The Legibility of the Clearview Typeface and Standard Highway Alphabets on Negative and Positive Contrast Signs

Philip M. Garvey (Corresponding Author)
The Larson Institute at Penn State
201 Transportation Research Building, University Park, PA 16802
Telephone: (814) 574-0803 | Facsimile: 814-863-3707 | email: pmg4@psu.edu

M. Jennifer Klena
Penn State
Agricultural Engineering Building
University Park, PA 16802
Telephone: (814) 574-2294 | email: mjd229@psu.edu

Wei-Yin Eie
The Larson Institute at Penn State
201 Transportation Research Building, University Park, PA 16802
Telephone: (814) 777-5314 | Facsimile: 814-863-3707 | email: wue108@psu.edu

Donald T. Meeker
Meeker and Associates
56 Sherwood Drive, Larchmont, NY 10538
Telephone: (914) 834-1904 | email: dtmeeker@meekerdesigns.com

Martin T. Pietrucha
The Larson Institute at Penn State
201 Transportation Research Building, University Park, PA 16802
Telephone: (814) 863-7306 | Facsimile: 814-863-3707 | email: mtp@psu.edu

Total Number of Words: 4,794
Total Number of Figures: 6
Total Number of Tables: 1
Total: 6,544
Abstract

The main objective of this research was to compare the legibility distance of the negative-contrast Clearview Typeface System with that of comparable Standard Highway Alphabets on black-on-white signs in the daytime and nighttime for older and younger motorists. Mixed-case Clearview (2-B, 3-B, and 4-B) was compared to both mixed and all-uppercase Standard Highway Alphabets (Series C, D, and E). In addition, the researchers evaluated the effects of letter height on the legibility distance of mixed-case Clearview. A small set of positive contrast white-on-green signs were displayed as well, comparing Clearview Typefaces 2-W, 3-W, and 4-W with Standard Highway Alphabet Series C, D, and E, all in mixed-case. Overall, Clearview negative contrast in mixed case performed as well as Standard Highway all uppercase (even though it took up less sign space), and better than Standard Highway mixed-case. This was true in both daytime and nighttime. Overall, Clearview positive contrast (white on green) outperformed the comparable Standard Highway Alphabets. In addition, a survey of U.S. State Departments of Transportation current use of Clearview in positive contrast and potential use of Clearview in negative contrast is discussed.
OBJECTIVE

The objective of this research was to compare the legibility distance of the negative-contrast (i.e., darker letters on a lighter background) Clearview Typeface System with that of comparable Standard Highway Alphabets on black-on-white signs in the daytime and nighttime for older and younger motorists. Mixed-case Clearview 2-B, 3-B, and 4-B were compared to both mixed and all-uppercase Standard Highway Alphabets Series C, D, and E. (Mixed-case words have an initial capital letter followed by all lower-case letters. All-uppercase words are the standard condition of negative-contrast regulatory, warning, and work zone signs.) The three Standard Highway Alphabets were selected as they are the most commonly found typefaces in negative-contrast applications, many being safety-critical messages.

As a reference base to earlier research that found Clearview positive contrast to perform better than Standard Highway Alphabets (e.g., 1) and to recent research (2), which did not find significant improvements with Clearview over Standard Highway, a small set of white-on-green shoulder mounted signs were reviewed as well. These compared Clearview 2-W, 3-W, and 4-W with Standard Highway Alphabet Series C, D, and E; all of these positive contrast signs were in mixed-case.

Furthermore, a survey of U.S. State Departments of Transportation was conducted to determine the current use of Clearview in positive contrast and the potential use of Clearview in negative contrast.

