Title: A New Font and Arrow for National Park Service Guide Signs

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ABSTRACT
Although highly legible, the National Park Service's (NPS) Clarendon font produces sign legends that can be ten to 20 percent longer than legends depicted in conventional san-serif fonts. Placing these wider signs on narrow park roads and in urban historic districts can be prohibitive. To address this problem, a project was initiated to create a new NPS Roman-style (i.e., serif) font that requires less horizontal sign space than NPS Clarendon while improving sign readability and retaining Clarendon's unique "signature quality." The present study also evaluated a set of guide sign arrows to select the most legible for use on National Park Service (NPS) guide signs.

Three candidate typefaces were developed for daytime and nighttime field evaluation, using 72 older and younger subjects. Based on the results of the evaluation, a fourth font was created and field-tested using 12 additional subjects. Words created with the fourth font (NPS Roadway) were five to 11.5 percent shorter than those created with NPS Clarendon. Further, subjects were able to read these words at average legibility distances 10.5 percent greater than the words composed in NPS Clarendon.

The relative legibility of twelve candidate guide sign arrows was evaluated in an outdoor field study. Forty-eight subjects participated in the daytime and thirty-two subjects viewed the arrows at night. There were statistically significant differences in legibility distance among the various arrow shapes. The arrow ultimately recommended for use on NPS road guide signs performed 18 percent better than the Federal Highway Administration "Standard Arrow."

INTRODUCTION

In the summer and fall of 2002 traffic safety researchers from the Pennsylvania Transportation Institute (PTI) at the Pennsylvania State University and graphic designers from Meeker and Associates and Terminal Design conducted a series of studies to improve the visibility of National Park Service (NPS) guide signs. Two distinct evaluations took place: the first was a study to improve the font used by the NPS and the second assessed potential arrows forms for use on NPS guide signs. The present paper describes the research objectives, rationale, results, and conclusions from this research effort.

STUDY 1: GUIDE SIGN FONTS

Over the past 60 years, the legibility of highway sign fonts has been the subject of numerous research projects (for a review of the literature see *1*). Much of the early work was designed to establish a standardized highway sign font (*2, 3,* and *4*), while later work focused on testing that font using modern retroreflective materials and older drivers (*5, 6,* and *7*).

Recently, researchers have questioned the continued effectiveness of fonts developed for highway use in the 1940s and 1950s (*8* and *9*). These researchers developed and tested a new sign font designed to be responsive to the use of modern high-reflectance sign materials, brighter headlamps, and an increasingly older driving population. The result was the Clearview Typeface for highway signs, which is legible at distances up to 15 percent further than those for the comparable Standard Highway Alphabets. A similar effort was envisioned for improving the NPS's Clarendon sign font.

In 1966, the NPS instituted a standardized sign program for use at all NPS locations. The intent of the program was to create a common visual identity for the service. Integral to this graphic program was the use of the Clarendon typeface and the color brown for the background of the signs and white for the sign copy.

Clarendon is a slab serif font that was designed in 1845 for use as a heavy face font for emphasis in dictionary listings. It was used in the late 19th century in advertising and has the characteristics of what are generally termed Egyptian typefaces, those arising during the period in England that corresponded to the discovery of King Tutankhamen's tomb. In a Memorandum of Understanding to the NPS dated August 29, 1973, the Federal Highway Administration (FHWA) sanctioned the use of the Clarendon font on NPS road guide signs in lieu of FHWA's Standard Highway Alphabet (*4*).

Although Clarendon is very readable in large sizes (*5*), the large slab serifs make for sign legends that can be ten to 20 percent longer than conventional Roman typefaces. Placing wide signs on narrow park roads and in urban historic districts is prohibitive; consequently letter height is often reduced, compromising sign legibility.

In 1993, the NPS began a project to develop new sign and graphic standards for the agency. Although the NPS wanted to retain the unique "signature quality" of the Clarendon typeface as an integral part of their identity, the agency required a font optimized for both road guide signs and print communications. Working with the graphic design consultants who developed the Clearview Typeface system for the FHWA (*8* and *9*), four Roman (i.e., serif) typefaces were identified to replace Clarendon: Century Old Style; Cheltenham; Sabon; and Plantin. These are all classic Roman typefaces with an underlying structure that would allow a signage version to be developed from the basic character of the fonts. However, since these Roman typefaces were designed for printed text, the graphic designers believed they were too thin-stroked for use on highway signs and would require modifications for road guide sign applications. A signage version would have the appropriate stroke width in both the thin (horizontal), and thick (vertical) strokes of each Roman letterform while retaining the character of the typeface design.

After careful study, the graphics design team hypothesized that the typeface Plantin had attributes that could, if incorporated into a new type design in conjunction with Sabon, create a more readable typeface when used on signs.

The result was a modern typeface influenced by, and true to, the earlier designs. The serifs were thin, slightly cupped, and horizontal in orientation (instead of heavily bracketed as with Clarendon) to reduce the mass created in the radius of a bracketed serif while retaining the desired stroke width. Three variations of this font were developed for field evaluation; these were called NPS-1, -2, and -3. Each of these typefaces had the same lowercase “x” height (i.e., height of the lower case letter form excluding ascenders and descenders) which closely matched that of Clarendon (70.3 percent of the capital letter height). Although the three fonts were very similar, there were differences designed into the fonts to help determine the effect of small changes in stroke or letter width on sign legibility (Figure 1).

1. *NPS Roadway 1* had a stroke width that was nearly equal to Clarendon (1.3 percent less) and a nominal word length that was approximately 9.5 percent shorter than Clarendon.
2. *NPS Roadway 2* had a stroke width that was slightly heavier (7.7 percent) than Clarendon and a nominal word length that was about 9.4 percent shorter than Clarendon.
3. *NPS Roadway 3* was designed with a 6.2 percent narrower stroke width than Clarendon and letters condensed by five percent. The resulting word length was 14.1 percent shorter than Clarendon.

