

Regional Differences in Preferences for Median Crossover Signing

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Described in this paper is a study of advance warning signs for median crossovers on divided highways. Candidate crossover signs were identified from a literature review, survey of current state practices, and discussions with FHWA personnel. Seven of these signs were selected for further testing in a laboratory study for legibility, understanding, and driver preference. Sixty subjects representing a cross-section of drivers participated in the study: 30 at the Turner-Fairbanks Highway Research Center in McLean, Virginia, and 30 at the University of Missouri-Rolla in Rolla, Missouri. Two of the seven signs were word messages and five were symbolic signs. The results from both groups of participants showed that the most appropriate word message sign would appear to be "median crossover." This sign was understood best by the participants to whom it was shown, and "crossover" was the word the majority of participants believed best conveyed the intended meaning. Of the symbolic signs tested, the one found to be the best was that of two median noses. This symbolic sign performed well in tests of legibility and understanding and was the sign least often confused with other signs. It was also the symbolic sign most preferred by the participants and was the simplest of the symbolic designs. The symbolic signs were substantially more legible than the word messages, and the symbolic design of two median noses is recommended to identify median crossovers.

Median crossovers are often provided on divided highways between intersections for the use of emergency vehicles and to accommodate minor turning movements for convenient access to adjacent roadside development. About 35 percent of the accidents that occur between intersections on four-lane highways involve median openings (1). As a result concern has been expressed that public-use crossovers may be hazardous, especially where visibility of the crossover is limited. If used, such crossovers should be signed to provide advance warning to drivers. Hazards associated with crossovers include (a) vehicles slowing down in the fast lane of a divided highway or accelerating into it, (b) vehicles turning across the divided highway, and (c) vehicles making sudden lane changes. These maneuvers may possibly lead to rear-end or broadside collisions.

The third revision of the 1978 *Manual on Uniform Traffic Control Devices* (MUTCD) (2) provides for the use of a median crossover sign (D13-1, see Figure 1) but this is a large (6- \times 3-ft) guide sign and there may not be sufficient room on suburban divided highways to erect such a large sign. Also, it is not the color that is customarily used for warning messages.

The MUTCD does not currently suggest an advance warning sign for median crossovers, although it does suggest that a green and white advance message sign showing the distance to the crossover (D13-2) may be used.

The principal findings of a study to determine the most appropriate design of an advance warning median crossover sign are discussed in this paper. The objective of the study was to identify alternative designs for median crossover signs from a nationwide review of practices for signing median crossovers and related literature on traffic signs. These alternative designs were then tested for legibility, recognition, meaning, and preference. They were first tested at the Turner-Fairbanks Highway Research Center in McLean, Virginia, and later at the University of Missouri-Rolla, thus enabling a comparison to be made between the results obtained in Virginia and those obtained in Missouri.

METHOD

Participants

The Virginia participants were paid volunteers recruited from among research fellowship students and computer center staff at the Turner-Fairbanks Highway Research Center and from a list of participants in previous experiments at the center.

Thirty participants were tested, 10 (5 males and 5 females) in each of the following age groups: 17 to 29, 30 to 49, and 50 and over. The mean age of participants in each group was 22.6, 40.4, and 58.6 years, respectively. All participants had their vision tested on an Ortho-Rater to ensure corrected visual acuity of 20/33 or better and to ensure normal color vision. The mean visual acuity was 20/20.

The Missouri participants were unpaid volunteers recruited from among psychology and civil engineering students, staff, faculty, and wives of faculty members at the University of Missouri-Rolla. Thirty subjects in the 17 to 29, 30 to 49, and 50

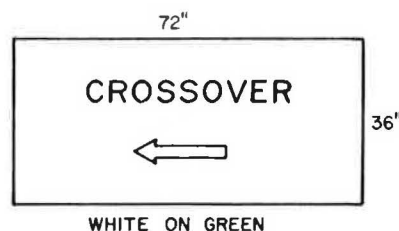


FIGURE 1 Median crossover sign (D13-1) (2).

and over age groups were tested. The mean age of participants in each group was 20.7, 41.2, and 58.3 years, respectively. The differences in mean ages for the Missouri and Virginia participants were fairly small.

