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Effects of Font and Capitalization on Legibility of Guide Signs

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The research objective was to improve highway guide sign legibility by replacing the 40-year-old guide sign font with a new font called Clearview. It was believed that the current guide sign font's thick stroke design, made with high-brightness materials and displayed to older vehicle operators, exhibited a phenomenon known as irradiation or halation. Irradiation becomes a problem if a stroke is so bright that it visually bleeds into the character's open spaces, creating a blobbing effect that reduces legibility. The Clearview font's wider open spaces allow irradiation without decreasing the distance at which the alphabet is legible. Results are presented of two daytime and two nighttime controlled field experiments that exposed 48 older drivers to high-brightness guide signs displaying either the current or the Clearview font. The Clearview font allowed nighttime recognition distances 16 percent greater than those allowed by the Standard Highway Series E(M) font, without increasing overall sign dimensions.

The goal of this study was to identify ways to improve legibility and recognition of legends on conventional road guide signs, with consideration for night vision, high-brightness sign materials, and aging drivers, by replacing the 40-year-old guide sign font with a new font called Clearview. The rationale for the research was twofold. First, a widely accepted notion is that the thick stroke of the current highway guide sign font, rendered in high-brightness materials, exhibits a phenomenon known as irradiation or halation (*1*). Irradiation becomes a problem if a stroke is so bright that it usually bleeds into the character's open spaces, creating a blobbing effect that reduces character legibility. The Clearview font's wider open spaces allow irradiation without decreasing the distance at which the alphabet is legible (Figure 1). Second, it was thought that there was a need to revisit the notion that the use of properly sized mixed-case legends, instead of all-capital displays, for destination names on conventional road guide signs would improve driver recognition of destination names through word patterning (*2*).

FONT DEVELOPMENT

The Clearview font was developed by Meeker & Associates, Inc., a graphics design firm, and tested by the Pennsylvania Transportation Institute (PTI) at Pennsylvania State University. For purposes of this research, the font was required to have some relationship to the two existing federal typefaces that were being compared [Standard Highway Series E(M) and Standard Highway Series D]. To that end, the new typeface was designed in regular and condensed version. These versions, subsequently named Clearview and Clearview Condensed, incorporate the desirable attributes of a group of typefaces studied by Meeker & Associates but retain the visual proportions of the existing FHWA typefaces. Initial versions of the fonts were improved and recreated numerous times. Formal comparisons of various early renditions of the fonts were made through subjective field evaluation, objective tests of the typefaces' degradability, and objective laboratory studies that used computer simulation. These comparisons resulted in the final versions of Clearview and Clearview Condensed that were used in the two objective field evaluations of this study. A detailed account of the font's development and subsequent laboratory and additional field testing was reported elsewhere.

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UPPERCASE VERSUS MIXED CASE

Forbes et al. (*2*) conducted what are perhaps the definitive studies of the difference in legibility between text depicted in all uppercase letters and that depicted in lowercase with initial capital letters. When upper- and mixed-case words occupied the same sign area, Forbes and his colleagues found a significant improvement in reading distance with the mixed-case words. It must be understood, however, that these results were obtained with a recognition task. That is, the observers knew what words they were looking for. In instances in which the text is not known to the observer, improvements with mixed-case words are not evident (*1*,*2*). Although mixed-case superiority is fairly well accepted in the traffic engineering community [Markowitz et al. (*4*) provided specific information suggesting the use of mixed-case lettering for conventional road guide signs in 1968], conventional road guide signs still are being created with all uppercase letters.

STUDY 1: EFFECT OF FONT, CASE, AND REFLECTIVE SHEETING ON WORD RECOGNITION

Objective and Methodology

The objective of this study was to compare the recognition distances of words displayed in the mixed-case Clearview font with the Standard Highway Series D all-uppercase font and the mixed-case Standard Highway Series E(M) font, by using older vehicle operators under daytime and nighttime viewing conditions. The effect of sheeting material on the recognition distance of words displayed in Clearview and Standard Highway fonts also was evaluated.