EXPERIMENT 1

Motorists read signs in one of two ways. When motorists read a sign that displays unfamiliar or unexpected words, they must identify each letter and then construct the word (*10*); this is known as a legibility task. When motorists know what word they are looking for, all they need to do is identify the overall shape or footprint of the word on the sign and compare that shape with a mental image of the word they are looking for (*11*); in sign visibility research this is called a recognition task. It should be expected that global word recognition would be accomplished at a greater distance than individual letter recognition. Research supports that expectation (*3*) but also demonstrates that manipulating letter characteristics (e.g., all-uppercase versus mixed-case) has a different effect on recognition than it does on legibility (*9*). Therefore, to fully assess the effectiveness of the fonts evaluated in this study, both legibility and recognition tasks were used.

Method

The study was a daytime and nighttime field evaluation of six fonts displayed on signs with white retroreflective lettering on brown backgrounds. The evaluation took place at PTI’s test track in August of 2001. Test subjects were seated in the front passenger seat of a test vehicle, driven toward the signs, and asked to read each sign as soon as they were close enough to do so accurately.

Subject Recruitment and Screening

Seventy-two subjects were paid 20 (U.S.) dollars each to participate in the one-hour test session. All subjects held valid Pennsylvania driver’s licenses. Thirty-six subjects ranged from 19 to 30 years of age (mean = 24.3), and 36 ranged from 65 to 80 years of age (mean = 73.6). Each subject’s high contrast, binocular, distance visual acuity was measured using a standardized test

(Good-Lite Co. Model A Translucent Eye Cabinet). Subjects wore corrective lenses if necessary. The range in acuity scores for the young was 6/5 to 6/9 (mean of 6/6) and for the older group 6/5 to 6/15 (mean of 6/8).

Variables
The dependent variables were legibility distance threshold and recognition distance threshold. Recognition distance was defined as the maximum distance at which a subject was able to correctly identify the location of a specified target word on a sign that contained three words. Legibility distance was defined as the maximum distance at which a subject was able to correctly read one of the remaining two words on that same sign.

The independent variables were font (NPS-1, NPS-2, NPS-3, Standard Highway Series D, Standard Highway Series E(M), and NPS Clarendon), time of day (daylight and night), and subject age group (young and old). Font was a repeated measures (i.e., within subjects) variable while time of day and age group were non-repeated (between subjects). The words in the NPS and Standard Highway Series E(M) fonts were displayed in mixed case (i.e., initial capital letter followed by lowercase letters), while the words in Standard Highway Series D were all-uppercase.

Site and Apparatus
The test site was PTI's Test Track Facility. The test track is a two lane 1.6 k oval. To avoid artificially truncating reading distances, the signs were placed at the end of a tangent section of the test track allowing for 350 m of sight distance.

A single observation vehicle (a 1999 Plymouth Grand Voyager with halogen headlamps) was used for all subjects. The signs were 1.2 x 1.2 meter aluminum sheets covered with Avery Dennison Company's T-6500 high intensity white sheeting and 4809 Series Brown Overlay Film resulting in signs that had white words on a brown background. The retroreflective material was microprismatic and conformed to ASTM Types III and IV minimum R_A requirements. Each of the words had a 125 mm capital letter height and, when mixed case was used, proportionally sized lowercase letters. The panels were mounted on a flat wooden frame for presentation purposes (Figure 2).

Procedure
Subjects were run individually. The subject was seated in the front passenger seat with an experimenter in the driver seat. At night, the headlamps were set on low beam.

The observation vehicle was driven to the 350 m mark upstream of the sign and parked in the center of the 4.6 m wide travel lane. The cart upon which the sign panel was mounted was placed 2.3 meters outside of the edge line and the sign was raised to 2.3 m as measured from the bottom of the sign to the pavement. This arrangement resulted in a sign with a lateral offset of 4.6 m to the right of the center of the observation vehicle. The sign was turned approximately four degrees toward the shoulder to avoid specular reflections from the test vehicle's headlamps at night.

Each sign panel contained three place-names (Figure 2). Before each sign was shown, the experimenter read aloud a place-name for the subject to find. With the observation vehicle parked at 350 m, the sign was shown, and the subject attempted to find the target word and was asked to respond by saying, "top," "middle," or "bottom." The experimenter then drove the vehicle toward the sign at approximately 10 to 20 kph until the subject correctly stated the target word position. The subjects were instructed to wait until they were certain of the target word position; guessing was strongly discouraged.

The travel lane was marked every 1.5 meters. When the subject correctly located the target word, the experimenter stopped the vehicle and recorded the distance as the recognition threshold for that condition. The experimenter then indicated the position of one of the other words on the sign (e.g., the “top” word) and asked the subject to read that word. The experimenter then continued to drive the vehicle toward the sign until the subject correctly read the indicated word. When the subject correctly read the target word, the experimenter stopped the vehicle again and recorded the distance as the legibility threshold for that condition. The car was then turned around and again parked 350 meters upstream of the sign. The procedure was repeated until recognition and legibility thresholds for all six fonts were established. To avoid learning or fatigue effects, the order of font presentation was counterbalanced across subjects.

Analysis and Results

Analysis of variance (ANOVA) found a significant main effect of font for the recognition dependent variable ($F=2.41$, $p=0.04$), but there was no significant main effect of font on legibility ($F=0.46$, $p=0.81$). No significant interactions were found between font and age group or time of day for either recognition or legibility.

A Tukey HSD post-hoc test was performed on the font recognition data to determine which of the six fonts were significantly different from the others in the recognition task. The only significant difference was between Clarendon and Standard Highway Series D ($p=0.01$), wherein the Clarendon font outperformed the all-uppercase Standard Highway Series D font by 17 m.

Discussion

That the newly designed NPS fonts did not result in statistically significant improvement in either legibility or recognition indicates that these new fonts were not a substantial improvement over Clarendon. However, descriptive statistics did hint that the new NPS fonts might be producing small improvements in legibility distance; although at only about two to four percent these were neither statistically nor practically significant. A second study was conducted to evaluate a fourth NPS font, specifically designed to incorporate what the graphic designers thought were the best features of NPS 1-3 with modifications to emphasize word shape that included a heightened lower case letter height, simplification of letter form, and slightly condensed overall font (Figure 1). This font was called NPS Roadway.