The only method available for testing to ensure corrected visual acuity of 20/30 or better was a Snellen Eye Chart, which only allowed visual acuity to be classified as 20/20 or 20/30. Unfortunately, color vision could not be tested but their color vision was correct according to each participant and no one had problems with colors during the experiment.

Apparatus

Seven candidate signs for median crossovers were studied in the experiment. These included five symbolic designs and two word signs. The design of the signs came from several sources, including a survey of state highway departments (two signs), a literature review (one sign), FHWA personnel (two signs), and a Virginia crossover sign. The word signs included "crossover," as this is the wording on the signs in Revision 3 of the 1978 *Manual on Uniform Traffic Control Devices*, and "median opening." Questions about wording were included in the last part of the experiment. The 7 signs along with the 13

distractor signs used in the experiment are shown in Figure 2. Nine other sign designs (from the same sources) were considered, but in order to keep testing time to approximately 1 hr, only a limited number of signs could be tested. The other designs considered are shown in Figure 3. When time was available, the "median crossover" sign was shown to the Missouri participants.

At the suggestion of the FHWA Office of Traffic Operations, all the signs tested were black on yellow diamond warning signs, with the exception of the Virginia crossover sign and the permissive U-turn sign suggested by the Office of Traffic Operations. Instead of a green ring to denote a permissive sign as has been tested in previous sign studies (3) the Office of Traffic Operations suggested using a green periphery (see Figure 2). The signs were composed on a computer graphics system and superimposed onto a digitized photograph of a median crossover from which slides were made.

Thirteen signs were used as distractors. These included a permissive right-turn sign, similar to the permissive U-turn sign, and a railroad crossbuck outlined in red, which was part of another FHWA study. Of 11 signs from the MUTCD, 10 were chosen because they had already been drawn on the computer graphics system. A type 3L object marker was also used because the Virginia crossover sign was similar in size to

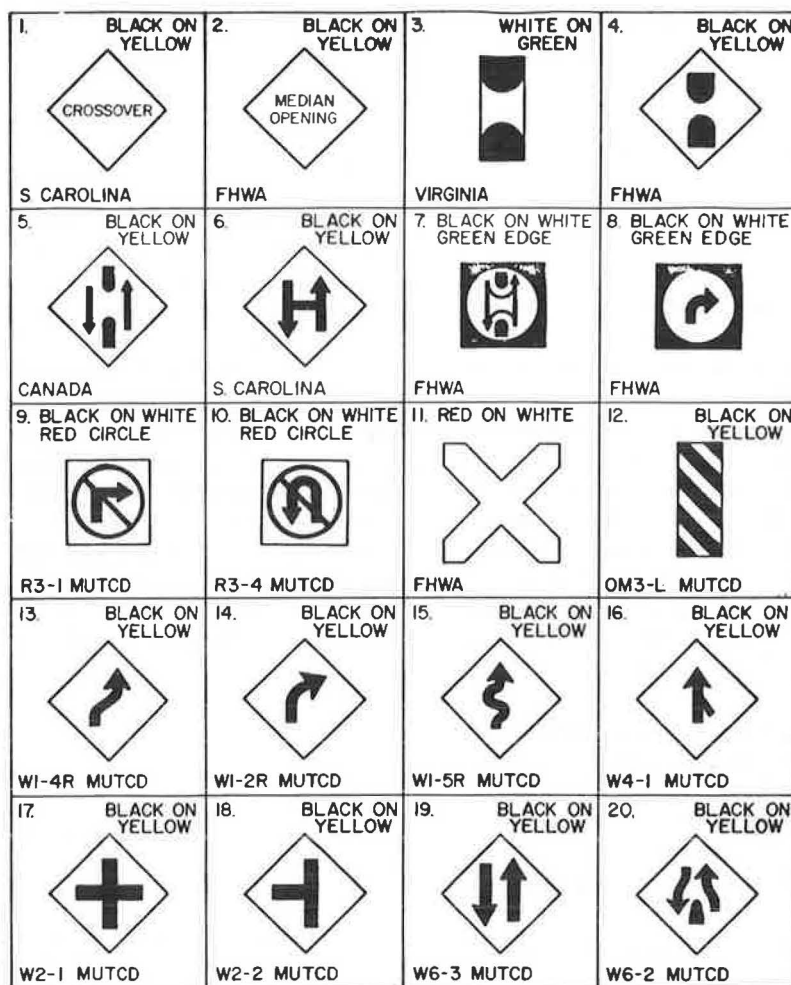


FIGURE 2 All distractor and test signs used in experiment.