BACKGROUND

The development of the Clearview typeface began in response to a Federal Highway Administration (FHWA) study that recommended a 20-percent increase in sign letter height to provide greater reading distances for aging drivers (3). This 20-percent letter height increase would result in an approximately 50-percent increase in sign area. The original Clearview studies, however, showed that it was possible to obtain significant improvements in guide sign reading distances for older drivers without increasing sign size by using mixed-case Clearview typefaces in place of all-uppercase Standard Highway Alphabets in studies that included both legibility and ease of recognition (1). Furthermore, the positive contrast mixed-case Clearview typefaces were found to be significantly more readable than the mixed-case Standard Highway Series E(M) in several independent studies (1; 4; 5; and 6, see also 7), particularly in recognition tasks at night with poor-vision drivers. This body of research led to the FHWA’s 2004 interim approval of Clearview on positive-contrast guide signs. To date, 26 state departments of transportation (DOTs) have been granted interim approval to use the Clearview Typeface (8).

Clearview was specifically designed to improve guide sign readability at night for older drivers when used with high-brightness sign materials, by creating letter forms designed for viewing at a distance, enhancing word pattern recognition, and by crafting the letters to reduce or eliminate the negative effects of halation and overglow. However, the Clearview Typeface System also includes negative-contrast versions for use on regulatory and warning signs. The difference between negative and positive contrast versions of Clearview are limited to stroke width, with negative contrast being heavier, to counterbalance the halation effect of the lighter background when viewed at a distance with high-brightness retroreflective materials. While the research discussed above led to the development of guidelines and approval for the use of Clearview in positive contrast, research results using negative-contrast Clearview have been limited to a single study, the results of which were less encouraging (9).
In 2002, the final Clearview positive-contrast design was shown to representatives from the FHWA Office of Highway Safety at Penn State’s Larson Transportation Institute test track. At that meeting and in subsequent conversations that coincided with the 2004 interim approval, the design team was encouraged to extend the research to Clearview in negative contrast. The present study is the first of a series designed by researchers at the Larson Institute to accomplish that early request from FHWA.

INTERVIEWS WITH STATE AND LOCAL DEPARTMENTS OF TRANSPORTATION

The research team conducted an electronic survey, with follow-up telephone interviews when necessary, of state and local DOT use of the Clearview typeface. The questionnaire determined whether or not the agency used the Clearview typeface, how long they have used it, for what applications, and any positive or negative experiences they have had. Agencies that have elected not to use positive-contrast Clearview were asked to explain this decision and all agencies were asked if they would use negative contrast Clearview if it were approved.

Results

All fifty states were contacted and 32 states responded, a response rate of 64 percent. While it is impossible to determine the exact extent and nature of Clearview’s use based on this survey alone, or even when supplemented with the list of approved states provided by FHWA (8), the following summary gives an informative indication of the state-of-practice.

Does your agency use the Clearview typeface on its highway signs?

- Yes 20  63-percent
- No 12  37-percent

In summary, most of those who are using Clearview have a blanket jurisdiction approval for positive-contrast signs and are using them as guide signs. Most experiences have been favorable and what feedback has been received has been generally positive and includes improved legibility and public approval. Negative responses include: problems with Clearview numbers and fractions; some necessary sign size increases; and, though Clearview is compatible with most operating systems and CAD programs, some states reported software issues.

Those states not using Clearview chose not to because of the following reasons: cost of the software; because it was not upgraded beyond Interim Approval status in the 2009 MUTCD; the potential benefits did not justify making the change; sign size would need to be increased, often causing the state to replace the sign; and the proprietary nature of the Clearview font.

If Clearview were approved for negative contrast applications (that is, regulatory, warning, and construction signs), would your agency be inclined to use it on these signs?

- Yes 10  31-percent
- No 4  12.5-percent
- Don't Know 14  44-percent
- No Response 4  12.5-percent

TRB 2016 Annual Meeting  Paper revised from original submittal.
The ten states that answered positively, said that they would evaluate the research and would be inclined to use it if it had been established by the research to be more legible and if it was supported by the FHWA and used nationwide. The five states that said they would not use it based their responses on the current research and stated that they were not convinced of its effectiveness in negative-contrast applications. The following test-track human factors study was designed to address the lack of research on Clearview negative contrast.

