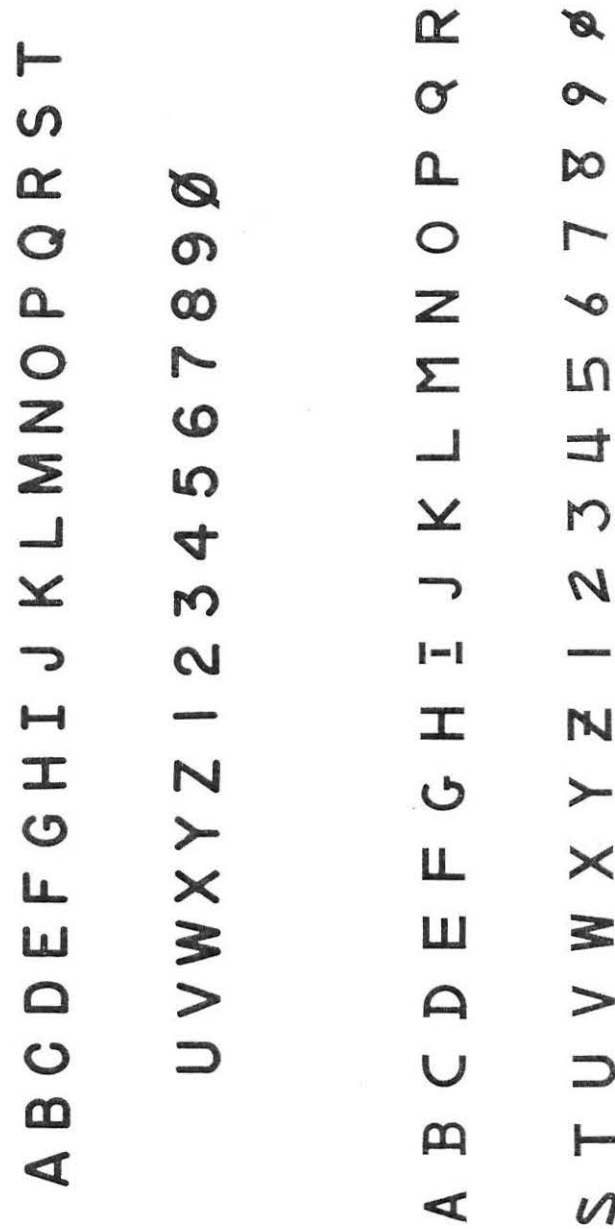


Figure 1. Leroy font (top) and Lincoln/MITRE font.

tinuing interest at MITRE, it seemed reasonable to extend the evaluation of the L/M font by comparing it with the Leroy font on a television monitor. Television represents a unique problem in symbol design because of the way in which the symbols are constructed and displayed. There are two major characteristics of television which influence symbol geometry; the cutting up of symbols by the active lines of the television raster, and the "on-off" characteristics of the scanning element. The first characteristic affects symbol geometry by deleting selected parts of the symbol, while the second characteristic may affect symbol geometry by smearing, which is caused by the lack of a sharp "on-off" response of the scanning element in horizontal transitions from light to dark areas. Both of these characteristics, the cutting up and the smearing of symbols, are shown clearly in Figure 2 where photographs of selected televised symbols at 10 lines are presented.

Previous attempts to develop a font uniquely suited to television have failed.^{7,8} In each case, the improved font was no better than standard Leroy symbols. In the present study, the Leroy font was compared with the L/M font at symbol resolutions of 8, 10, 12, and 14 lines per symbol height. The results showed no marked superiority of L/M symbols over Leroy symbols at any of the resolutions studied. As in previous studies^{2,3,8,9} legibility for both fonts was greatly impaired for resolutions below 10 lines per symbol height. While the findings for the L/M symbols were disappointing, the results provided some new insights into other, and hopefully more fruitful techniques for improving the design of symbols for television displays.

Methods

The subjects were four MITRE employees who had 20/20 near and far acuity, normal color vision, and no marked phoria.