Subjects

Two groups of 12 subjects age 65 and older were recruited for the nighttime and daytime portions of this study. All subjects were

FIGURE 1 Clearview font development.

FIGURE 2 Sign area as a function of font.

required to have a valid Pennsylvania driver's license. Subjects were vision tested before participating; the results are shown in Table 1.

Variables

The dependent variable was threshold distance for word recognition. The subjects were to find a target word on a sign containing three words. The operational definition of *threshold* was the furthest distance at which a subject could correctly identify the target word's location on the sign: top, middle, or bottom. A word recognition task, as opposed to a pure legibility task, was used to better represent what the researchers believed to be true field performance. The premise was that most people know the name of the town or street for which they are looking and have a mental picture of the word when they attempt to read a guide sign.

Because of the increased "openness" of the Clearview characters, the font's intercharacter spacing is smaller than that of Standard Highway (Figure 2). Clearview spacing results in words that take up 12 percent less sign space than do the Standard Highway fonts. A 12 percent increase in Clearview character height produces words equal in sign space to those shown in the Standard Highway fonts. This study included Clearview fonts matched in letter height with Standard Highway and Clearview fonts matched in overall sign size with Standard Highway. The resulting fonts are called *Clearview* (or *Clearview Condensed*) *at 100 percent* (of Standard Highway letter height) and *Clearview* (or *Clearview Condensed*) *at 112 percent* (of Standard Highway letter height), respectively. Specifically, the fonts tested were Clearview Condensed at 100 percent (mixed case), Clearview Condensed at 112 percent (mixed case), Standard Highway Series E(M) (mixed case), Standard Highway Series D (all uppercase), Clearview at 100 percent (mixed case), and Clearview at 112 percent (mixed case). The sheeting materials tested were encapsulated lens (ASTM Type III; $R_A = 250$ cd/lx/m^2) and microprismatic sheeting designed for short-distance brightness ($R_A = 430$ cd/lx/m$_2$).

TABLE 1 Mean Study 1 Vision Test Scores

Subjects	Age	Acuity	CS[a]	CS[b]
Daytime	70.9	20/25	50, 97, 75, 30, 7	1.84
Nighttime	74.8	20/27.5	58, 110, 100, 38, 15	1.77

[a]Vistech wall chart
[b]Pelli-Robson

Site and Apparatus

The test site was the PTI Bus Research and Testing Facility. Data were collected on a tangent section of the track 3.7 m (12 ft) wide and 305 m (1,000 ft) long, which had been surveyed and marked with edge and centerlines. The left side of this "travel lane" was marked every 7.6 m (25 ft). The observation vehicle was a 1993 Ford Probe with a five-person maximum occupancy. The headlamps were aligned before nighttime testing.

Two 1.2 m^2 (4 ft^2) aluminum sign panels were created; white encapsulated lens material was applied to one and microprismatic sheeting was applied to the other. A translucent green sheeting was applied to both panels to create a standard highway guide sign appearance. The two sign panels were mounted on either side of a flat wooden frame. The wooden frame was slid onto a pole that was screwed to a flange mounted on the platform of a hand truck (Figure 3). A set of 64 white-on-green word panels was created for display on the two sign panels. Clear plastic mirror brackets were bolted to the two sign panels. These brackets were used to mount the word panels (Figure 4).

On the word panels, the Series D letter height was 12.7 cm (5 in.), and the Series E(M) had a capital letter height of 12.7 cm with a 9.9-cm (3.9-in.) lowercase loop height, as specified in *Standard Alphabets for Highway Signs* (5). The Clearview and Clearview Condensed uppercase letter heights also were 12.7 cm and Clearview had a lowercase loop height of 9.9 cm. Clearview and Clearview Condensed at 112 percent had uppercase letter heights of 12.4 cm (5.6 in.) and Clearview at 112 percent had a lowercase loop height of 11.2 cm (4.4 in.).

