Legibility of Highway Guide Signs

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A study concerned with the legibility of the message elements displayed on highway guide signs is reported. The work was carried out on a vision testing alley, and scaled-down replicas of highway signs were used. The findings indicate that route numbers had the poorest legibility of the eight types of information displayed on the guide signs tested. They were seen at 10 percent shorter distance than place names. Cardinal-direction indications (North, South, East, West) demonstrated satisfactory legibility. They could be identified farther away than any of the sign elements except the message "NEXT RIGHT". Capital/lower-case cardinal-direction indications were seen 10 percent farther away than conventional block letters. The use of capital/lower-case lettering can increase element legibility without requiring appreciably more sign space. The feasibility of performing sign legibility research on small-scale replicas is supported. A minimum letter height of 0.85 cm (0.33 in) is recommended to achieve adequate subject testing distance.

The study reported in this paper was initiated by a request to the Traffic Systems Division from the Office of Traffic Operations of the Federal Highway Administration (FHWA). Motorists had complained of difficulties in reading the cardinal directions (North, East, South, West) on highway signs. On the basis of subsequent discussions, it was decided that a study of cardinal-direction legibility should be undertaken. It was thought that legibility might be enhanced by capitalizing and increasing the size of the first letters of the directions. South and North have the letters o, t, and h in common; East and West both include the letters s and t. However, the first letters--N, E, S, and W--are unique to each direction. By increasing the size of the first letters, the uniqueness of the directions could be enhanced. The legibility of guide-sign categories other than cardinal directions was also tested in this study. These elements included such categories as place names, route numbers, exit numbers, and the warning, "EXIT ONLY". Since complete sign replicas were made to test the legibility of cardinal indications, with a little additional effort the legibility of other sign elements could also be assessed.

This study differs from previous work (1) in that it is concerned with the legibility of the elements of a complete sign rather than single isolated words or letters. Recognition of the sign elements may be affected by cues of familiarity, position, color coding, and word sequence. For example, if the driver identifies either word of the sequence "EXIT ONLY", he or she is likely to guess the entire element. Position on the sign and color coding also aid this identification. If the driver knows that he or she is viewing a direction indication, the choice is only among the four cardinal directions. Because these effects are present in the operational situation, it is of interest to study legibility in context, by using the complete sign.

METHODOLOGICAL CONSIDERATIONS OF SIGN TESTING ON SMALL-SIZED REPLICAS

In this study, legibility was tested on small-sized replicas rather than on full-scale signs. The advantages of using replicas are readily apparent. A 38.4-cm (15-in) high word, such as appears on highway guide signs, can be read at a distance of 305 m (1000 ft) or more by a person with normal vision. A legibility study carried out with full-scale letters would require, in addition to this distance, a preliminary range to prevent instant word recognition by subjects with especially keen eyesight. Full-sized signs also require cumbersome display material and a method of communication between the experimenters overseeing the subjects and those manipulating the sign display.

The testing of legibility on small-sized replicas assumes that a subject's acuity, over a large range, can be described by an angular threshold measurement. Legibility distance would consequently be directly proportional to the linear height of the sign lettering. A replica 1/45th the size of the actual road sign, for example, would be readable at 1/45th the legibility distance of the original sign. If these assumptions were not true, and acuity varied with distance, the "walk-to" method of determining legibility would be incorrect. Indeed, optometric acuity testing, which is usually done at a fixed 6-m (20-ft) distance, would have but limited applicability.

Considerable evidence exists that the legibilities obtained on small replicas can be extrapolated to full-sized signs. Visual accommodation is not a problem; ophthalmological studies show that, at distances as close as 1 m (3.28 ft), even the far-sighted person can fully accommodate (2). A study by Forbes and others (3) has demonstrated constancy of threshold visual angle. In the published report of that research, the legibility distances associated with letters 12.7, 20.32, and 30.48 cm (5, 8, and 12 in) in height were separately shown (see Figure 1). The data points in Figure 1 are fitted by lines that depart only slightly from linearity. (A straight-line fit would indicate a linear relation between letter size and legibility distance.) The negligible deviation from straight-line fit is probably accounted for by variable error.

