TECHBRIEF

Enhancing Conspicuity for Standard Signs and Retroreflectivity Strips on Posts

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FHWA Contact: Laura Mero (0000-0002-2048-9988), Office of Safety Research and Development, (202) 493-3377, Laura.Mero@dot.gov

INTRODUCTION

The 2009 *Manual on Uniform Traffic Control Devices* (MUTCD) provides various options for enhancing the conspicuity of traffic signs (Federal Highway Administration 2009). For the purposes of this study, "conspicuity" refers to the quality or state of standing out and attracting attention. MUTCD examples of enhanced conspicuity for signs are shown in figure 1 through figure 6. Improving the conspicuity of signs may have direct and indirect effects on safety, such as increasing compliance with signs, decreasing speeds, reducing crashes, or other possible improvements. Although the MUTCD provides many options for conspicuity treatments, there is little information or research on the effectiveness of conspicuity treatments on driver behavior. There has been some documentation of multiple conspicuity enhancements being made simultaneously; however, there is little information or research on the effectiveness of conspicuity treatments on driver behavior. State departments of transportation (DOTs) may be considering or using other new or trial treatments that may be effective in influencing driver behavior.

Source: FHWA.

U.S. Department of Transportation
Federal Highway Administration

Turner-Fairbank
Highway Research Center

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

https://highways.dot.gov/research

Figure 1. Graphic. Example of enhanced conspicuity for signs: W16-15P (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

Figure 2. Graphic. Example of enhanced conspicuity for signs: red or orange flags (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

Figure 3. Graphic. Example of enhanced conspicuity for signs: W16-18P (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

Figure 4. Graphic. Example of enhanced conspicuity for signs: diagonally striped retroreflective sheeting (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

Figure 5. Graphic. Example of enhanced conspicuity for signs: vertical retroreflective strip (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

Figure 6. Graphic. Example of enhanced conspicuity for signs: supplemental beacon (Federal Highway Administration 2009).

Source: FHWA (MUTCD).

OBJECTIVE

This research project explores and evaluates the effectiveness of enhanced conspicuity for standard signs.

APPROACH

The research team conducted a literature and state-of-the-practice review to identify methods for enhancing sign conspicuity. The research team also reviewed the MUTCD and consulted with the Traffic Control Devices Pooled Fund Study (TCD PFS) members, who were part of the project panel, to determine which treatments were being used in their States, which treatments they had found to be effective, and which treatments they thought should be included in the study. Although the research team considered including novel conspicuity treatments in the study, the decision was made, based on conversations with the TCD PFS members, to focus the study on examining conspicuity treatments that are currently included in the MUTCD.

Because conspicuity—especially retroreflectivity—cannot be reliably translated to any digital medium, researchers employed field experiments to provide the level of ecological validity necessary to produce actionable insight regarding these treatments. In other words, a laboratory experiment could not provide results that could be generalized to real-world scenarios. The research team collected data using two approaches: observational field data collection, and an eye-tracking field study. This two-part approach allowed researchers to determine how conspicuity treatments influence driver behavior (observational data), whether the treatments result in drivers spending more time looking at signs that have treatments versus signs that do not have treatments (eye-tracking data), or whether there are cases where drivers are seeing the signs but not changing their behavior.

Eye-Tracking Field Study

For the eye-tracking field study, participants drove along a predetermined 24-mi route in Elliston, VA. The research team installed three speed limit sign treatments along the test route and used one control Speed Limit sign. The study examined driver eye-glance behavior toward each of the test signs and the control sign.

Observational Field Data Collection

The research team worked with three State DOTs from Iowa, New Hampshire, and Virginia to collect observational field data. The team selected the States based on TCD PFS member States that volunteered to participate in the study and because of the proximity to the research team. This proximity allowed for efficient travel to and from research sites as needed. The team coordinated with State DOT officials to identify specific locations where enhanced conspicuity treatments could be applied. The research team implemented only one treatment per sign location. The team selected signs in locations that were well traveled so that robust sampling data could be collected for each sign. Additionally, the team focused on selecting signs that were intended to elicit specific behaviors (e.g., STOP signs, Speed Limit signs), and thus would result in more quantifiable measures. Although there were some instances in which a State requested the inclusion of a particular sign because of problematic driver behavior at the site, most signs were selected because of the aforementioned factors and proximity to other signs that were selected. Depending on the sign type, the research team evaluated some or all of the following criteria at each sign location: driver speed, stopping behavior, and turning behavior. The team examined mean speed and 85th percentile speed when driver speeds were collected.[1] The definition from the data collection devices to examine mean speeds by vehicle classification: small (<14 ft long), medium (14–20 ft in length), and large (>20 ft in length) were used. In Virginia, the signs and treatments used for the observational data collection were the same as those used in the eye-tracking field study conducted.