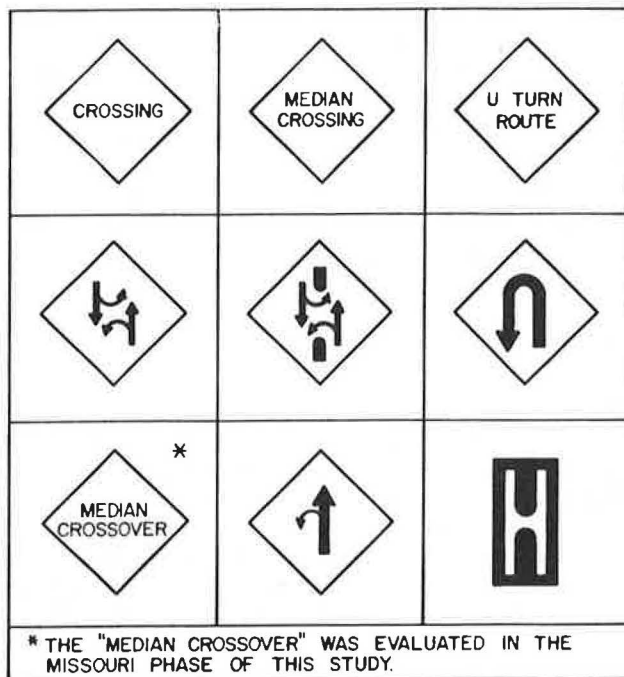


FIGURE 3 Additional signs considered for use in experiment.

an object marker. All distractor and test signs used are shown in Figure 2.

The slides were rear-projected onto a translucent screen. The size of the projected image of the signs was 2-3/8 in. from point to point of the yellow diamond in a 16-5/8- × 10-1/2-in. background scene of a median crossover. This size was chosen so that the participants with the best eyesight, although they could see a yellow and black sign, for example, could not recognize the meaning of familiar signs at the farthest distance from the image (110 ft). This was purely a laboratory experiment and no attempt was made to relate the distances measured to equivalent distances for standard-sized signs.

The experiment was conducted in a concrete tunnel approximately 12 × 12 × 120 ft underneath the structures laboratory at the Turner-Fairbanks Highway Research Center in McLean, Virginia. The slide projector and hanging screen were set up at one end of the tunnel.

The same set of slides was shown to the Missouri participants with the addition of "a median crossover" sign. The slides were again rear-projected using exactly the same type of slide projector as that used in Virginia except that it had a smaller screen and stood on a table. A facility equivalent to the tunnel in Virginia was not available so the test was conducted in the third floor corridor of the civil engineering building at the University of Missouri-Rolla.

Procedure

The participants completed a biographical data and consent form first. If they wore corrective lenses for driving, they also wore them during the test. The same procedure was followed in Missouri and Virginia.

Legibility and Meaning

The instructions for Parts I and II of the test were read to the subjects. After answering any questions the participants might have had, the examiners presented the first slide on the screen. The participants walked individually toward the projected sign until they could identify any feature on the sign. The feature and the distance at which it was identified were recorded. This procedure was repeated until all the major features of each sign had been identified.

The participants were also instructed to give the meaning of the sign as soon as they believed they knew what it meant. If they gave the wrong meaning, they were instructed to try again, and their error was recorded as a misinterpretation.

When all of the features of the sign had been identified, the participant walked back to the 110-ft mark, the next slide was presented, and the procedure was repeated. This process was repeated until the participant had seen all 20 slides. The slides were presented in random order (which was different for each participant) with the proviso that the first two signs were not crossover signs. In this way the participant had some practice in the procedure before seeing a candidate sign, although they were not told this.

Recognition

After the participants had completed the legibility and meaning section of the test, the intended meaning of the crossover signs was explained to them and they were given prints of the seven signs to become familiar with them. The next section of the test concerned recognition of the signs once their meaning was known by the participants.

The instructions for Part III were read to the subjects and they were again shown the 20 slides, but in a different random order. The participants walked individually toward the projected sign until they could identify it. Participants were encouraged to guess the meanings of the signs as far away as possible from the screen so as to maximize confusion. All instances of confusion and the distance at which they occurred and the distance at which each sign was correctly identified were recorded.