Data on the constancy of the threshold visual angle at short viewing distances have been presented by Smith (4). The Smith study involved 547 subjects who made a total of 2007 legibility observations on 314 types of common printed materials. Results indicated that threshold visual angle did not systematically change between the limits of 1 and 22 m (3.28 and 72 ft). At distances closer than 1 m, the threshold angle did increase, which indicates that the walk-to method may not be reliably applied at these very close viewing positions.

SUBJECTS

The 50 experimental subjects were recruited from the Virginia Employment Office and from the U.S. Department of Transportation's Fairbank Highway Research Station in McLean, Virginia. The Employment Office subjects were paid $15 for participation in this and an associated study on sign information load. The sample included an almost equal number of males and females and a wide range of ages, education, and driver experience. All subjects held valid driving permits.

EQUIPMENT

Testing Alley

The investigation was carried out in a vision testing alley at the Fairbank Highway Research Station. Viewing positions for the Snellen and cardinal-direction charts were marked in tape on the floor at distances of 7.62, 10.67, 12.19, and 15.24 m (25, 35, 40, and 50 ft) from the chart position. The highway sign replicas were tested at the following closer distances (1 m = 3.28 ft):

Position	Distance from Sign (m)	Position	Distance from Sign (m)
1	1.0583	7	3.16
2	1.27	8	3.79
3	1.52	9	4.55
4	1.83	10	5.46
5	2.19	11	6.55
6	2.63	12	7.86

It will be noted that these distances form a geometric series; each step is 1.2 times the distance of the next closer step. A geometric sequence provides subjectively equal size increments in conformity with Webers Law that a perception unit is a constant fraction of the stimulus magnitude. The data, calculated in terms of steps and fractions of a step, may be directly used in the computation of means, standard deviations, and other descriptive statistics.

The signs were displayed against a 56-cm (22-in) high by 71-cm (28-in) wide sheet of white cardboard centered 1.42 m (56 in) above the floor. Illumination of 377 lx (35 ft•c) was furnished by two spotlights at chart height. The lights were sufficiently separated to the front and sides of the charts as not to throw specular reflections into the subject's eyes.

Test Charts

The tests included a Snellen E chart, cardinal-direction charts, and replicas of highway signs.

TESTS

The design and administration of the tests were as follows.

Snellen E Test

A Snellen test was included in order to relate the other test results to the subjects' visual acuities. The Snellen test showed the letter E with the open side facing up, down, right, or left in random sequence. The lines on the chart represented acuities of 20/200, 20/100, 20/70, 20/50, 20/40, 20/30, 20/20, and 20/15. Since subjects viewed the chart binocularly and with corrected vision, scores were better than they would have been had the usual monocular testing been used. To effectively grade keen-sighted subjects who were able to read all lines of the chart, the test was administered at a 9.1-m (30-ft) rather than 6.1-m (20-ft) distance. This procedure allowed the chart to adequately cover the acuities of the tested group.

A 95 percent probability level was adopted in this acuity testing. To pass an acuity level (line) on the test, the subject was required to equal a performance attained only 1 in 20 times by chance alone. The E may appear in any one of four positions; hence, the chance of correctly guessing its position is 1 in 4, or 25 percent. The probability of correctly guessing two consecutive orientations is 1 in 16. The probabilities are therefore given by cumulating the following binomial expansion:

$$(1/4\,A + 3/4\,B)^N$$

where

A = success,
B = failure, and
N = number of letters on a line.