Six test words were used in this study: Purcel, Dorset, Conyer, Bergen, Ordway, and Gurley. Three word-selection criteria were used. The first was similarity of word length, used to avert word recognition based on word length only. The second was similarity of

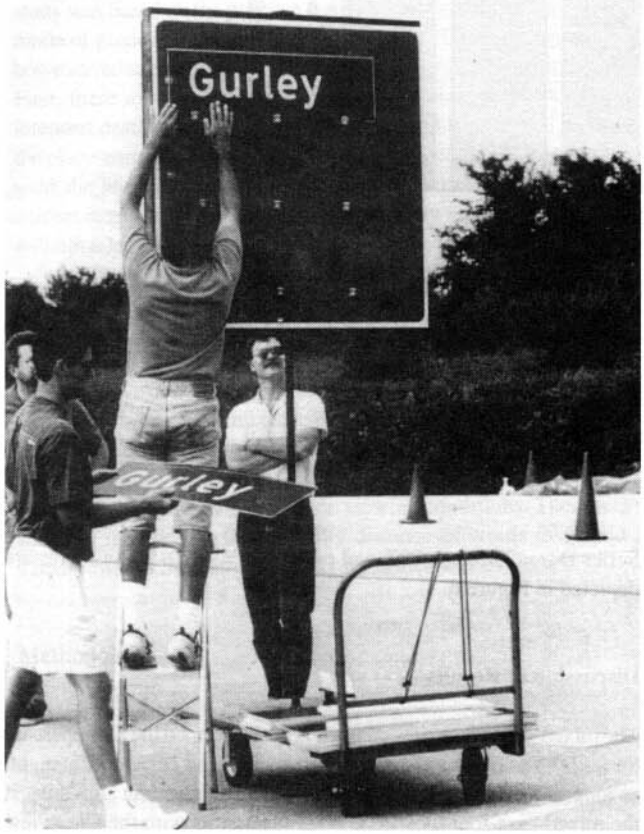

FIGURE 3 Experimental sign apparatus and stimuli.

initial letter; that is, all words began with a rounded letter form. The third criterion was dissimilarity of global word shape or "footprint"; Purcel and Dorset have ascenders at the end, Conyer and Bergen have descenders in the middle, and Ordway and Gurley have ascenders in the middle and descenders at the end. Words with similar initial letters were selected to avoid word recognition based solely on initial letter recognition. Words with dissimilar footprints were selected to allow global word shape to affect word recognition distance.

FIGURE 4 Sign panel for recognition task.

Procedure

Each subject was tested individually. A repeated-measures experimental design was used in which all subjects viewed all 12 experimental conditions (i.e., six fonts and two materials). The subject was located in the front passenger seat and an experimenter was in the driver's seat. At night, low-beam headlamps were used.

The observation vehicle was driven to the 305-m mark upstream of the sign and parked in the center of the 3.7-m-wide travel lane. The hand truck was placed 1.8 m (6 ft) outside the right edge line and the sign was raised to 1.8 m as measured from the bottom of the sign to the pavement. This arrangement resulted in a sign with a lateral offset of 3.7 m to the right of the center of the observation vehicle.

Each sign panel contained three place-names. Before each sign was presented, the experimenter read aloud a place-name for the subject to find. With the observation vehicle parked at 305 m, the sign was presented and the subject attempted to find the target word. The experimenter then drove the vehicle toward the sign at approximately 16 kph (10 mph) until the subject correctly stated the target word position: top, middle, or bottom. When the subject correctly located the target word, the experimenter stopped the vehicle and recorded the threshold distance. The car was turned around and driven back to the 305-m mark. The second sign was then displayed and the procedure was repeated. This procedure was in turn repeated until a threshold for each of the 12 signs was established.

The subjects were divided into two groups. To avoid the possible confounding effects of fatigue or learning, the font presentation order was counterbalanced across the two groups. To counter the possibility that word position could affect recognition distance, the target word for one-third of the subjects from each group was located in the top position, for one-third, in the middle position, and for one-third, in the bottom position. To control potential word superiority effects (where some words are inherently more recognizable than others), all six words were tested in each of the font-by-material conditions across the two subject groups.