**TYPEFACE LEGIBILITY**

**Objective**

Using a procedure that was previously developed, tested, and replicated at the Larson Institute at Penn State for similar studies (e.g., 1), the legibility distances of three weights of mixed-case, negative-contrast Clearview were compared to three comparable weights of the FHWA Standard Highway Alphabets Series in all uppercase and to three mixed-case companion weights of the Standard Highway Alphabets. These signs were white with black legends and border. Several white-on-green signs were also displayed in the Clearview Typeface and Standard Highway Alphabets (Figure 1). (For a full description of the characteristics of the FHWA typefaces see (10), for a full description of the Clearview Typeface, please see (11) or Clearviewhwy.com.)
FIGURE 1 Stimuli used in the research study
Method

Overview

Whereas reading a guide sign is primarily a recognition task (e.g., a viewer looking for “Richmond” couples his mental image [or footprint] of the word with the legend on the sign and so differentiates it from “Washington”), this is not the case with regulatory signs, where motorists must often read each sign completely without knowledge of its content before processing the specific command (this is known as a legibility task). For over 60 years, research has shown that using mixed-case words can improve recognition distance (11). The present study evaluated whether the use of mixed-case Clearview could improve legibility distance over all-uppercase and mixed-case Standard Highway Alphabets on regulatory-type signs.

Subjects

One hundred and fourteen subjects (Table 1) were paid $50.00 each to participate in one-hour test sessions. All subjects held valid drivers’ licenses, and their visual acuity was measured using a standardized test (GOOD-LITE Co. light box using Sloan Letters at 10 feet).

TABLE 1 Classification of Participants

<table>
<thead>
<tr>
<th></th>
<th>Daytime</th>
<th>Nighttime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Younger Drivers (18-34)</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Middle Age Drivers (35-64)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Older Drivers (65+)</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Total (114 participants)</td>
<td>31</td>
<td>30</td>
</tr>
</tbody>
</table>

Site and Apparatus

The test site was a straight, flat section of the Larson Institute’s test track (Figure 2). The signs were mounted on a series of signposts placed 200 feet apart. This allowed multiple signs to be tested with each subject pass. As per MUTCD recommendations for comparable highway signs, the test signs were mounted at a height of 7 feet from the road surface with a lateral offset of 2 feet to the right of the edgeline. The observation vehicle was a 2006 Dodge Stratus.

The signs were based on a 6-inch capital letter height with panel heights and widths that allowed adequate space around the test words. Clearview signs used mixed-case lettering while Standard Highway Alphabets used either all-uppercase or mixed-case letters. Each of the Clearview weights was also reduced in size by 20 percent (from 6.0-inch capital letter height to 4.8-inch height) to evaluate smaller versions of the Clearview typeface versus larger Standard Highway Alphabet signs.

The sign panels were displayed with high-intensity prismatic retroreflective white background sheeting and black non-reflective letters and borders. Additional white-on-green guide signs were displayed in the Clearview Typeface using high-intensity white sheeting and a green transparent overlay.
Eighteen words were selected to evaluate the negative-contrast application in this study: Forgan, Lompoc, Helena, Fulton, Dunnel, Luning, Dorsey, Harney, Larned, Frazee, Harper, Lowery, Hosper, Dupree, Lavaca, Borger, Linsey, Dassell. This set of 18 words was used successfully in developing and evaluating NPS Roadway, the U.S. National Park Service’s new guide sign font (13). Six additional words were selected to evaluate the positive-contrast applications: Purcel, Dorset, Conyer, Bergen, Ordway, and Gurley. These were the words used in the original development and testing of the Clearview Typeface (1). The words were designed to be emotionally neutral, easy to read, and contain lower case letters with ascenders and descenders, but without being commonly known.

With the exception of the use of black legend and white backgrounds and border, the negative contrast test signs were not intended to replicate the design of standard regulatory signs. They were designed specifically to evaluate the threshold distances at which motorists could read short words in the various typefaces and thereby determine whether negative-contrast Clearview could provide improvements in legibility over the Standard Highway Alphabets.