EXPERIMENT 2

Following a review of the Experiment 1 findings, the type designers suggested increasing the lower case “x” height by 4.8 percent to 73.7 percent of capital letter height to allow for more interior space in the letterforms and to make the typeface appear larger while maintaining the same capital letter height. With additional changes to stroke width and letter spacing, this new design resulted in word length that was 5 to 11.5 percent shorter than Clarendon (Figure 1).

Methodology and Procedure

The procedures and methodologies described in Experiment 1 were replicated in Experiment 2, with some exceptions. Only two fonts were tested in Experiment 2: NPS Roadway and NPS Clarendon. As there was no age group by font interaction (i.e., age did not affect ordinal ranking of font visibility) in Experiment 1, the subject sample in Experiment 2 was restricted to young observers. To stay within the study's budget, the number of subjects was reduced to twelve. To increase the total number of observations, each font was replicated on six signs for a total of twelve observations per subject or 72 observations per font in the day and night.

Analysis and Results

A MANOVA was conducted on the data to determine if there were any main or interaction effects. Font was found to be a significant factor in sign legibility (F=6.02, p=0.02), but not recognition (F=0.03, p=0.86). The mean legibility distance for NPS Roadway was 10.5 percent greater than for NPS Clarendon (81 and 73 meters, respectively). Figure 3 depicts the combined results of Experiment 1 and 2, plotting the relative legibility of all tested fonts against NPS Clarendon.

STUDY 2: GUIDE SIGN ARROWS

Guide sign arrows play a pivotal role in the safe and efficient flow of traffic as they often are placed at high demand "choice points" where there is a great deal of visual information to be processed and integrated with vehicle handling responsibilities in a short period of time (*12*). Central to an arrow's effectiveness is the ease with which motorists can determine its orientation (i.e., its legibility). The goal of Study 2 was to determine the most legible arrow style for use on NPS guide signs.

While several studies have evaluated the effect of arrow style on traffic signal and lane control visibility (e.g., *13, 14,* and *15*) and others have looked at the legibility of pavement arrows (e.g., *16*), there is little research guidance on selecting the optimum arrow for roadway guide signs (*12*). Past research on arrow legibility, while not always directly relevant to the goal of optimizing guide sign arrow legibility, however provides a useful background and framework for achieving this goal.

Previous researchers (*15*) investigated the relationship between traffic signal arrow shape and legibility in a series of lab experiments. These researchers found significant differences between arrow shapes, however they found the choice of dependent measure (i.e., optical blur versus contrast reduction) had a profound effect on arrow shape legibility ranking, a finding emphasized in other reports (*17*). For example, some arrow shapes performed well when blurred, but when contrast was reduced performed poorly. These researchers (*15*) concluded that while "no simple choice of a 'best' arrow shape exists…the use of a wide-angled head and, less certainly, a wide shaft" results in the most consistently superior legibility across dependent measures. However, when these researchers replicated this lab study in a controlled field environment (*13*), the results were less convincing. In this study, six arrows types were evaluated under daylight and night conditions using reaction time as the dependent variable. With the exception of the "ARRB (Australian Road Research Board) Design," all the arrows were based on the ITE (Institute of Transportation Engineers) design (separated shaft and head), which was varied mainly in stroke width and shaft length for this experiment. In this more applied study; arrow shape did not have a significant effect on legibility.

Another researcher (*18*) evaluated the visibility of directional arrows to be used as part of exit signing in buildings. In one experiment, he evaluated 16 arrow shapes tested in positive and negative contrast (Figure 4) under adverse visibility conditions (i.e., reduced luminance). Mean errors in reporting arrow orientation was the dependent measure. Seven subjects viewed the slide presentation. Under the most adverse stimulus luminance conditions this researcher found large differences in arrow legibility. The best arrow shape resulted in an error rate of only 8.3 percent (Arrow C) while the worst yielded 65.5 percent errors (Arrow N). Fifty-two subjects then subjectively ranked a subset of thirteen of the arrow shapes (Arrows F, J, and L of Figure 4 were omitted). Conventional “head with shaft” arrows resulted in the highest rankings based on “connotation of exit,” “appearance,” and “direction.”

Overall, this researcher found a strong relationship between legibility and arrow style, but he had a difficult time generalizing exactly what makes one arrow more or less legible than another. For example, in some cases the inclusion of a shaft improved performance while in others it made the arrow less legible. In summarizing the visibility experiment, he stated, “perhaps the main conclusion is that the arrow head should be the dominant graphic element. The shaft may be useful in reinforcing the message, but should be a secondary feature.” Combining the visibility and the ranking experiments he suggested the best arrows were A, B, C, and M, with B emerging as the best overall choice.

In one of the few studies that investigated the effect of guide sign style on legibility (*12*), seven arrow types were studied. Five of the arrows were delta-winged (Figure 5, Arrows 1, 3, 5, 6, and 7), with two being very similar to FHWA’s Standard Arrow (Arrows 3 and 5), and two were “crow’s foot” type arrows (Arrows 2 and 4). Five subjects were shown eighty tachistoscopic presentations (i.e., short durations ranging from 0.015 to 0.030 sec) in ten, two-hour sessions.

Each of the arrows was orientated in one of the four cardinal directions. The subjects were asked to identify the arrow orientation and to rate their response confidence. The dependent measure was an “index of recognizability” derived from signal detection theory. These researchers found a significant orientation effect, with the “north” orientation having the best legibility. They found that an arrow with “a wasp-wasted fuselage, a slightly smaller arrow head and a slightly longer shaft” (Arrow 1) showed “clear superiority.” The two that were similar to the FHWA Standard Arrow were ranked third and fifth. The authors concluded that directional information (i.e., arrow orientation) is contained in both the arrowhead and the shaft.