Analyses and Results

Daytime

Material A repeated measures analysis of variance (ANOVA) showed no significant main effect of material ($F = .85$, $p = .376$) and no significant interaction between material and font ($F = .86$, $p = .515$).

Font A highly significant font main effect was evidenced ($F = 7.58$, $p < .001$). The data were collapsed across material and the font effect was further probed with paired sample t-tests. There were no significant differences between either the Clearview or Clearview at 112 percent and the Series E(M) fonts. Comparisons between the Clearview and Clearview Condensed at 112 percent versus Series D, however, showed that the mixed-case fonts produced significantly longer recognition distances than the all-uppercase Standard Highway font ($t = 2.29$, $p = .022$, and $t = 3.14$, $p = .005$). Mean scores are depicted in Figure 5.

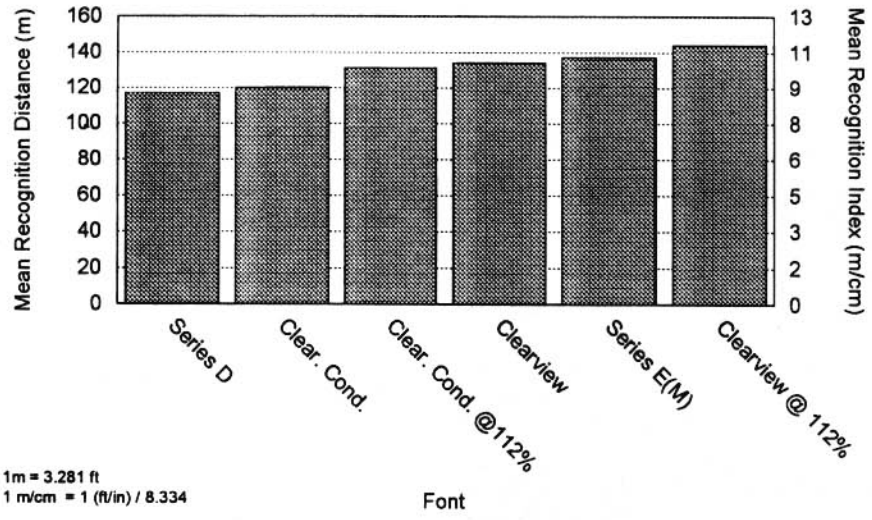

FIGURE 5 Daytime Study 1: font recognition distance.

Nighttime

Material A repeated measures ANOVA showed no significant main effect of material ($F = .26$, $p = .621$) and no significant interaction between material and font ($F = 1.29$, $p = .283$).

Font A repeated measures ANOVA revealed a significant font main effect ($F = 9.07$, $p < .001$). The data again were collapsed across material and t-tests for select paired samples were conducted to determine differences between font mean scores. Although the Clearview font at 100 percent did not result in a significant improvement over Series E(M), the Clearview font at 112 percent had significantly greater recognition distance than the E(M) ($t = 2.88$, $p = .008$). The mixed-case Clearview and Clearview Condensed at 112 percent again significantly outperformed the all-uppercase Series D ($t = 2.93$, $p = .007$, and $t = 2.44$, $p = .017$). Mean scores are depicted in Figure 6.

Discussion of Results

The mixed-case Clearview characters outperformed the all-uppercase Series D by as much as 14 percent in daytime and 16 percent at night, as long as the mixed-case font subtended an equivalent sign area. If the mixed-case font took up less sign space, as with the Clearview Condensed at 100 percent, there was no difference between mixed-case and all-uppercase characters. During daytime testing there was no difference between Series E(M) and any comparably sized Clearview font (i.e., Clearview and Clearview at 112 percent). At night, however, with both high-brightness materials, the Clearview font at 112 percent outperformed the Series E(M) by 16 percent.