**Procedure**

The subjects drove the vehicle with an experimenter in the front passenger seat. At night, low-beam headlamps were used. The vehicle was parked in the center of the travel lane around a horizontal curve in the test track upstream of the signs, such that the participants were not able to see the signs prior to the test. Each subject drove the vehicle at 15 mph toward the first sign until he or she read it correctly. Using the Microdynamics DOT-Z1 distance-measuring instrument, the experimenter recorded that distance as the legibility threshold for that sign condition. The subject continued driving and the experimenter asked him or her to read the next sign. This was repeated until all signs were evaluated.
Variables

The dependent variable was legibility distance threshold, defined as the maximum distance at which a subject was able to correctly read the signs.

The independent variables were typeface (Clearview 2, 3, and 4 and Standard Highway Alphabets C, D, and E), case (mixed-case and all uppercase), time-of-day (daytime and nighttime), letter height (6.0 inches and 4.8 inches), and subject age group (young, middle, old). There were 12 negative-contrast typeface/spacing/letter height conditions and 9 positive-contrast conditions (Figure 1).

To control for learning and/or fatigue effects, the order of sign presentation was counterbalanced across subjects. To control for the possibility of a “word superiority effect” (where some words are easier to read than others, regardless of typeface), the words were randomly assigned to typeface/spacing conditions, and each word was presented on three separate condition-combinations across subjects.

Analyses and Results

There were 61 participants in the daytime test sessions, including 23 younger (age 18 to 34), 19 middle age (age 35 to 64), and 19 older drivers (age 65 and older). The proportions of the male and female participants were 51 and 49 percent, respectively. For the nighttime test sessions, 13 younger, 18 middle age, and 22 older drivers participated in the experiment (a total of 53 participants). The proportions of the male and female participants were again 51 and 49 percent, respectively. The IBM SPSS Statistics 22 and Minitab 17 statistical software were used in the analyses.

Descriptive Statistics

Negative Contrast

Typeface Overall, the mixed-case Clearview signs were legible at equivalent distances to the comparable all-uppercase FHWA Standard Highway Alphabets. The mixed-case Clearview signs had longer mean legibility distances than the mixed-case FHWA Standard Alphabets. The uppercase FHWA Standard Alphabet series had longer legibility distances than the mixed-case FHWA Standard Alphabets.

Positive Contrast

Typeface and Letter Height Overall, the 6.0-inch Clearview Typefaces outperformed the comparable 6.0-inch FHWA Standard Alphabets. The legibility distances of the 4.8-inch Clearview Typefaces were equivalent to the comparable 6.0-inch FHWA Standard Alphabets.

Age Group and Time of Day

Not surprisingly, overall, legibility distances were shorter at night than in the daytime and were shorter for older participants than younger participants.

Inferential Statistics

Analysis of variance (ANOVA) statistical techniques were used to determine whether the differences in mean legibility distances for typeface and letter height were statistically significant. Separate analyses were conducted for the positive and negative contrast conditions.
Negative Contrast

Typeface  Six-inch Clearview 2-B, 3-B, and 4-B were paired with the FHWA Standard Highway Series C, D, and E, respectively (Figure 3 shows the results graphically, with red arrows indicating statistical significance and red text showing percent improvement). There were no statistically significant differences between Clearview and the comparable all-uppercase Standard Highway Alphabets, however overall the Clearview signs showed significantly longer legibility distances than those using the mixed-case Standard Highway Alphabets. Clearview 2-B performed significantly better during nighttime (160 feet) than the mixed-case FHWA Series C (132 feet) with p = 0.04. The difference between Clearview 3-B (241 feet) and FHWA series D (185 feet) during daytime was also significant, p < 0.01. Clearview 4-B was legible significantly further away than FHWA Series E during both daytime and nighttime, p < 0.01 and p = 0.02, respectively. In this case, the mean legibility distance of Clearview 4-B was 261 feet during daytime and 200 feet during nighttime, compared to the mixed-case FHWA series E, which was legible at 200 feet during daytime and 162 feet during nighttime.