METHOD

Apparatus

Arrows

Twelve guide sign arrows (Figure 6) were evaluated in Study 2. These arrows included three proposed by the NPS (i.e., Color Detour I and II, and Rounded Crow’s Foot) and one suggested by the FHWA (i.e., FHWA Standard Arrow (M6-3)). The other eight included in the study were arrows already in use by the FHWA (standard or with shaft modification) and arrow symbols used for other route guidance applications. Arrow length for most styles was approximately 23 cm (9 in), with some deviation due to arrow design (Table 1). The twelve arrows were:

FHWA Arrows (*4* and *19*):

1. Down Arrow (6-3)
2. Down Arrow (6-3) with extended shaft
3. Standard Arrow (M6-3)
4. Camper Symbol Arrow (6-49)

“Crow’s Foot”:

5. Color Detour Arrow I - thin stroke
6. Color Detour Arrow II – thick stroke
7. Rounded Crow’s Foot Arrow

8. Montreal Expo Arrow with short shaft (*20*)

Shaftless Arrows:

9. Winged Delta
10. Chevron

Other Arrow Styles:

11. Traffic Signal Head Arrow - Similar to the ITE design found to be "one of the best" arrows (*2*), but with a more rounded head.
12. Serif Arrow – designed for this study to match the NPS serif font (Clarendon)

Retroreflective Materials

The signs were fabricated using the same white on brown materials used as in Study 1.

Test Site and Setup

As in Study 1, the evaluation took place at PTI's test track. Test subjects were seated in the front passenger seat the late model minivan described in Study 1. A single arrow was displayed at the end of the 305 m tangent section of the test track. The van was located in the center of the 3.7 m travel lane. The arrows were mounted to a frame using standard lateral and vertical offsets (*8*). They were placed 1.8 m outside the roadway edge line, with the arrow raised 2.4 m as measured from the bottom of the sign panel to the pavement. The immediate visual surround forming the background, or external contrast, for the signs under daytime conditions was consistently green leaves on trees (Figure 7).

Variables

The dependent measure was the threshold distance at which the subjects could correctly identify arrow orientation (i.e., north, northeast, east, southeast, south, southwest, west, and northwest). The independent variables were arrow style (12 levels), observer age group (younger and older), and time of day (daylight and night).

Participants

Forty-eight subjects (24 younger/24 older) participated in the daytime sessions and thirty-two subjects (16 younger/16 older) viewed the arrows at night. The subjects were paid 20 (U.S.) dollars each for the one-hour session. All subjects held valid Pennsylvania driver's licenses. The forty younger subjects ranged in age from 20 to 36 (mean = 28), and the forty older subjects ranged from 64 to 83 years of age (mean = 72). Each subject's high contrast, binocular, distance visual acuity was measured using same standardized test as in Study 1. Subjects wore corrective lenses if necessary. The range in acuity scores for the young was 6/4.8 to 6/7.5 (mean of 6/5.1) and for the older group was 6/4.8 to 6/15 (mean of 6/6.6).

PROCEDURE

Each subject was seated in the front passenger seat of the test vehicle. A single arrow was displayed at the end of the 305 m tangent section of the test track. The experimenter drove the van toward the arrow at a speed of approximately 8-16 kph, and the subject was asked to identify the arrow's orientation. They were told to respond only when they were "certain" they could do so accurately; guessing was strongly discouraged resulting in a false alarm rate of less than five percent.

The threshold distance at which the subject was able to correctly identify the arrow's orientation was recorded as the measure of effectiveness. The van was then driven back to the starting point, and a new arrow was displayed. This procedure was repeated until each of the twelve arrow types had been evaluated. The order in which the arrow types and orientations were presented was counterbalanced between subjects to avoid practice, fatigue, and arrow orientation effects.

RESULTS

Orientation

An analysis of variance (ANOVA) revealed a significant main effect of arrow orientation ($F(7, 864)=4.74$, $p<0.05$). Subsequent post-hoc analyses revealed that the vertical orientations were more legible than the obliques with the south, or downward, arrow position being the most legible of all orientations. The ANOVA revealed no significant interaction between arrow type and arrow orientation, indicating that any arrow type could be used to indicate any orientation without loss in legibility distance, eliminating the need to inventory orientation-specific arrows such as the FHWA Down Arrow (6-3). As orientation was counterbalanced across arrow types, and there was no statistically significant interaction between orientation and arrow type, the rest of the analyses were conducted with the data collapsed across orientation.

Arrow Style

There were no interactions between arrow style and any of the other variables, therefore the discussion of the arrow style results are confined to main effects. The arrow style main effect showed that there were significant differences in legibility distance between the various arrow shapes (Figure 8). A Tukey-LSD post-hoc analysis was conducted to determine which of the arrows performed significantly better than the others (Table 2).

FHWA Arrows

FHWA Down Arrow The FHWA Down Arrow "shall be used only for overhead guide signs to prescribe lane assignment for traffic bound for a destination or route that can be reached only by being in the designated lane(s)" (*19*). While on the highway this particular arrow is used mainly in the downward position, the FHWA Down Arrow was tested in all eight orientations. The FHWA Down Arrow was the second least legible of all the arrows tested.

FHWA Down Arrow with Extended Shaft When the shaft of the Down Arrow was increased from 7 to 18 cm (extended version), it became the most legible arrow in mean ranked legibility distance. The extended shaft Down Arrow was legible 31 percent further than the standard FHWA Down Arrow, but it was still not significantly better than five other arrows that subtended substantially less sign space. The Montreal Expo and Serif Arrows could fit in a 471 cm^2 panel while Color Detour I and II, Rounded Crow's Foot, and Traffic Signal Head all could fit within an 523 cm^2 panel. The FHWA Down Arrow with extended shaft would require a 703 cm^2 panel, which represents a 35 to 49 percent increase in panel size for no appreciable gain in legibility distance over the smaller arrows.

FHWA Standard Arrow The shaft length of the FHWA Standard Arrow is adjustable (*4*). The length chosen for this research was 10.5 cm, representing the arrow proportions of Directional Arrow Auxiliary Sign M6-3 (*19*). This arrow resulted in a mean legibility distance that was third to last in the ranking. It was as legible as the other four poorest performing arrows and significantly less legible than seven of the other arrows. This is consistent with earlier findings (*12*), where arrows similar to the FHWA Standard ranked 3rd and 5th out of seven tested.

FHWA Camper Symbol Arrow The arrow used in conjunction with the FHWA camper symbol to indicate a septic dumpsite, ranked 9th. The only arrow that the Camper Symbol Arrow significantly outperformed was the Winged Delta, which was the least legible overall. Other researchers (*15*) found a similar arrow (with a thicker shaft) to perform poorly with optical blur, but to hold up well under reduced contrast.