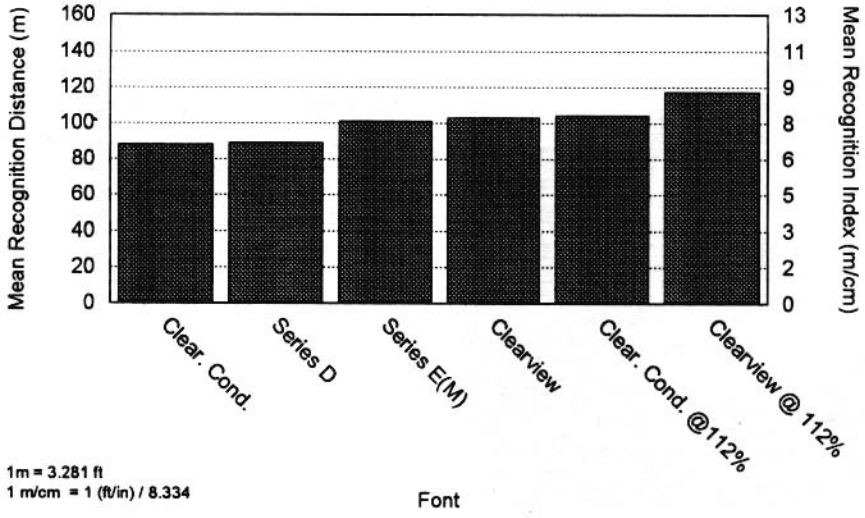

FIGURE 6 Nighttime Study 1: font recognition distance.

STUDY 2: EFFECT OF FONT AND REFLECTIVE SHEETING ON WORD LEGIBILITY

Word recognition as the measure of effectiveness in the previous study was based on the premise that word recognition is the dominant mode of guide sign reading in the real world. There are two reasons, however, to supplement the recognition data with pure legibility data. First, there may be situations in which travelers do not know their intended destinations, or at least do not have a firm mental picture of the place-names. Second, a great deal of sign readability literature has used the legibility paradigm; therefore, a direct comparison of the current research with the bulk of the literature would not be possible without a legibility component.

Objective

The objective of this study was to compare the legibility distances of words displayed in the mixed-case Clearview font with the Standard Highway Series D all-uppercase font and the mixed-case Standard Highway Series E(M) font, by using a sample of older vehicle operators under daytime and nighttime viewing conditions. The effect of sheeting material on the legibility distance of words displayed in Clearview and Standard Highway fonts also was evaluated.

Methodology

Subjects

Two groups of 12 subjects age 65 and older were recruited. One group was used in the nighttime portion of the study and one was used in the daytime portion. All subjects were required to have a valid Pennsylvania driver's license. No subjects participated in both Study 1 and Study 2. Subjects were vision tested after participating in the field research; the vision test scores are shown in Table 2.

Variables

The dependent variable was threshold distance for word legibility. The subjects were to read a word on a sign containing only one word. The operational definition of *threshold* was the furthest distance at which a subject was able to read the word correctly. The fonts and retroreflective materials tested (independent variables) were the same as described in the previous recognition study.

Site and Apparatus

The test site, signs, word panels, and test vehicle were identical to those described in the previous study, except that the signs in this study were shown with a single word placed in the middle position on the sign.

TABLE 2 Mean Study 2 Vision Test Scores

Subjects	Age	Acuity	CS[a]	CS[b]
Daytime	71.3	20/26	70, 105, 99, 41, 11	1.9
Nighttime	73.9	20/25	53, 122, 58, 20, 7	1.8

[a]Vistech wall chart
[b]Pelli-Robson

Procedure

The procedure was the same as for the previous study except that the subjects were required to read a single word mounted in the middle of the sign. The subjects were not told what word would be on the sign. When the subject read the word correctly, the experimenter stopped the vehicle and read and recorded the threshold distance. This procedure was repeated until thresholds for all 12 signs were established. The same experimental techniques used to avoid biasing the results of the previous study were used in this study.

Analyses and Results

Daytime

Material A repeated measures ANOVA revealed a marginally significant main effect of material ($F = 4.96$, $p = .048$) created by a 4 percent improvement in legibility distance with the microprismatic sheeting. There was no significant interaction between material and font.