FIGURE 3  Comparison of negative-contrast 6-inch Clearview and FHWA Alphabets (means for all participants).
Letter Height  To compare the reduced letter height Clearview mixed-case typefaces to the 6-inch Standard Highway Alphabets, the mean values of the 4.8-inch Clearview fonts were compared with both all-uppercase and mixed-case Standard Alphabets. Not surprisingly, most of the all-uppercase 6.0-inch Standard Alphabets provided statistically significantly longer legibility distances than the 4.8-inch mixed-case Clearview fonts, the one exception being the uppercase FHWA series C compared to the mixed-case 4.8-inch Clearview 2-B in daytime which did not reach statistical significance.

On the other hand, the 4.8-inch mixed-case Clearview signs performed as well as the 6.0-inch mixed-case Standard Highway Alphabets, with the single exception of a significant improvement with mixed-case FHWA series D (165 feet) compared to the 4.8-inch Clearview 3-B (134 feet) during nighttime.

Positive Contrast (all mixed case) The mean legibility distances of the positive contrast (white-on-green) Clearview Typefaces were compared with the Standard Alphabets (Figure 4 shows the results graphically, with red arrows indicating statistical significance and red text showing percent improvement).

Overall, the positive contrast, 6-inch Clearview typefaces had significantly longer legibility distances than the comparable Standard Alphabets, with the single exception being the comparison between the Clearview 4-W (228 feet) and the FHWA Series E (204 feet) during daytime, which did not reach statistical significance.

Most of the 4.8-inch Clearview Typefaces had equivalent legibility to the Standard Alphabets 6.0-inch fonts, with the notable exception being the 4.8-inch Clearview 2-W, which had significantly longer (16.8-percent improvement) mean legibility distance than the FHWA Series C during daytime (p = 0.02).
There were a number of instances with the older subjects where large mean differences did not result in statistical significance. To probe this further, as a final analysis, each older subject’s individual legibility distances for the relevant typeface pairs (e.g., Clearview 2-B vs. FHWA series C) were compared to determine the percentage of older subjects who read the Clearview Typefaces further away versus the percentage who read the FHWA Standard Alphabets further away (Figure 5 (a-c) and Figure 6 (a-c)). This is a descriptive statistic intended to show patterns in the data.

Negative Contrast The result shows that, for negative contrast, approximately 60 to 90 percent of the older subjects had longer legibility distances while reading the Clearview fonts. The largest difference occurred in the comparison of the Clearview 4-B vs. FHWA Series E, where 89 percent of older drivers read the Clearview 4-B signs further away during daytime.
FIGURE 5  Percent of older drivers who read the sign further away: negative contrast conditions, mixed case.
**Positive Contrast**  For positive contrast signs, over 70-percent of older subjects had longer legibility distances while reading the Clearview fonts compared to the FHWA Standard Alphabets. The percentages are especially high (approaching 90 percent) in the Clearview 2-B vs. FHWA Series C comparison during both daytime and nighttime conditions.

![Positive Contrast Diagram](image)

*(a) Clearview 2-W vs. FHWA Series C*

![Positive Contrast Diagram](image)

*(b) Clearview 3-W vs. FHWA Series D*

![Positive Contrast Diagram](image)

*(c) Clearview 4-W vs FHWA Series E*

**FIGURE 6** Percent of older drivers who read the sign further away: positive contrast conditions.

**Summary and Conclusions**

The main objective of this research was to evaluate the legibility distance of the negative contrast Clearview Typeface System in three weights with comparable negative contrast Standard Highway Alphabets. This was done in a test track environment with full-sized signs.
using black letters on white retroreflective materials in the day and at night for older and younger subjects. To assess the possibility of using mixed-case words on regulatory and warning signs, mixed-case Clearview was compared to all-uppercase Standard Highway Alphabets Series C, D, and E.

A 20 percent reduction in letter height was evaluated to determine whether smaller Clearview words would perform as well as larger Standard Highway Alphabet words.

A small set of white-on-green signs were displayed as well, to determine whether Clearview in positive contrast would result in improvements in legibility distance as it has in the past been shown to provide improvements over Standard Highway Alphabets in a recognition task.