When each sign had been correctly identified, the participant walked back to the 110-ft mark, the next slide was presented, and the procedure was repeated. This process was repeated until each participant had seen all 20 slides.

Preference

The last part of the experiment was a preference test. The participants were instructed to arrange prints of the seven crossover signs in order from the one they liked best to the one they liked least. The order in which the participants ranked each sign was then recorded. The participants were then asked seven questions about crossovers in general. A full description of the methodology is presented by Worsey (4).

RESULTS

Legibility

Although the different experimental conditions preclude statistical comparison, the data in Table 1 indicate that the legibility distances for both groups of participants were similar. The distances for the Missouri participants were slightly longer in most but not all cases.

Understanding

The data in Table 2 indicate that the Missouri participants had more difficulty in guessing the meaning of the signs than the Virginia participants. This was particularly true for the symbol signs although only the arrows sign was guessed by more than one-half of the participants in Virginia. However, this difference was not statistically significant.

The total number of misinterpretations of the signs by uncued participants was approximately the same (98 in Virginia and 103 in Missouri). The data in Table 2 indicate that the Missouri participants generally misinterpreted the signs more often than the Virginia participants. They also failed more frequently to guess the meaning of the signs, with the exception of the permissive U-turn sign. However, these differences were not statistically significant.

In Virginia, the arrows sign was misinterpreted most often, followed by the nose plus arrows sign and the crossover sign. In Missouri, the nose plus arrows sign was misinterpreted most

often, followed by the "crossover" sign and the permissive U-turn sign. The most frequent misinterpretations of the crossover signs were basically the same for both groups of participants.

The data in Table 2 indicate that the mean distances at which participants in both states understood the meaning of the signs were similar. The word signs were understood at much shorter distances, and of the symbol signs, the arrows sign was understood at the farthest distance.

Recognition

The data in Table 3 indicate that the mean distances at which participants in both states recognized the signs were somewhat similar, with the Missouri participants recognition distances being slightly shorter for all the signs except the arrows sign. The greatest difference was for the "median opening" sign, which Missouri participants recognized at a mean distance approximately 12 ft shorter than the distance Virginia participants recognized it. In both sets of results the Virginia crossover sign was recognized at by far the greatest average distance and the worded signs were recognized at the shortest distances.

The total number of instances in which participants confused the crossover signs with other signs was 20 for both data sets. These confusions followed a similar pattern for both data sets. In Missouri all the signs were recognized by all the participants, whereas in Virginia one participant did not recognize the crossover nose sign.

TABLE 1 COMPARISON OF SIGN FEATURE MEAN LEGIBILITY DISTANCES (ft)

Feature	State	Type of Sign						
		1 Crossover	2 Median Opening	3 Crossover Virginia	4 Crossover Nose	5 Crossover Nose Plus Arrows	6 Crossover Arrows	7 Permis- sive U-Turn
Sign shape	Virginia	100	107	63	102	104	108	101
	Missouri	104	106	65	102	103	109	102
Sign color	Virginia	106	108	99	106	107	108	100
	Missouri	109	108	96	108	108	105	86
Symbol or letter color	Virginia	75	71	57	79	84	89	55
	Missouri	83	76	55	93	95	101	76
Symbol or letter presence	Virginia	48	54	52	83	85	90	66
	Missouri	41	50	69	93	95	101	85
Median nose presence	Virginia	N/A	N/A	34	36	35	N/A	26
	Missouri	N/A	N/A	37	40	35	N/A	29
Road pattern	Virginia	N/A	N/A	N/A	N/A	34	52	25
	Missouri	N/A	N/A	N/A	N/A	38	59	28
Crossover movement	Virginia	N/A	N/A	N/A	N/A	N/A	48	25
	Missouri	N/A	N/A	N/A	N/A	N/A	50	27
Read legend	Virginia	.12	.11	N/A	N/A	N/A	N/A	N/A
	Missouri	.12	.12	N/A	N/A	N/A	N/A	N/A

NOTE: N/A = not applicable.