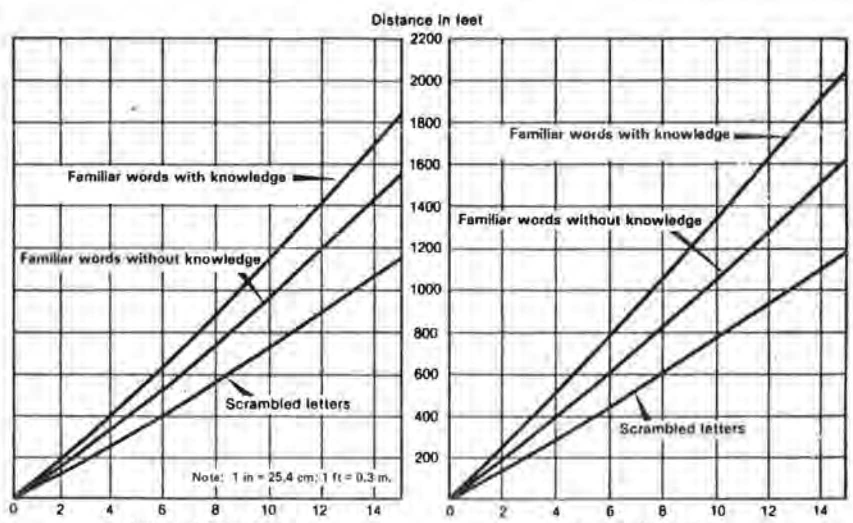
The expansion of the expression indicates that the subject fails at the 0.05 chance level if more than two items are wrong on a six-item line or if more than one item is wrong on a four-item line (there are no five-item lines on the chart).

A person who correctly reads the 20/40 line of an acuity test and fails the next line is able to read at 6.1 m (20 ft) what a normally sighted person can read at 12.2 m (40 ft). Since the test was administered at a 9.1-m (30-ft) distance rather than at 6.1 m, subjects were credited with better vision than the eye chart actually indicated. A subject who read a 20/15 line was graded 20/10. He or she could read at 5.1 m (20 ft) what a normally sighted person would just be able to read at 3.05 m (10 ft). A 20/20 score was classified as 20/13. Similar corrections were made in grading the other line scores.

Cardinal-Direction Charts

The cardinal-direction charts showed either block or capital/lower-case (CLC) letters (see Figure 2). The directions "North", "South", "East", and "West" were displayed in white letters on a highway green background. The charts were 25.4 cm (10 in) high and 42.5 cm (16.5 in) wide. Each chart had two lines of eight items (two Norths, two Souths, two

Figure 1. Relation between legibility distance and letter height: block and capital/lower-case styles.



Easts, and two Wests) to a line. The conventional block letters were 0.64 cm (0.25 in) in height; the initial capital letters of the other style were 0.87 cm (0.34 in) in height, and the lower-case letters were 0.65 cm (0.255 in) in height. The letter styles duplicated those illustrated in the Manual on Uniform Traffic Control Devices (MUTCD) (5). As shown in the MUTCD, lower-case letters have a somewhat thicker stroke width than do the block letters. Following the rule that a subject passed at a success level exceeded in only 5 percent of trials by chance, the cumulative binomial expansion indicated that a subject failed if more than three mistakes were made on any of the eight item lines.

Highway Sign Replicas

The four highway sign replicas used in the study were taken from the MUTCD (see Figure 3). The designs were modified slightly: North was never paired with South nor East with West. Subjects were therefore unable to deduce a cardinal direction from its paired opposite on the sign. Two of the signs were conventional exit warning signs, and two were diagrammatic advance warning signs. The block and CLC signs were similar except for the difference in style of the cardinal-direction indications.

PROCEDURE

The experimental tests were presented in the following order: (a) Snellen E, (b) block and CLC cardinal-direction charts, and (c) highway sign replicas. The 50 experimental subjects were randomly assigned into two groups of 25 subjects each. These groups were designated "experimental" and "conventional", respectively. Both groups took the three types of tests, but the conventional group viewed only the block-letter highway sign replicas. The experimental group viewed the sign replicas with CLC letters. (Since subjects might remember the contents of the sign replicas, only one letter style of replica sign was viewed by each subject.) A counterbalanced order of viewing the cardinal-direction charts was used to offset order effects. It required approximately 15 min for a subject to complete the session.