Television Equipment. The television equipment and manner of presenting symbols to each subject is described in detail in a previous report¹ and only a brief description is given here. The symbols were projected onto a translucent screen which was mounted on a modified Motion Analyzer. The symbols were picked up by a 945-line General Precision camera (Model 820) and shown to the subject on a Conrac (Model CQE 14/945) 14 inch video monitor. The camera-to-screen

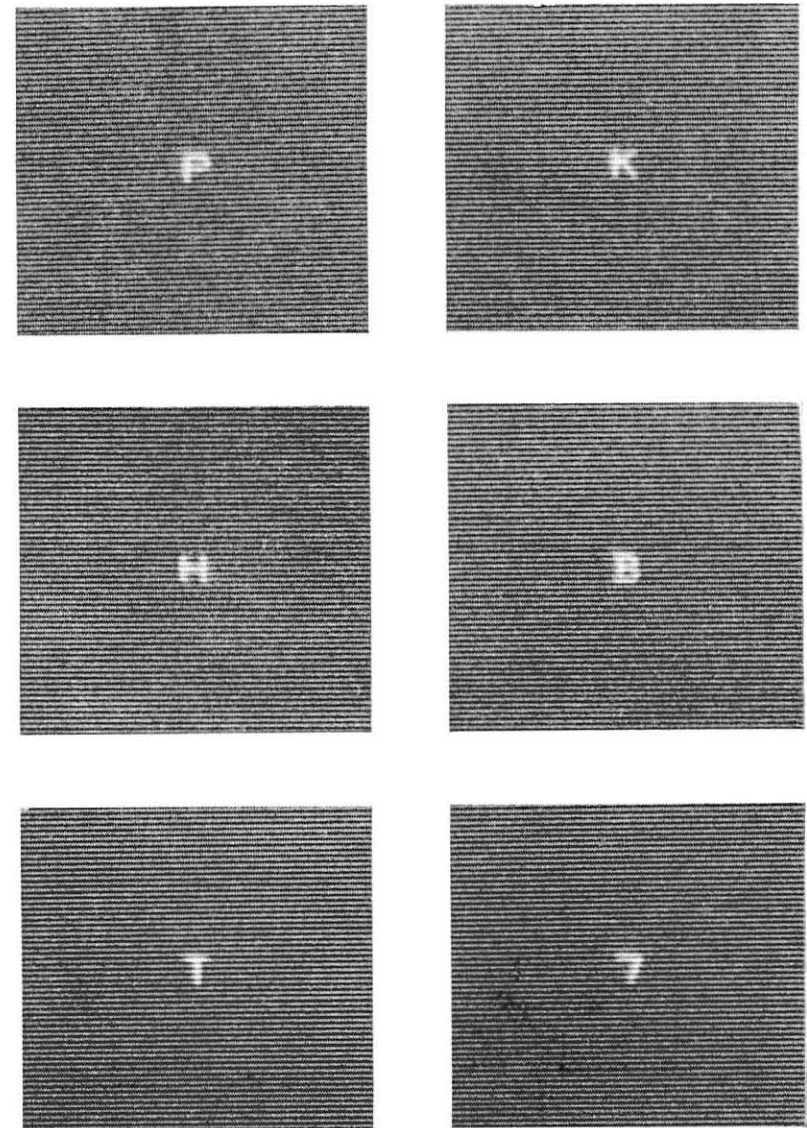


Figure 2. Symbols resolved by ten scan lines.

distance was arranged to obtain the desired line resolution, and the subject-to-monitor distance was arranged to maintain an angle of subtense at the eye of 16 minutes of arc. The subject initiated the exposure of a symbol by depressing a button. The exposure of the symbol was ended when the subject made his verbal identification. The subject was instructed to make his identifications as quickly and accurately as possible. The time required to identify each symbol, and the symbol named, were recorded.

The L/M and Leroy Symbols. The symbols were photographed on 35mm. film strips. Each strip contained 180 symbols of a given font with the 36 symbols appearing five times each. The average symbol width for the two fonts was three-quarters of the symbol height. The two fonts had a ratio of stroke-width to height of one-sixth. It was necessary to modify the standard Leroy O and I in order to differentiate the O from the letter O, and the numeral 1 from the letter I.

The sequence of symbols on the film strip was determined by a table of random numbers. A stepping switch controlled the advance of the film through the film projector and provided a number of different symbol sequences, which helped to prevent the subjects from memorizing the letter sequences.

Experimental Design. Each subject identified symbols in both fonts at each of the four values of resolution (8, 10, 12, and 14 lines). The subjects viewed one font at all resolutions before being presented the other font, two of the subjects seeing Leroy first and the other two seeing Lincoln/MITRE first. The two subjects seeing Leroy first were presented the resolutions in two different orders which were determined by a table of random numbers. These same sequences of resolutions were used also for the two remaining subjects who started with the L/M font. When the subjects were switched to the alternate font, two new orders of resolutions were made up with a table of random numbers. Each subject seeing the Leroy font viewed one of the new sequences and these same sequences were used for the two subjects who saw the L/M font.

Each of the subjects made a total of 180 symbol identifications (five per symbol) for each font at each of the four resolutions. Before each series of sessions with a given font, the subjects were given practice in identifying the symbols making up that font. The practice session

included 180 identifications, five for each symbol of the font. These symbols were shown on the television monitor and were resolved by 60 active lines per symbol height. During practice any errors made by the subject were corrected by the experimenter and errors rarely occurred during practice.