TABLE 2 COMPARISON OF THE UNDERSTANDING OF SIGNS IN VIRGINIA AND MISSOURI

	State	Type of Sign						
		1 Crossover	2 Median Opening	3 Crossover Virginia	4 Crossover Nose	5 Crossover Nose Plus Arrows	6 Crossover Arrows	7 Permis- sive U-Turn
Understanding distance (ft)	Virginia	14	11	25	33	31	41	22
	Missouri	13	12	26	29	28	37	19
Correct answer first attempt (freq)	Virginia	16	27	13	18	15	13	9
	Missouri	12	24	12	9	11	14	9
Incorrect guess before correct answer (freq)	Virginia	10	3	4	5	8	11	6
	Missouri	13	5	2	4	4	8	5
Did not make a correct guess (freq)	Virginia	4	0	13	7	7	6	15
	Missouri	5	1	16	17	15	81	16
Misinterpretations (freq)	Virginia	18	5	10	11	18	23	13
	Missouri	20	7	8	15	24	12	17
Subjects who would not attempt to guess meaning (freq)	Virginia	0	0	8	3	2	0	10
	Missouri	2	0	10	9	4	1	8

Preference

The data in Table 3 indicate that the Virginia participants had a much more clearly defined set of preferences than the Missouri participants. (Their mean preference rankings ranged from 3.07 to 6.00, whereas the Missouri participants' mean preference rankings had much less spread, from 3.52 to 4.76.)

The permissive U-turn sign, followed by the Virginia crossover sign, was least preferred by Virginia participants, whereas the Virginia crossover sign, followed by the permissive U-turn sign, was least preferred by Missouri participants. The Virginia participants most preferred the crossover nose sign, followed by the nose plus arrows sign and then the word signs. The Missouri participants most preferred the "median opening" sign, followed by the crossover nose sign and then the arrows and nose plus arrows signs. The rankings given to each sign by the Virginia and Missouri participants were found

to be significantly different for all the signs except for "crossover" and the Virginia crossover signs.

All participants were asked their opinions on median crossovers; 80 percent of the Missouri participants considered crossovers to be hazardous whereas only 73 percent of Virginia participants considered them hazardous (Table 4). The types of hazards participants associated with median crossovers were slightly different for both groups. Traffic accelerating into the fast lane was considered as much of a hazard as traffic slowing in the fast lane by Missouri participants but not Virginia participants (Table 5). Missouri participants appeared to be more concerned with traffic crossing the divided highway than the Virginia participants (13 participants, compared with 4 Virginia subjects, mentioned traffic pulling out in front of them or turning traffic). One Missouri participant mentioned gravel crossovers as being dangerous.

The responses to the question, "What effect would a

TABLE 3 COMPARISON OF THE RECOGNITION AND PREFERENCE RANKINGS OF SIGNS IN VIRGINIA AND MISSOURI

	State	Type of Sign						
		1 Crossover	2 Median Opening	3 Crossover Virginia	4 Crossover Nose	5 Crossover Nose Plus Arrows	6 Crossover Arrows	7 Permis- sive U-Turn
Recognition distance (ft)	Virginia	39	42	82	48	47	57	61
	Missouri	34	29	76	48	45	60	58
Confusions (freq)	Virginia	2	2	0	2	8	5	1
	Missouri	0	2	0	3	9	6	0
Subjects who did not know the meaning (freq)	Virginia	0	0	0	1	0	0	0
	Missouri	0	0	0	0	0	0	0
Mean preferences (rank)	Virginia	3.47	3.37	4.57	3.07	3.23	4.30	6.00
	Missouri	4.10	3.52	4.76	3.62	3.79	3.66	4.62

TABLE 4 SUBJECTS' OPINIONS ON MEDIAN CROSSOVERS

	Yes				No			
	Virginia	Percent	Missouri	Percent	Virginia	Percent	Missouri	Percent
Do you think median crossovers constitute a hazard on a divided highway?	22	73	24	80	8	27	6	20
Do you think a sign would help identify a crossover if you wanted to use one?	29	97	29	97	1	3	1	3
Would the addition of a distance plate help you locate a crossover?	28	93	25	83	2	7	5	17

TABLE 5 TYPES OF HAZARDS ASSOCIATED WITH MEDIAN CROSSOVERS

Hazard	Frequency	
	Virginia	Missouri
Traffic slowing in fast lane	20	10
Traffic accelerating into fast lane	8	10
Turning traffic	4	8
Sudden lane changes	3	2
Traffic pulling out in front	0	5
Rear-end collisions	7	6
Broadside collisions	4	5
None	2	5

crossover sign have on your driving?" were basically the same for both sets of participants (Table 6). However, a larger number of the Missouri participants indicated that they would slow down if they saw a crossover sign (11 compared to 5 in Virginia) and that such a sign would have no effect on their driving (3 compared to 1 in Virginia).