**Daytime**

**Negative Contrast** With all the subjects combined, Clearview mixed-case performed as well as Standard Highway all uppercase for all comparisons (i.e., Clearview 2-B, 3-B, 4-B, compared to Standard Highway Series C, D, E, respectively). This is true even though the overall footprint of the mixed case Clearview Typefaces compared to the respective uppercase Standard Highway Alphabets C, D, E was consistently and considerably smaller.

Clearview mixed-case performed significantly better than Standard Highway mixed-case for Clearview 3-B versus Standard Highway D (30 percent improvement), and Clearview 4-B versus Standard Highway E (31 percent improvement).

Looking at only the older participants, Clearview mixed-case performed as well as Standard Highway all uppercase for all comparisons. It was also shown that Clearview 2-B was read further away than Standard Highway Series C by 56 percent of the subjects, Clearview 3-B was read further away than Series D by 63 percent of the subjects and 89 percent of the subjects read Clearview 4-B further away than Series E.

**Positive Contrast** With all the subjects combined, Clearview 2-W performed significantly better than Standard Highway Series C (a 35 percent improvement), and Clearview 3-W performed significantly better than Standard Highway Series D (a 29 percent improvement).

Looking at only the older participants, even though no statistically significant differences between Clearview and Standard Highway were found in the ANOVA analyses, Clearview 2-W was read further away than Standard Highway Series C by 89 percent of the subjects and 72 percent of the subjects read Clearview 3-W and Clearview 4-W further away than Standard Highway Series E and Series D.

**Nighttime**

**Negative Contrast** In the negative contrast comparisons with all the subjects combined, Clearview mixed-case performed as well as Standard Highway all uppercase for all comparisons (i.e., Clearview 2-B, 3-B, 4-B, versus Standard Highway C, D, E, respectively), Clearview mixed-case performed significantly better than Standard Highway mixed-case for Clearview 2-B versus Standard Highway Series C (21 percent improvement) and Clearview 4-B versus Standard Highway Series E (24 percent).

Looking at only the older participants, there were no significant differences between Clearview mixed-case and Standard Highway uppercase, or Clearview mixed-case versus Standard Highway mixed-case. However, Clearview 2-B was read further away than Standard Highway Series C by 60 percent of the subjects, and 64 and 67 percent of the subjects read
Clearview 3-B and Clearview 4-B further away than Standard Highway Series E and Series D, respectively.

**Positive Contrast** In the positive contrast comparisons with all the subjects combined, Clearview 2-W performed significantly better than Standard Highway Series C (29 percent improvement), Clearview 3-W performed significantly better than Standard Highway Series D (22 percent improvement), and Clearview 4-W performed significantly better than Standard Highway Series E (18 percent improvement).

Looking at only the older participants in this case as well as the other evaluations discussed above, the mean differences found were large (ranging from about 25 to 40 percent) but resulted in non-significant p-values in the 0.15 range during the ANOVA testing. These results are likely due to the large variances in legibility distances found with the oldest participants. That there were improvement trends with the Clearview font in this case, however, was again borne out by the percentage evaluations, where Clearview 2-W was read further away Standard Highway Series C by 86 percent of the subjects, Clearview 3-W was read further away than Series D by 71 percent of the subjects and 74 percent of the subjects read Clearview 4-W further away than Series E.

**DISCUSSION**

This study was part of an ongoing research program to learn how signs could be better designed for ease of readability by drivers of all ages in the daytime and at night. The objective of this program is to study the elements of design (e.g., typeface, figure-field relationships, borders, and layouts) and placement of signs on the roadway in an effort to make essential safety and regulatory information easier to read without ambiguity. This research was planned as Part 1 of a three-part study effort into the readability of negative-contrast highway signs, though it holds up as a stand-alone research effort. Part 1, detailed here, identified the relative legibility of various typefaces and mixed versus all uppercase words. Part 2 will address recognition, or the understanding of messages, using various typefaces in both uppercase and mixed case. Part 3 will address figure/field and format to learn how display variables may enhance sign readability.

**REFERENCES**