Characteristics of Televised Symbols. The active lines in the symbols had an average brightness of approximately 20 fL and a background brightness (to one side of the symbol) of approximately 2 fL as measured by a Spectra Brightness Spot Meter. The procedure followed in adjusting the television equipment before each experimental session is described by Bell.¹

Results and Discussion

The percentage of identification errors for L/M and Leroy symbols at each of four values of resolution are shown in Figure 3; the identification speed for these two fonts at the same values of resolution are shown in Figure 4. As Figures 3 and 4 indicate, there were no marked differences between the two fonts in either accuracy or speed for any of the resolutions studied. The speed and accuracy of symbol identification for each subject are presented in Tables I and II. From Tables I and II it is evident that none of the differences between fonts were very large and statistical analysis revealed no significant differences in these data. Even the relatively large mean differences in identification time for the two fonts at a resolution of eight lines was not statistically significant.

The effects of decreases in resolution on speed and accuracy of symbol identification for both fonts is similar to that reported in many previous studies.^{2,3,8,9}

Two conclusions follow from these (1) data: Televised L/M symbols are not superior in legibility to televised Leroy symbols, and (2) a minimum resolution of 10 lines per symbol height is required for a 90% or better accuracy of identification.

Inter-symbol Confusions. The particular symbols which had the highest concentration of errors were similar for the two fonts at resolutions of 8 and 10 lines. The only notable difference between the two fonts was at a resolution of 12 lines where there was no confusion among the

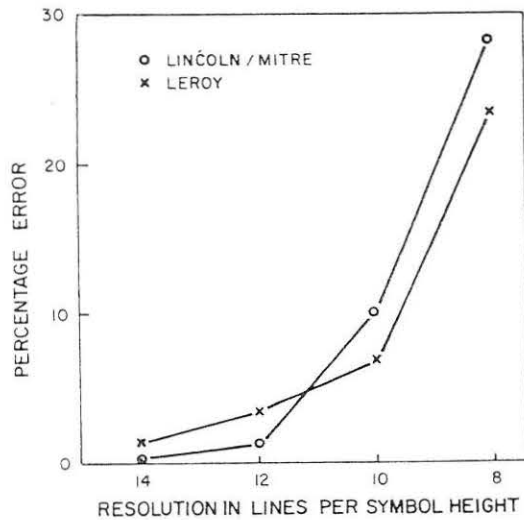


Figure 3. Percentage error for L/M and Leroy symbols.

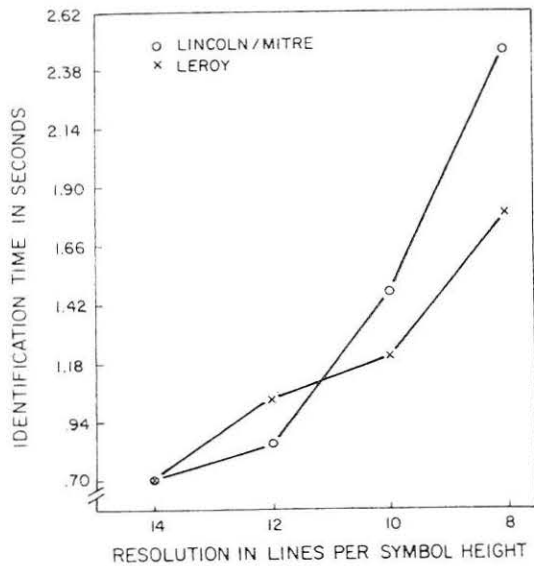


Figure 4. Identification time for L/M and Leroy symbols.

TABLE I. Percentage Error for Each of Four Subjects

Subjects	Resolution in Lines Per Symbol Height							
	14		12		10		8	
	L/M	Leroy	L/M	Leroy	L/M	Leroy	L/M	Leroy
1	0	1	0	6	2	7	8	14
2	1	3	2	2	8	9	36	42
3	0	0	3	3	12	5	23	17
4	0	1	0	3	18	7	46	22
Mean	0.25	1.25	1.25	3.50	10.00	7.00	28.25	23.75

TABLE II. Identification Time in Seconds for Each of Four Subjects

Subjects	Resolution in Lines Per Symbol Height							
	14		12		10		8	
	L/M	Leroy	L/M	Leroy	L/M	Leroy	L/M	Leroy
1	0.65	0.69	0.76	1.49	1.01	1.32	2.93	1.41
2	0.63	0.69	0.75	0.71	1.08	0.90	1.38	1.50
3	0.54	0.57	0.87	0.71	1.42	0.82	1.63	1.36
4	0.96	0.84	1.04	1.25	2.36	1.75	3.92	2.93
Mean	0.70	0.70	0.86	1.04	1.47	1.20	2.46	1.80