"Crow's Foot Arrows"
Color Detour Arrows I and II The Color Detour Arrow is used extensively in Pennsylvania to direct traffic from interstates to other roads that would be able to accommodate the heavy truck traffic if the interstate is closed due to an emergency. Color Detour Arrow II had a 17 percent wider stroke width than Color Detour Arrow I. Although there was no statistically significant difference between the two arrows, they ranked 7th and 3rd with Color Detour Arrow I having a nine meter longer mean legibility distance. An arrow of this type ranked fourth of seven in earlier research (*12*).

Rounded Crow's Foot Arrow The Rounded Crow's Foot ranked fourth. No other arrow shape was significantly more legible, and the Rounded Crow's Foot was significantly more legible than the four poorest performing arrows.

Montreal Expo Arrow As its name implies, the Montreal Expo arrow was originally designed for use at the 1967 World's Fair (*20*). This arrow ranked sixth overall, significantly outperforming the bottom three arrows and providing statistically equivalent performance to the remaining eight arrows. With a wider stroke width, this arrow type fell in the bottom half of the arrows tested in earlier research (*15*) under both blur and reduced contrast conditions, while at similar proportions to the one tested here was found by other researchers to perform in the top three (*18*) and second (*12*).

Shaftless Arrows
Winged Delta The Winged Delta arrow had the shortest mean legibility distance of all the arrow forms tested. This arrow performed significantly worse than nine of the other arrows.

Chevron The Chevron ranked eighth in legibility distance. The Chevron significantly outperformed only two of the other eleven arrows: the Winged Delta and the FHWA Down Arrow. Other research (*15*) found a similar symbol (with a narrower stroke width) to perform well with optical blur, but poorly with reduced contrast, while another researcher (*18*) found a wide stroke chevron to have the highest visibility score, and a thinner stroke chevron to rank second to last out of the thirteen arrow shapes tested.

Other Arrow Styles
Traffic Signal Head Arrow This arrow was based on the turn symbol used in intersection traffic signal heads. This segmented arrow ranked second overall, significantly outperforming

five other arrow shapes and resulting in statistical equivalence with the remaining six. Previous research (*15*) found a similar symbol (with a narrower stroke width and larger space between shaft and head) to perform well with optical blur, but poorly with reduced contrast.

Serif Arrow The Serif Arrow was designed for this study to allow the researchers to evaluate an arrow that typographically matched the serif Clarendon font used on NPS signs. The Serif Arrow ranked fifth overall in mean legibility distance, significantly outperforming four other arrows and achieving statistical equivalence with the remaining seven.

CONCLUSIONS AND DISCUSSION

The objective of this research was to design and test new fonts and arrows for use on NPS guide signs. The NPS wanted a font that had the signature quality of the current NPS Clarendon font, but provided greater visibility with a significantly smaller sign panel. The NPS Roadway font developed for Study 1, Experiment 2 resulted in a 10.5 percent increase in legibility distance and no loss in recognition distance while requiring 5 to 11.5 percent less sign width.

The FHWA has verbally endorsed the use of NPS Roadway on NPS guide signs. While awaiting a formal sanction through a new Memorandum of Understanding between the FHWA and the NPS, the NPS is currently testing the new font at several parks. NPS Roadway can be found on signs in Mt. Rushmore in South Dakota, and at George Washington's Birthplace in Virginia. Several signs using the new font are also under production for use in Jewel Cave, South Dakota.

Study 2 provided evidence that relatively small design changes (e.g., stroke width and edge rounding) have little effect on arrow legibility. This was evidenced by the finding that changing the stroke width of the Color Detour arrow did not significantly affect its legibility, and that all arrows from Montreal Expo through FHWA Down Arrow extended shaft (Figure 8) had statistically equivalent legibility.

Study 2 also showed that, while motorist age and time-of-day affect arrow legibility distance; these effects are not arrow specific. In other words, arrow styles that are good for young motorists work well for older motorists and arrows with good daytime visibility also perform well at night.

Arrow orientation also had a significant effect on arrow legibility. The cardinal arrow orientations (i.e. north, south, east, and west) had better legibility than the intermediate orientations, but again, there was no interaction with arrow type. This signifies that the idea of specific arrow styles for specific orientations (e.g., FHWA (6-3) "Down Arrow") may not be necessary or desirable.

In the end, Color Detour I was recommended to the NPS for use in their guide sign system. The only arrow that performed better (a non-statistically significant 3.6 m) was the FHWA down arrow with extended shaft, which subtends a 35 percent larger sign area. Considering the overall poor performance of the FHWA arrows in standard form, the present researchers are planning to further evaluate the legibility of these arrows.

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LISTS OF TABLES AND FIGURES

TABLE 1 Study 2: Arrow Dimensions

Arrow Style	Shaft Length in cm (in)	Head Width in cm (in)
Winged Delta	21.0 - head length (8.3)	16.5 (6.5)
FHWA Down Arrow (6-3)	17.5 (6.9)	24.8 (9.8)
FHWA Standard (M6-3)	23.8 (9.4)	17.2 (6.8)
FHWA (6-49)	28.5 (11.22)	10.5 (4.1)
Chevron	16.5-head length (6.5)	19.5 (7.7)
Color Detour II	23.0 (9.1)	23.0 (9.1)
Montreal Expo	23.8 (9.4)	17.5 (6.9)
Serif	24.0 (9.5)	20.0 (7.9)
Rounded Crow's Foot	23.5 (9.3)	22.5 (8.9)
Color Detour I	23.0 (9.1)	23.0 (9.1)
Traffic Signal Head	23.2 (9.1)	23.2 (9.1)
FHWA Down (extended)	28.5 (11.2)	24.8 (9.8)

TABLE 2 Study 2: Results of the Post-Hoc Statistical Analysis Comparing Pairs of Arrow Styles

												
												