When asked about word message signs, "crossover" was chosen by most participants in both groups (67 percent in Virginia and 76 percent in Missouri) as best conveying the intended meaning. "Opening" was the next-favored sign by the Virginia participants (23 percent) and "crossing" was the next favored by the Missouri participants (17 percent).

When asked the question, "Which word best conveys the presence of such a facility to you?" subjects responded as follows:

Crossover		Crossing		Opening	
Virginia (%)	Missouri (%)	Virginia (%)	Missouri (%)	Virginia (%)	Missouri (%)
20	23	3	5	7	2
67	76	10	17	23	7

When asked, "Would the addition of the word "median" help to clarify the meaning of the sign?" subjects responded as follows:

Yes		No	
Virginia (%)	Missouri (%)	Virginia (%)	Missouri (%)
24	22	6	8
80	73	20	27

The distances at which participants responded that they believed the sign should be placed in front of a crossover tended to be greater in Missouri than in Virginia. This is reflected in the mean distances, which were 838 ft in Virginia and 1,322 ft in Missouri.

Word Message Signs

A median crossover sign can be worded or symbolic. The "median opening" sign was the word message sign understood best by uncued participants in Virginia, and the majority of them chose "crossover" as conveying the intended meaning better than "crossing" or "opening." A "median crossover" sign was therefore made and shown to those Missouri participants for which there was time available to do so.

The data in Table 7 indicate that the legibility, understanding, and recognition distances for the "median crossover" sign were about the same as that for the other word message signs. An intermediate percentage of uncued participants guessed the meaning of the "median crossover" sign without a wrong guess first (87 percent compared with 90 percent of the Virginia participants and 80 percent of the Missouri participants for the "median opening" sign). All of the participants eventually managed to guess the meaning of the "median crossover" sign. There were only three misinterpretations of the "median crossover" sign by the uncued participants compared with five for the "median opening" sign in Virginia and seven in Missouri. There were no instances of confusion with other signs once the participants had had the meaning of the sign explained to them, whereas the "median opening" sign was confused with other signs twice in both Virginia and Missouri.

TABLE 6 EFFECT OF SIGN ON SUBJECTS' DRIVING

Effect	Frequency	
	Virginia	Missouri
Would look for sign if wanted to use a crossover	12	7
Would change lanes if wanted to use a crossover	1	1
Would signal if wanted to use a crossover	1	0
Would look for slowing traffic	15	12
Would slow down	5	11
Would change lanes	4	3
None	1	3

TABLE 7 COMPARISON OF THE "MEDIAN CROSSOVER" SIGN WITH THE "MEDIAN OPENING" AND "CROSSOVER" SIGNS

	Crossover		Median Opening		Median Crossover
	Virginia	Missouri	Virginia	Missouri	Missouri
Legibility distances (ft)					
Sign shape	100	104	107	106	102
Sign color	106	109	108	108	107
Legend color	75	83	71	76	93
Letter presence	48	41	54	50	49
Read legend	12	12	11	12	12
Understanding distance (ft)	14	13	11	12	12
Recognition distance (ft)	39	34	42	29	28
Correct answer	16	12	27	24	21
First attempt (freq)					
Percent	53	40	90	80	87
Incorrect answer	10	13	3	5	3
Before correct one (freq)					
Percent	33	43	10	17	13
Don't know (freq)	4	5	0	1	0
Percent	13	17		3	
Misinterpretations (freq)	18	20	5	7	3
Confusions (freq)	2	0	2	2	0

CONCLUSIONS

From this study there appears to be justification for the use of signs indicating the presence of a median crossover that can be used by the general public. The majority of participants tested in both groups perceived crossovers as hazardous locations, and from their responses to the questions they were clearly aware of the potential hazards that crossovers can cause. Most participants indicated that if such a sign were installed, it would likely have a beneficial effect on their driving behavior.