RESULTS

Comparative Legibility of Guide-Sign Elements

It is convenient to describe the sign replica results before the other findings. The median distances at which guide-sign elements were read on each sign are given in Table 1. In computing median

Figure 2. Cardinal-direction charts.

Figure 3. Highway sign replicas used in the study.

Table 1. Observed and relative legibility distances of guide-sign elements.

Sign Element	Sign 1 Median (m)	Sign 1 Relative Ratio	Sign 2 Median (m)	Sign 2 Relative Ratio	Sign 3 Median (m)	Sign 3 Relative Ratio	Sign 4 Median (m)	Sign 4 Relative Ratio	Geometric Mean	Rank
"EXIT"	3.86, 4.01	0.955	2.83	1.029	2.70	1.019			1.001	4
Exit number	3.54, 3.58	0.864	2.65	0.964	2.63	0.992			0.938	7
Cardinal direction	4.32, 4.91	1.120	3.00, 3.27	1.140	2.48	0.936	7.02	1.376	1.132	2
Place name	4.11, 4.13	1.000	2.67, 2.83	1.000	2.65	1.000	5.10	1.000	1.000	5
Route number	4.00	0.971	2.60, 2.66	0.956	2.37, 2.22	0.866	4.15	0.814	0.899	8
Distance number			2.98	1.084	2.88	1.087			1.085	3
"NEXT RIGHT"	5.13	1.245					5.40	1.059	1.148	1
"EXIT ONLY"					2.49	0.940			0.940	6

Notes: 1 m = 3.28 ft.
Relative legibilities are in reference to median place-name distances, which were given a value of 1.00 (based on legibility of the four guide signs shown in Figure 3, read by 50 subjects).

distances, if a subject passed at a particular position and failed at the next more distant one, he or she was credited with reading the sign element at the geometric mean of the positions. The relative ratio column in Table 1 expresses reading distances of each element divided by place-name legibility distance. Where two similar categories appeared on a sign, legibility distances were averaged. The geometric mean was used in computing the next to last column of Table 1 to ensure that two ratios, such as $4/5 = 0.80$ and $5/4 = 1.25$, averaged to 1.00. The ranking of the geometric means of element legibilities is given in the last column of Table 1.

Cardinal-direction indications showed good legibility. They ranked second highest in legibility among the sign categories tested. The possibility was also considered that the superior legibility of cardinal-direction indications might be due to practice on the previously administered cardinal-direction charts. To test this possibility, an additional 10 subjects who had no previous practice on cardinal-direction indications were tested solely on sign replicas. The Spearman rank-difference correlation between the last column of Table 1 and the corresponding legibility rankings recorded for the new group was 0.88. On the additional tests, cardinal-direction indications had the best legibility of the eight sign elements, place names ranked fifth as indicated in Table 1, and route numbers had the poorest legibility--i.e., they again ranked eighth.

The finding that cardinal-direction indications do not pose a legibility problem is in contradiction to the letters of complaint received from several motorists. It is possible that directional signs may be confused if the driver is careless or if he or she views the signs under the adverse visibility conditions of rain, snow, or dusk. In addition, drivers may not be sure of the cardinal direction of their destination. However, it does not seem reasonable to insist that the cardinal-direction indications be even more legible than they currently seem to be. Until firm evidence accumulates that cardinal-direction indications pose a special reading problem, the matter of improving their legibility must be held in abeyance.

Route numbers had the lowest legibility of the sign elements tested (Table 1). The legibility distance of route numbers was 10.1 percent less than that of place names. The nine possible comparisons of place-name versus route-number legibilities show differences to be beyond the 0.01 chance level of significance (binomial expansion test).