	=[1]											
	=	=										
	>[2]	=	=									
	>	>	=	=								
	>	>	>	=	=							
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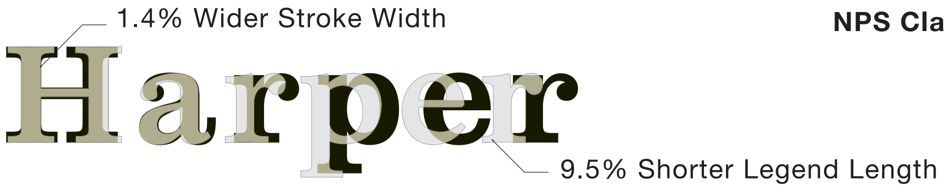
	>	>	>	>	>	=	=	=	=			
	>	>	>	>	>	=	=	=	=	=		
	>	>	>	>	>	>	=	=	=	=	=	

[1]non-significant row/column comparison

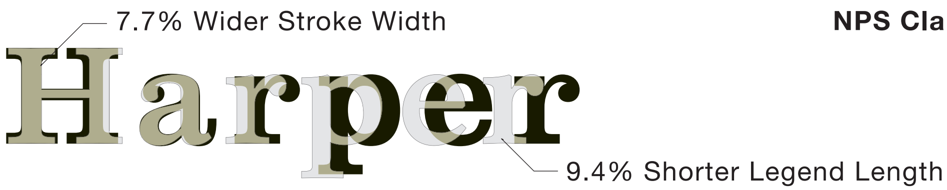
[2]row arrow significantly more legible than column arrow

Comparison of Test Typeface to Clarendon

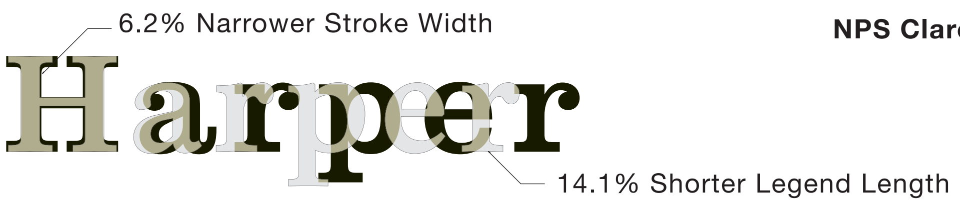
NPS Clarendon v. NPS Roadway 1



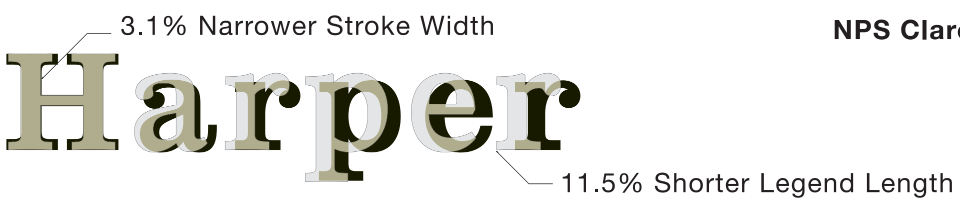
NPS Clarendon v. NPS Roadway 2



NPS Clarendon v. NPS Roadway 3



NPS Clarendon v. NPS Roadway 4



Test Typeface

Clarendon

Harper

Standard Highway Series E(modified)

HARPER

Standard Highway Series D

FIGURE 2 Study 1: Experimental apparatus.

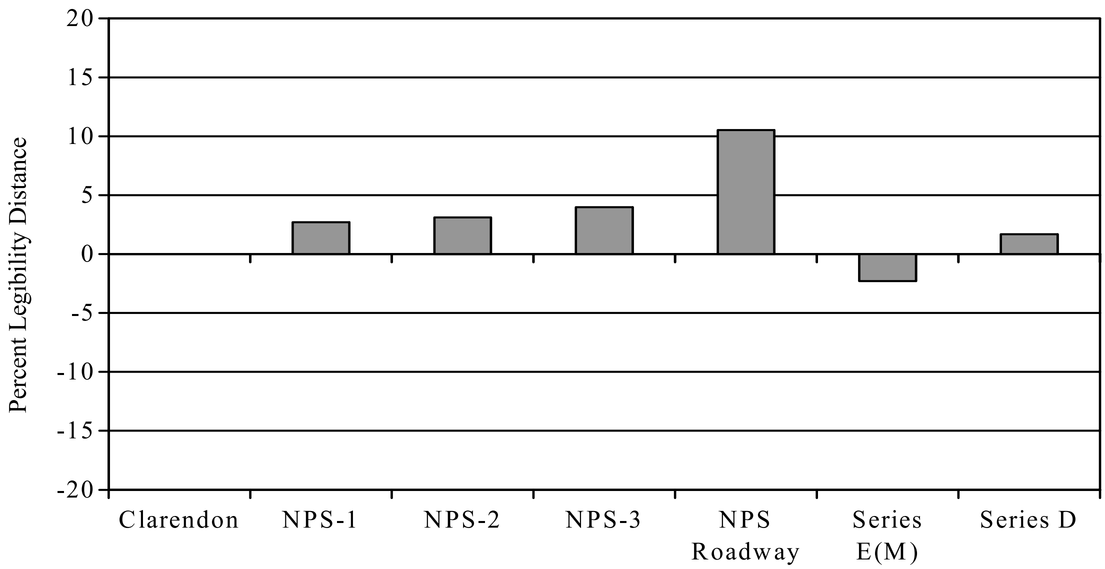


FIGURE 3 Study 1: (Experiments 1 and 2) Percent change in legibility distance compared to Clarendon.