Although word message signs can usually be understood once they are read, they are not as legible as symbolic signs. Of the symbolic signs, the arrows sign had the best average legibility and understanding distances in both Virginia and Missouri, but it had by far the most misinterpretations by participants in Virginia. Although it was ranked second among the symbol signs by the Missouri participants in terms of preference, it was ranked fifth by the Virginia participants and is therefore not recommended.

Of the other symbolic signs, the permissive U-turn sign had low average legibility and understanding distances in both Virginia and Missouri and was not well understood by the participants. This is reflected in its being ranked last in the preference test by the majority of participants in Virginia and many in Missouri. The significance of the green periphery to indicate a permissive sign was not understood, and this sign is not recommended.

Of the symbolic signs, the Virginia crossover sign also had low average legibility distances and again was not well understood by uncued participants in both Virginia and Missouri. In the preference test it was not well liked by either group of participants. However, it did very well in the recognition test in both Virginia and Missouri, presumably because of its different color and shape. It was recognized at a far greater average distance than any of the other signs and was the only sign not confused in Virginia. Several participants in both Virginia and

Missouri mentioned that if they had initially known the meaning of the sign they believed it would be the best one to use. The meaning of the sign was not obvious to the participants in either Virginia or Missouri. However, in Virginia the sign is placed at the median opening, which should lead to a high degree of self-education.

Of the remaining symbolic signs, the nose plus arrows sign had slightly better average legibility distances but the crossover nose sign had slightly better average understanding and recognition distances in both Virginia and Missouri. The latter sign also had fewer misinterpretations and instances of confusion in the understanding and recognition sections of the experiment than the former in both Virginia and Missouri. It was also given the best average rank out of all the signs in the Virginia preference test and the best average rank out of the symbol signs in Missouri. It also had the simplest design of all the signs tested. Of the symbol signs tested, the crossover nose sign (see Figure 2) is recommended to indicate the presence of a median crossover.

Despite the different experimental conditions, the legibility, understanding, and recognition distances of all the signs were similar for both groups of participants. However, the Missouri participants had more difficulty identifying the green (Virginia crossover and permissive U-turn) signs than the Virginia participants.

The Missouri participants had more difficulty than the Virginia participants in guessing the meaning of nearly all the signs, especially the symbol signs. They misinterpreted the signs more often and could not guess the meaning of the signs as frequently.

The greatest differences between the Virginia and Missouri results were in the preference rankings the participants gave to the signs. The Virginia participants had a much more clearly defined set of preferences, whereas the Missouri participants' preferences were much more evenly spread with little agreement among the participants. The Missouri participants also

TABLE 8 SUMMARY OF FAVORABLE AND UNFAVORABLE FINDINGS FOR EACH CROSSOVER SIGN

Sign Type	Favorable Aspects	Unfavorable Aspects
Word message	Usually understood once read	Much less legible than symbolic signs
Arrows	Most legible sign	Misinterpreted the most
	Understood the farthest away	Not liked by subjects
Permissive U-turn	Not confused with other signs	Legible at shorter distances
		Understood the closest out of symbol signs
		Least liked by most subjects
		Meaning of green periphery not understood
Virginia crossover	Recognized the farthest away	Legible at shorter distances
	Not confused with other signs	Understood the second closest out of symbol signs
		Not liked by subjects
		Not understood well
Nose plus arrows	Second most legible of symbol signs	
Crossover nose	Understood the second farthest away	
	Misinterpreted the second least of symbol signs	
	Most preferred of symbol signs	

preferred the word message signs more than the Virginia participants. This was especially true for females, particularly those over 50. The Virginia participants preferred the crossover nose and nose plus arrows signs over the word message signs, whereas the Missouri participants preferred the "median opening" sign.

Although there were some differences in the Virginia and Missouri results, the same conclusions were reached—that a "median crossover" sign would be the best word message sign to use and the crossover nose sign would be the best symbolic

sign to use to indicate the presence of a median crossover. Despite the Missouri participants' preferences for word message signs, legibility of the symbolic signs was so much greater that the crossover nose sign is the sign recommended for field evaluation to identify median crossovers. Table 8 contains a summary of the findings pertaining to the signs tested in this study and the impressions and preferences expressed by the subjects.

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