The relatively poor legibility showing of route numbers may be due to several difficulties. Even if the driver recognizes that he or she is viewing a route number, there are a total of 90 possible two-digit numbers and 1000 three-digit numbers. In addition, route numbers are often crowded on the Interstate seal. In contrast, an information element such as "NEXT RIGHT" occurs in a characteristic position on the sign, is not cluttered by other information, and presents minimal possibilities of choice. The relatively uncluttered exit and distance numbers also showed better legibility than route numbers.

A number of clues for improving sign legibility were suggested by the test subjects' comments. The white-on-blue Interstate route number had poorer legibility than the black-on-white U.S. route number (sign 3). The Interstate route number appears more cluttered than the other. A number of subjects mentioned that the diagrammatic arrows of signs 3 and 4 indicating splits and interchange geometrics could be seen before the sign elements were readable. The excellent legibility of diagrammatic symbols may give a useful orientation to upcoming road geometry. On sign 4, the cardinal direction "East" is surrounded by abundant uncluttered space. This cardinal-direction indication had very good legibility. It is likely that many signs can be made more legible by the application of effective graphic design principles.

The guide-sign legibilities in Table 1 are expressed as visual angles in Table 2. Table 2 indicates the relative threshold size of the sign elements at a fixed distance. For example, to be seen at the same distance as a place name, a route number on these signs would have to be, on the average, 1.17 times as tall. (The result is given by the division of the two geometric means, i.e., $3.941/3.358 = 1.174$.)

The angle figures given in Table 2 can also be used to determine legibility distances if the size of the element is known. Extrapolated from the 3.358-min visual angle threshold, a place name with 38.4-cm (15-in) high lower-case letters would have a legibility distance of 390 m (1200 ft). The legibility distance of a route number of the same size, calculated from the median visual angle of 3.94 min, would be 332 m (1090 ft). A cardinal-direction indication 38.4 cm in height would be seen at 476 m (1536 ft). Under these conditions of equal size, the route number would just be seen 58 m (190 ft) closer than the place name and the cardinal-direction indication 86 m (282 ft) farther away. The legibility results of Tables 1 and 2 need to be interpreted in relation to drivers' guidance needs. If drivers followed a stereotyped pattern in viewing a sign, the application would be straightforward. For example, if route numbers were always read first, followed by place names, cardinal-direction indications, distances, etc., the element legibilities could logically conform to the same sequence. Route numbers would be made most legible of the elements, followed by place names, and so on. Unfortunately, information on drivers' sequential reading of guide-sign elements is not available. Moreover, drivers' guidance needs differ. Some drivers may be looking for a route, others for a

Table 2. Legibilities of guide-sign elements expressed as visual angles.

Element	Threshold Visual Angle (min) Sign 1	Sign 2	Sign 3	Sign 4	Geometric Mean	Rank
"EXIT"	2.49, 2.40	2.07	2.26		2.253	1
Exit number	3.95, 3.91	3.29	3.32		3.501	7
Cardinal direction	3.23, 2.67	3.20, 2.94	2.82	2.24	2.750	4
Place name	4.04, 4.02	3.27, 2.94	3.30	3.08	3.358	6
Route number	3.71	4.70, 4.92	4.05, 4.53	3.15	3.941	8
Distance number		2.34	2.42		2.380	2
"NEXT RIGHT"	3.24			3.07	3.154	5
"EXIT ONLY"			2.62		2.620	3

Note: Based on the median distances given in Table 1.

place name, and still others may require no information from a sign. Therefore, a completely satisfactory, fixed formula for assigning sign element legibilities is not apparent.

However, it seems safe to assume that place names and route numbers are of primary interest and should be very legible. Elements such as "NEXT RIGHT", "EXIT ONLY", and distance indications such as "2 MILES" are subsidiary. They have meaning only when the relevant place or route number has first been identified. These subordinate, descriptive items are presumably read at closer distances and hence may be made less legible. Route numbers should not be difficult to read. They should be more legible than they are on present guide signs.