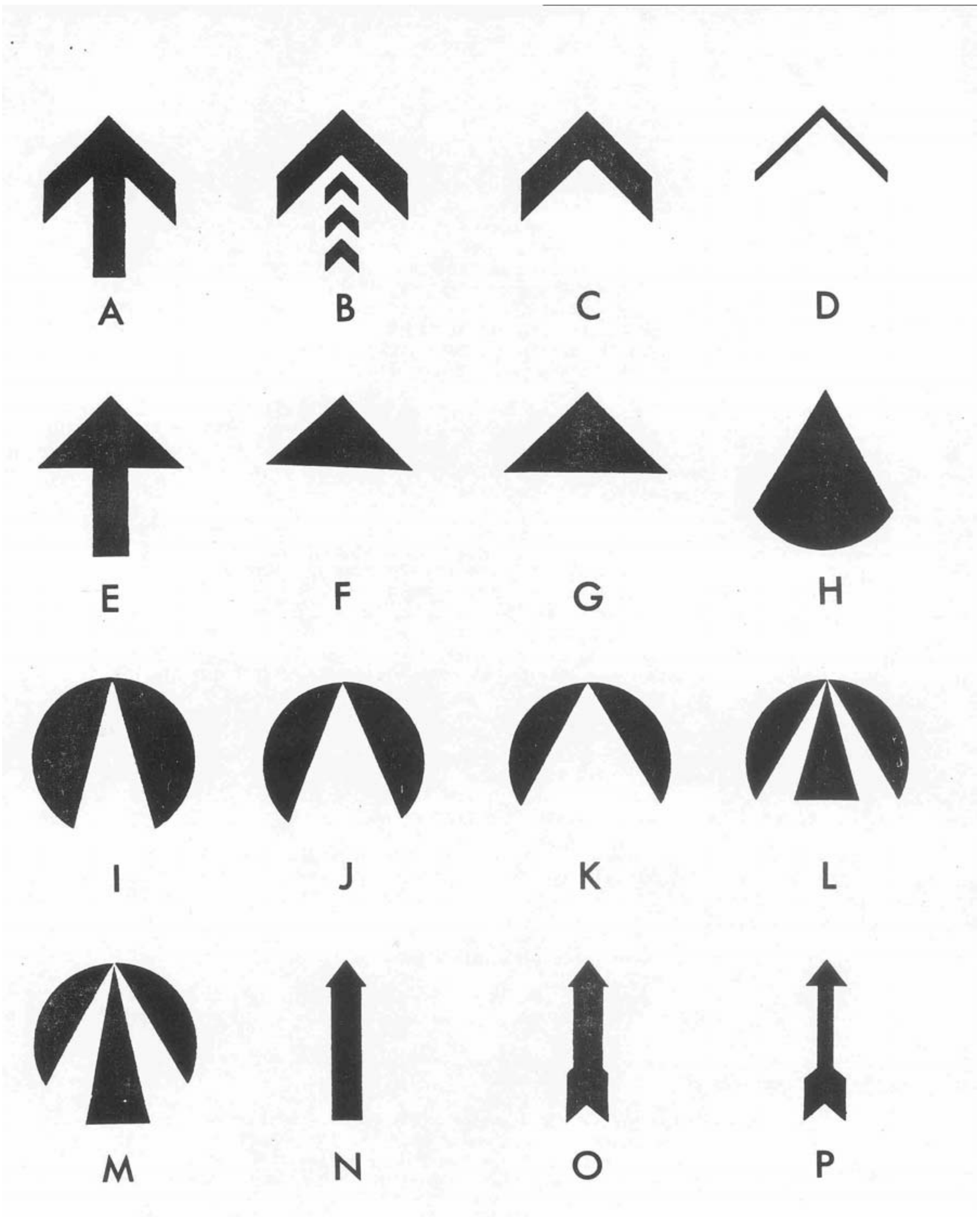


FIGURE 4 Study 2: Arrow shapes tested by Lerner, 1981.

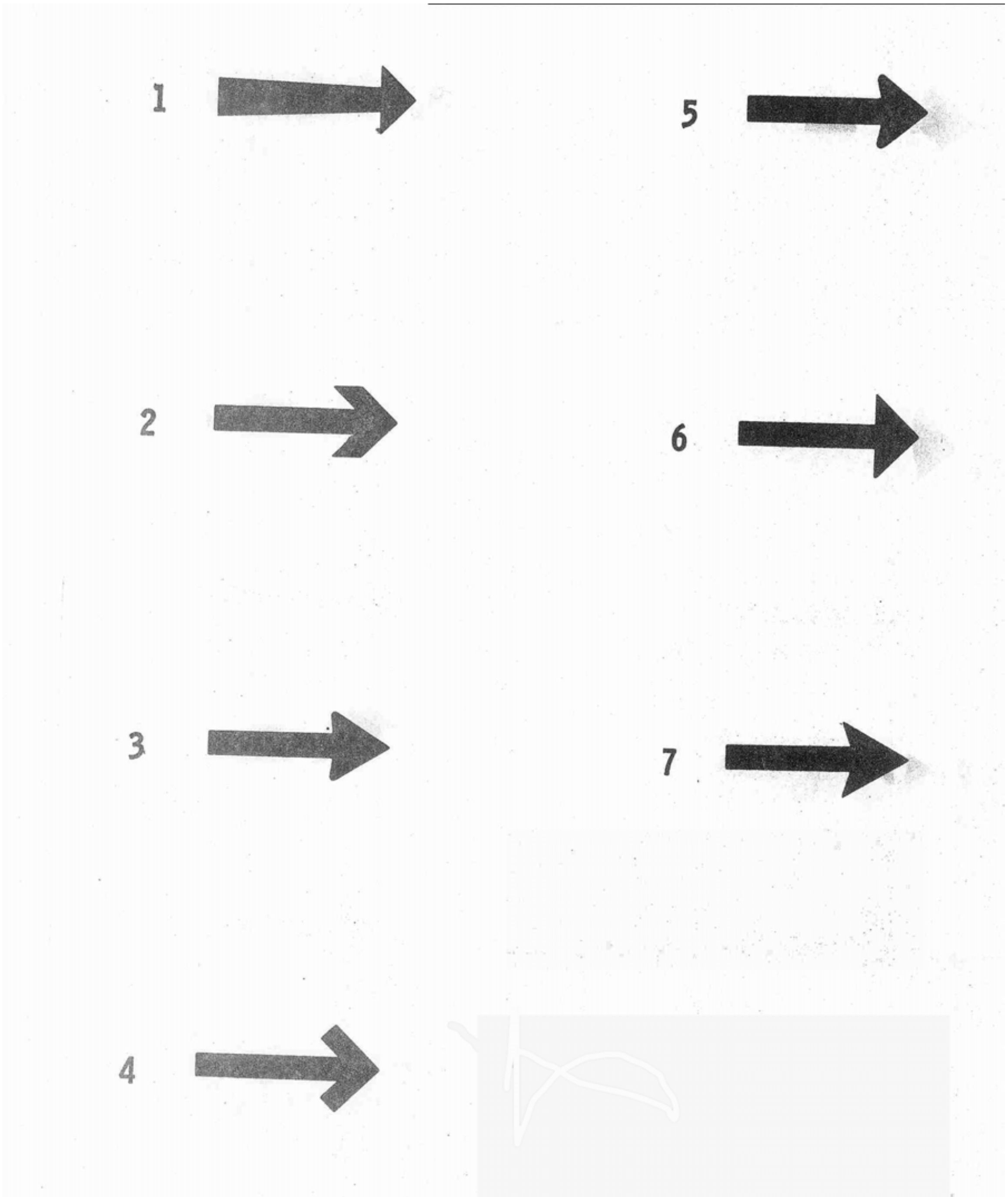


FIGURE 5 Study 2: Arrow shapes tested by Markowitz, et al., 1968.