Font An ANOVA showed a significant font main effect ($F = 7.10$, $p < .001$). Because there was no material by font interaction, the data were collapsed across material and the results were probed with one-tailed t-tests for paired samples. As in the previous daytime study, there were no significant differences in daytime legibility between Series E(M) and comparably sized Clearview fonts (Clearview and Clearview at 112 percent). Unlike in the previous study, however, there also were no differences between the all-uppercase Series D font and comparably sized mixed-case Clearview fonts (Clearview and Clearview Condensed at 112 percent). The all-uppercase Series D significantly outperformed the Clearview Condensed font at 100 percent ($t = 4.22$, $p < .001$). The daytime results of this study are shown in Figure 7.

Nighttime

Material A repeated measures ANOVA showed no significant material main effect ($F = 1.95$, $p = .19$). A significant material by font interaction ($F = 2.93$, $p = .02$), however, did surface.

Font By using ANOVA techniques, a significant font main effect was found ($F = 7.10$, $p < .001$). Because there was an interaction between font and material, separate single factor ANOVAs were run on the data from the two material conditions. The microprismatic sheeting showed no significant font main effect ($F = 1.03$, $p = .409$). The encapsulated lens sheeting ANOVA, however, showed a significant font effect with this material ($F = 5.29$, $p < .001$). Paired sample t-tests were used to determine where the font differences lay. One finding was that the Clearview font at 112 percent significantly outperformed the Series E(M) font ($t = 2.10$, $p = .03$), by 22 percent. As in the daytime portion of this study, there were no differences between the all-uppercase Series D

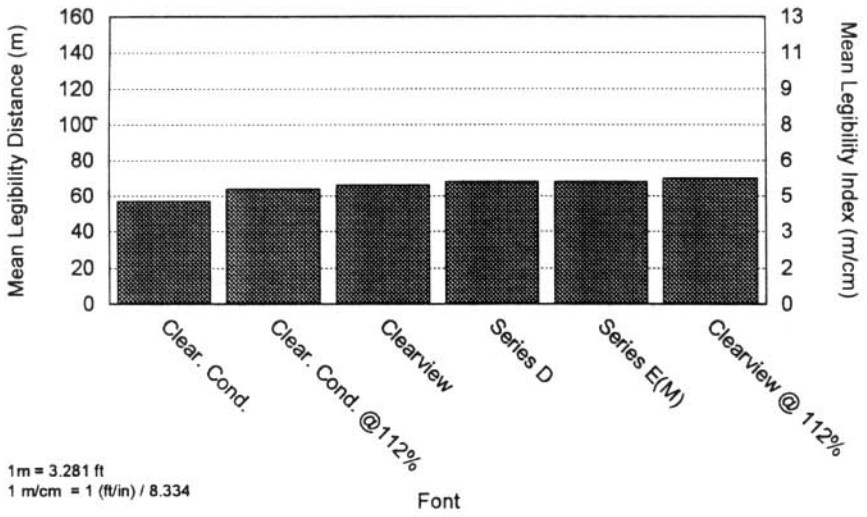

FIGURE 7 Daytime Study 2: font legibility distance.

font and comparably sized mixed-case Clearview fonts (Clearview and Clearview Condensed at 112 percent). The all-uppercase Series D significantly outperformed the Clearview Condensed font at 100 percent ($t = 5.38$, $p < .001$) under nighttime conditions. The results of these analyses are depicted in Figure 8.

Discussion of Results

A dramatic overall lowering of legibility index (LI) was found in the legibility study compared with the recognition study. LIs of about 9 m/cm (75 ft/in.) of letter height found with the recognition task fell to about 4.8 m/cm (40 ft/in.) in the legibility study. The subjects were almost twice as successful in recognizing expected words than in reading unknown words.

Although only the encapsulated lens sheeting showed statistically significant font results (22 percent), the microprismatic sheeting showed the same trend, with Clearview resulting in 11 percent longer legibility distance than Series E(M).

The lack of significant results in the mixed-case versus all-uppercase analyses in the legibility study was expected. The results are consistent with earlier work by Forbes et al. (2), who also found significant improvements with mixed case in a recognition task but not in a legibility task. Furthermore, given the size difference between Series D and Clearview Condensed at 100 percent it again would be expected that Series D would be superior with a pure legibility task because this task is tantamount to a large-scale acuity test.