Comparison of Legibility of Block and CLC Letter Styles

The number of test subjects passing the cardinal-direction charts at each viewing distance is given below (1 m = 3.28 ft; N = 50):

	Number Passing	
Distance (m)	Block	CLC
12.19	1	1
10.67		8
9.14	9	19
7.62	16	15
6.10	18	5
4.57	4	2
3.05	2	
Total	50	50

Visual angle was 2.59 min for median block style and 2.20 min for CLC style. The CLC chart is calculated to be read at an 18 percent greater distance. The legibility advantage of the CLC style is also shown by individual performance comparisons. Forty-five of the 50 subjects were able to read the CLC chart at a greater distance than the block chart. The remaining five subjects read both charts at the same distance. This difference would be obtained less than once in 100 trials if both charts were equally legible (binomial expansion test).

It will be recalled that the cardinal-direction indications were printed in the two styles on the sign replicas. Half the experimental group (25 subjects) viewed sign replicas with block letters, and the other half read the signs with CLC cardinal directions. The groups were closely equated in acuity. The median Snellen E score of the conventional group was 20/10.77, and that of the experimental group was 20/12.4. These scores did not differ significantly. Median distances at which the cardinal directions were read on the replicas are given in Table 3. On the average, the CLC indications were read 10 percent farther off than their block-letter counterparts. This result is in conformity with results obtained by Forbes and others (3) in their full-scale study. These investigators also found 10 percent greater legibility for CLC than for block-style lettering.

Abilities Involved in Reading Guide Signs

The intercorrelations of the various experimental tests for sign 2 are indicated in Table 4. The elements of the sign are also identified. The statistical signs of Snellen test correlations have been reversed to compensate for the fact that a low Snellen score represents superior visual acuity. The first intercorrelation in the table (0.75) represents the Pearsonian product-moment correlation of Snellen scores with scores on the block-letter cardinal-direction chart. The other entries are similarly interpreted.

The intercorrelations of Table 4 imply that abilities other than visual acuity are involved in reading road signs. As Table 5 indicates, the acuity type tests--the Snellen E, block, and cardinal-direction charts--intercorrelated highly. Intercorrelations ranged from 0.75 to 0.95. The high correlation of 0.95 represents that between the two cardinal-direction charts. The various guide-sign elements also intercorrelated highly. The averages of each with all the others ranged from 0.793 to 0.876. These averages do not include the 1.00 correlation of each test with itself. In contrast, acuity tests and guide-sign elements show lower correlation with each other. The averaged correlations ranged from 0.529 to 0.670.

These results suggest a possible advantage to including a sign-reading test in the driver-licensing examination. The ability of drivers to read signs at a distance is only partly related to visual acuity. Persons of very low literacy or

Table 3. Median legibility distances at which cardinal-direction indications were read on highway sign replicas.

	Sign 1		Sign 2		Sign 3	Sign 4
Item	South	West	North	East	North	East
Distance (m)						
Block	4.32	4.91	3.00	3.27	2.48	7.02
CLC	5.11	5.25	3.28	3.73	2.60	7.51
Advantage of CLC over block (%)	18	7	9	14	5	7

Note: N = 50.

Table 4. Intercorrelations among acuity tests and guide-sign elements.

Variable	2	3	4	5	6	7	8	9	10	11	12	13
1	0.75	0.78	0.69	0.70	0.72	0.74	0.72	0.70	0.68	0.51	0.67	0.57
2		0.95	0.50	0.57	0.56	0.62	0.49	0.46	0.51	0.44	0.53	0.61
3			0.55	0.65	0.60	0.70	0.52	0.53	0.53	0.46	0.56	0.63
4				0.92	1.00	0.88	0.86	0.81	0.89	0.81	0.91	0.74
5					0.92	0.97	0.83	0.78	0.86	0.78	0.81	0.75
6						0.90	0.86	0.80	0.89	0.83	0.91	0.77
7							0.82	0.79	0.86	0.80	0.81	0.76
8								0.93	0.88	0.71	0.86	0.71
9									0.83	0.69	0.85	0.66
10										0.77	0.86	0.74
11											0.82	0.84
12												0.75