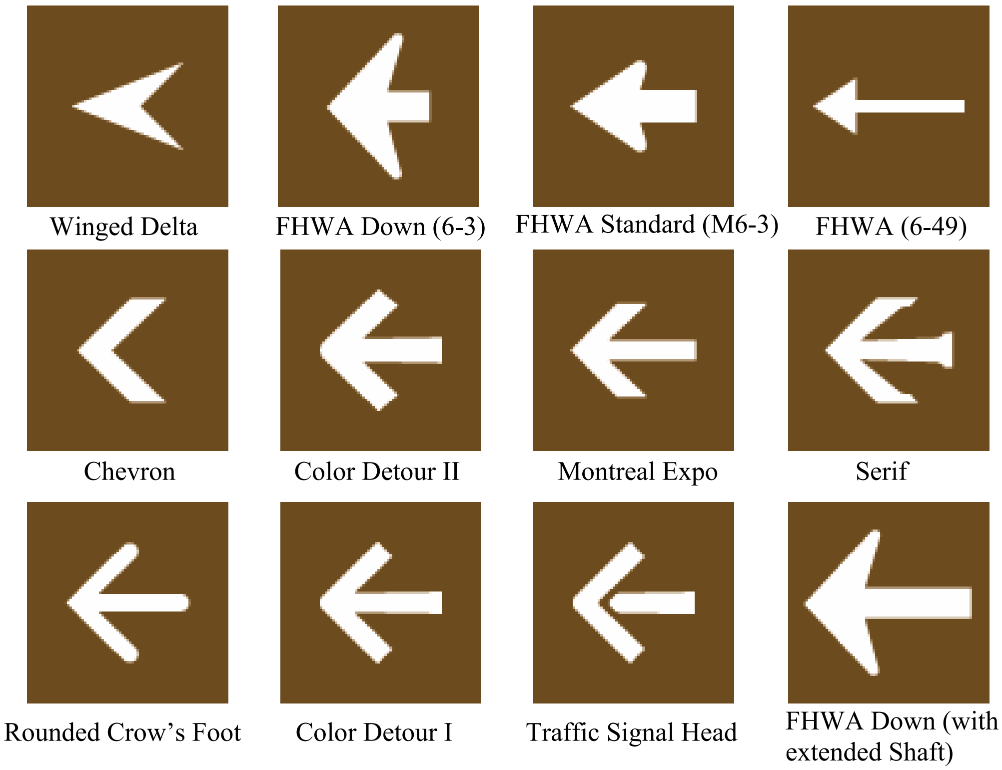


FIGURE 6 Study 2: Arrow shapes used in current study.

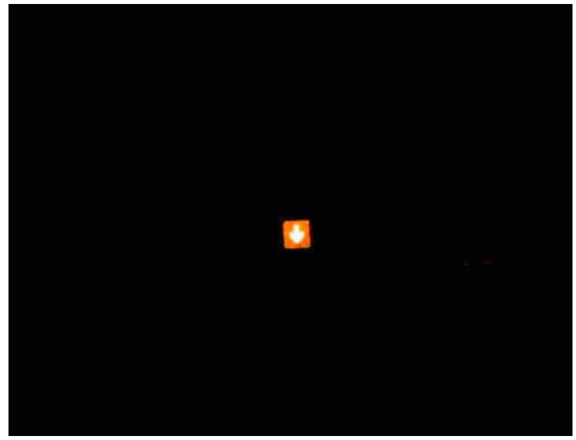


FIGURE 7 Study 2: Day and night view of experimental stimuli.

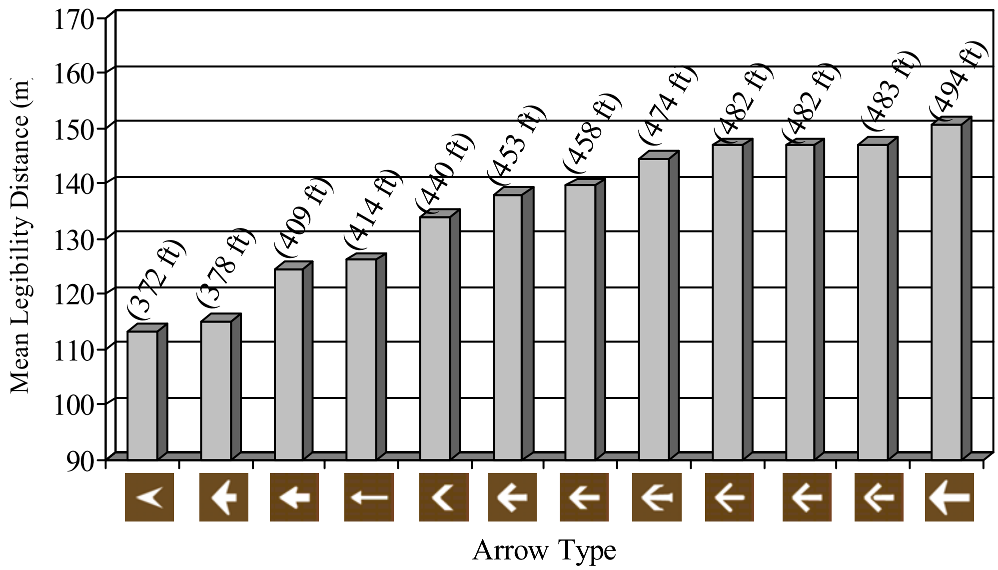


FIGURE 8 Study 2: Mean legibility distances for guide sign arrow styles.