L/M symbols while the B, 8, Q, O, G, and 6 of the Leroy font continue to be major sources of error. The absence of errors for the L/M font and the presence of errors for the Leroy font at 12 lines is not too surprising when it is recalled that the L/M font is essentially a refinement of the geometry of a font much like the Leroy.⁵ It is noted that by comparing the two fonts (see Figure 1) the geometric refinements include such things as increasing the size of small symbol detail (for example, increasing the length and changing the position of the horizontal bar of the letter G), changing the outline of symbols (for example, changing the upper part of the numeral 8 from a circle to a triangle), and altering the curvature of symbol strokes (for example, changing the curvature of the letter S). The failure of these design changes to aid identification at the lower resolutions is probably related to the fact that small differences in detail and stroke curvature are not resolved sufficiently by the coarse scan structure of the television. Apparently, a scan structure as fine as 12 lines per symbol height is needed before these geometric differences are

resolved sufficiently for the subject to be able to detect them and use them in his identifications.

Design of Symbols for Television

It is clear from the results of the present study and previous studies^{7,8} that small changes in detail and curvature of strokes of symbols are not going to improve the legibility of television displays. It appears that two other ways of changing symbols should be evaluated before the search for a better television font is abandoned.

In an earlier study⁷ twelve Leroy symbols were revised and tested for legibility on a television monitor. Eleven of these revisions involved small changes in symbol detail, but one revision involved a rather simple design change, that of increasing the width of the letter H from 75% to 100% of the symbol height. Most of the changes in small detail were not successful, but increasing the width of the H eliminated both the H-called-M and the H-called-N confusions which previously had been major sources of error. The finding suggests that increasing symbol width might be successful with other symbols involved in major confusions on television.

In addition to increasing symbol width, design changes involving a decrease in symbol stroke-width may be successful. Gross changes in symbol design such as increasing the width or decreasing the stroke-width of symbols may be expected to aid television legibility because the discrimination of gross detail is less dependent upon the fineness of the scan structure than is discrimination of small symbol detail. Furthermore, increasing the width or decreasing the stroke-width of symbols may be expected to improve legibility by reducing the amount of horizontal smearing of symbol strokes. Therefore, further work may produce better symbols for television by studying the effects of symbol width and stroke-width.

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Additional Studies of Television Legibility

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4. Kinney, G. C., Marsetta, M., and Showman, D. J., Studies in Display Symbol Legibility: XII. The Legibility of Alphanumeric Symbols for Digitalized Television, The MITRE Corporation, Bedford, Mass., ESD-TR-66-117, August 1966.

5. Shurtleff, D., and Marsetta, M., Studies in Display Symbol Legibility: XIV. The Legibility of Military Map Symbols on Television, The MITRE Corporation, Bedford, Mass., ESD-TR-66-315, September 1966.

The above papers may be obtained from: Clearinghouse for Federal, Scientific, and Technical Information, Springfield, Virginia 22151

Typographic Education

This department is an international forum for faculty members, students, practicing designers, and other interested persons who are invited to submit succinct articles dealing with educational trends, fields of study, design techniques, and student problems in the various typographic educational programs.

England: The Working Party on Typographic Teaching

1 *The Working Party*

1.1 *Origins.* The Working Party on Typographic Teaching was set up in October, 1966, by the Society of Industrial Artists and Designers (London), with the active support of the Society of Typographic Designers, in response to repeated criticism from assessors, teachers, and spokesmen from industry that much graphic design work in colleges of art and design was let down by an immature approach to typography. Since then, the Working Party has become an independent and permanent body with nearly fifty active members drawn from departments of printing, colleges of art and design, universities, and a number of branches of industry. Amongst them are representatives of leading national and international organizations and societies connected with typography and graphic design, heads of graphic design and printing departments, and teachers (both full- and part-time) from many parts of the country.

1.2 *Terms of reference.* The initial terms of reference were to consider the place of typographic design in graphic design courses and to suggest means of improving the quality of the teaching of the subject. As work progressed it soon became obvious that the traditional meaning of typography (printing) would have to be extended to include all visual communication systems involving the use of words, numbers, and other symbols. It also became clear that we were really concerned with the fundamental issues of the design process which, in our experience, can best be approached through the study of an industrial design discipline such as typography—engineering or architecture would serve equally well, but typography is the obvious choice in graphic design courses.