Notes: N = 50.
1 = Snellen E test, 2 = block-letter cardinal-direction chart, 3 = CLC cardinal-direction chart, 4 = "EXIT" legibility distance, 5 = "17" legibility distance, 6 = "North" legibility distance, 7 = "East" legibility distance, 8 = "270" legibility distance, 9 = "495" legibility distance, 10 = "Barstow" legibility distance, 11 = "Clearwater" legibility distance, 12 = "2" legibility distance, and 13 = "MILES" legibility distance.

Table 5. Principal intercorrelations and averages of intercorrelations.

Intercorrelation of Variables	Correlation	Implied Comparison
1 with 2	0.75	Acuity tests among themselves
1 with 3	0.78	
2 with 3	0.95	
Average		
1 with 4-13	0.670	Acuity tests versus sign elements
2 with 4-13	0.529	
3 with 4-13	0.573	
4 with 5-13	0.869	Guide-sign elements among themselves
5 with 4-13	0.847	
6 with 4-13	0.876	
7 with 4-13	0.846	
8 with 4-13	0.829	
9 with 4-13	0.793	
10 with 4-13	0.842	
11 with 4-13	0.783	
12 with 4-13	0.842	

intelligence were not included in these tests. If such persons were involved, they would be expected to have particular difficulty in comprehending the sign elements.

Walk-To Method of Testing Sign Legibility

The walk-to method of testing sign legibility was successfully used in this study. However, the testing positions become crowded at distances close to the charts. Position 2 was only 0.217 m (8.5 in) farther from the chart than position 1, which was itself only 1.08 m (3.5 ft) from the chart. At these close distances, it becomes difficult to precisely position a subject. Results are affected by slight forward leanings and swayings. It is recommended that testing be done at greater distances. Words with letter heights of 0.88 cm (0.348 in) are read by persons with 20/20 normal vision at about 6.1 m (20 ft). Persons with better than normal vision could read words with this letter height at distances ranging up to 12.2 m (40 ft) or more. These considerations imply that signs with a minimum letter height of 0.85 cm (0.33 in) would be satisfactory in this type of legibility testing.

Sign messages graded in size, such as those used on the Snellen charts, might also be used in legibility testing. However, it is not easy to reproduce the signs in a graded size series adjusted to testing a subject group. For most legibility investigations, the walk-to method of varying visual angle offers a most convenient and effective test method.

SUMMARY

This study was concerned with the legibility of information displayed on highway guide signs, and particularly cardinal-direction indications (North, South, East, West). The work was carried out in the FHWA vision testing alley by using scaled-down replicas of highway signs. A Snellen E chart was also included in the testing as a check on visual acuity. The test subjects attempted to read the signs at successively decreasing distances until all elements were correctly interpreted. The data obtained in the experiments support the following conclusions:

1. In contrast to what was assumed at the start of the study, the cardinal-direction indications demonstrated satisfactory legibility. They could be identified at a greater distance than any of the sign elements except the message "NEXT RIGHT".
2. CLC cardinal-direction indications were seen 10 percent farther away than conventional block letters on the sign replicas. The use of CLC lettering can increase element legibility without requiring appreciably more sign space.
3. Of the guide-sign elements tested, route numbers had the poorest legibility. They were identified at 10.1 percent shorter distance than place names.
4. The analysis of test intercorrelations indicated that abilities other than visual acuity are involved in reading guide signs. The guide-sign elements intercorrelated more highly among themselves than they did with the acuity test. The possibility of including sign-reading acuity tests in driver-licensing examinations should be considered.
5. The study supports the feasibility of using small-scale replicas in performing research on sign legibility. A minimum letter height of 0.85 cm (0.33 in) is recommended to achieve adequate subject testing distance.

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