CONCLUSIONS

Mixed Case Versus All Uppercase

In the legibility task, in which individual letter reading is required, the larger letters used with the all-uppercase Series D font resulted in greater legibility distances than did the smaller mixed-case Clearview Condensed font; however, when the mixed-case font was increased in size to take up the same sign area as the Series D font,

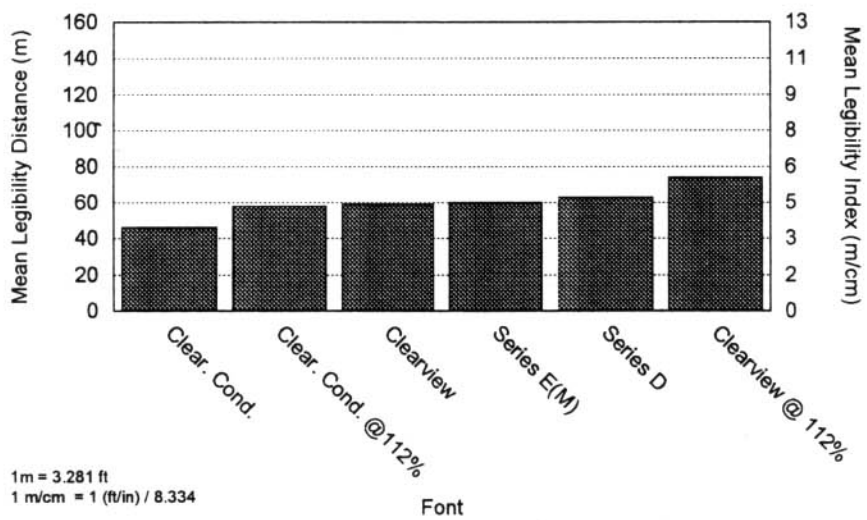

FIGURE 8 Nighttime Study 2: font legibility distance.

performance between the mixed-case and all-uppercase words was the same.

In the recognition task, the two mixed-case fonts that matched Series D in sign area performed significantly better than all-uppercase font. Even the version of Clearview Condensed that took up much less sign space performed as well as the Series D all-uppercase font. There are two likely reasons for the mixed case superiority in the recognition task. First, when viewed from far away, all-uppercase characters look like fuzzy rectangles whereas words in mixed case, with ascenders and descenders, have a distinct shape or footprint. Second, mental images of place-names (indeed, of all proper nouns) are likely to be in mixed case, making it an easier cognitive task to make a match with mixed-case sign copy than with words depicted in all-uppercase letters.

Guide signs probably are read by using both legibility and recognition criteria, depending on the specific needs of the traveler. The studies reported here indicate that if the size of mixed-case words is matched to the size of words depicted in all-uppercase letters (a cost-effectiveness measure), mixed case provides equivalent reading distance in a legibility task and superior reading distance in a recognition task. It is, therefore, the conclusion of this report that mixed-case words should be recommended for use not just on highway guide signs but on all guide signs, including conventional road and street name signs.

Clearview Versus Series E(M)

Under daytime conditions, there was no difference in either word legibility or recognition distance between the Series E(M) and either of the two comparably sized Clearview fonts. At night, however, with brightness sign materials, the Clearview font produced substantially longer reading distances. In both the legibility and the recognition tasks, the Clearview fonts that took up the same amount of sign space as did the Series E(M) resulted in significantly longer nighttime reading distances, and the version of Clearview that took up less sign space than did Series E(M) performed as well as the Series E(M).

Although the 12.7-cm letter height used in this research reflects the performance of the Clearview font on signs comparable to conventional road guide signs and street name signs, additional research is underway to evaluate this new font on freeway signs. Although the results of the initial effort to systematically improve the nighttime readability of guide signs reported here are extremely promising, further evaluation and validation of the Clearview font is necessary before blanket recommendations to replace the existing fonts can be made.

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