The literature review demonstrated there may be novelty effects from new treatments: the results produced immediately after the installation of new treatments may not be the same as the results after drivers have been exposed to the treatments for an extended period of time. Therefore, there were three data collection periods in each State: before (before treatments were installed); initial-after (immediately following installation); and second-after (approximately 2–4 mo after installation). The only exception to this approach was in New Hampshire, where there were only before and initial-after data collection periods. The conspicuity treatments were removed following the initial after period because winter tourists were arriving and may have skewed the data.

The exact dates of the data collection periods varied among the three States because of differing tourism and traffic trends, weather patterns, and other influences such as delays related to the Coronavirus pandemic. Other factors, such as data collection and device placement, varied between the States based on environmental factors and the schedules and availability of the State DOTs to install treatments. The following sections on observational field studies from Iowa, New Hampshire, and Virginia, and the eye-tracking field study from Virginia, present the methods and results for each State.

[1]The 85th percentile speed is the speed that 85 percent of drivers travel at or below.

IOWA OBSERVATIONAL FIELD DATA COLLECTION

Method

Table 1 describes the signs, conspicuity treatments, and data collection devices used in Iowa. Photos of the treatments installed at each site are shown in figure 7 through figure 10.

Table 1. Summary of data collection placement and equipment for Iowa.

SIGN	CONSPICUITY TREATMENT	DATA COLLECTION DEVICE	DATA COLLECTED
SPEED LIMIT 35	Add red flags	Speed radar devices	Driver speeds
STOP	Add red flags	Speed radar devices	Driver speeds
Curve Warning sign with 50-mph advisory speed plaque	Add beacon	Speed radar devices	Driver speeds
STOP	Add beacon	Speed radar devices	Driver speeds

Figure 7. Photo. Treatment in Iowa: Speed Limit flag.

Source: FHWA.

Figure 8. Photo. Treatment in Iowa: STOP-sign flags.

Source: FHWA.

Figure 9. Photo. Treatment in Iowa: curve beacon.

Source: FHWA.

Figure 10. Photo. Treatment in Iowa: STOP-sign beacon.

Source: FHWA.

At most sites, the research team collected data upstream from the treatment locations, where drivers could not yet see the treatments, and near each treatment. For the curve site however, instead of collecting data at the upstream location, the research team measured speed approaching the Curve Warning sign. The placement of data collection equipment varied for each treatment. The research team collected data for a minimum of 48 h at each site for each data collection period.

Data Analysis and Results

The research team compared the after-data to the before-data for each treatment. Changes in mean speeds were compared using a *t*-test to determine if the changes were significant. Changes in percentages of vehicles exceeding the speed limits were made using a test of proportions to determine statistical significance.

Mean (Average) Speeds

The changes in mean speeds for all vehicles are shown in table 2. A negative value corresponds to a decrease in speed after the installation of the treatments, and a positive value corresponds to an increase in speed after installation of the treatment. The *p*-value is also listed, and numbers in bold indicate a statistically significant change in speed at a 95-percent level of significance.

As seen in table 2, the flashing beacon resulted in slower speeds at the Curve Warning sign in both after periods by 0.3–1.3 percent. Speeds at the center of the curve saw no statistically significant decreases in the first after period. However, in the second after period, while speeds decreased significantly for the northbound direction, they increased significantly for the southbound.

The STOP-sign beacon site saw large decreases in speed near the intersection: 2.6 mph and 1.9 mph for southbound traffic for the two after-data collection periods, respectively. The beacons on the northbound approach saw statistically significant decreases in mean speeds near the intersection in the first after period; however, a significant increase in speeds occurred in the second after period. The northbound approach in the second after period saw drivers traveling at a lower mean speed at the upstream location. For the upstream location, data-collection equipment was placed on the nearest signpost located at least 100 ft upstream of the intersection.

The STOP-sign flags site also saw a small, statistically significant decrease near the intersection in the after periods. The research team noted little to no change upstream.

The Speed Limit flags site saw a small drop in mean speed downstream of the northbound Speed Limit sign in the first after-installation period and then a larger drop at the second after period. However, the decrease in mean speeds upstream of the Speed Limit sign with flags was greater than that seen downstream. For southbound traffic, speeds increased downstream of the treatment in the first after period by almost 1 mph, and a similar increase was also seen for upstream traffic. In the second after period, mean speed downstream of the treatment decreased by almost 3.5 mph; however, upstream of the treatment, mean speeds decreased by 4.8 mph. Therefore, the Speed Limit flag appears to have had little effect on vehicles' mean speeds.

Table 2. Change in mean speed for all vehicles for Iowa.

SIGN		LOCATION	POSTED/ ADVISORY SPEED (MPH)	BEFORE MEAN SPEED (MPH)	INITIAL-AFTER MEAN SPEED (MPH)	SECOND-AFTER MEAN SPEED (MPH)	INITIAL-AFTER CHANGE IN SPEED (MPH)	SECOND-AFTER CHANGE IN SPEED (MPH)
Flashing beacon on Curve Warning sign	Northbound	At Curve Warning sign	45	45.606	44.284	44.747	**–1.32 (*p* << 0.01)**	**–0.86 (*p* << 0.01)**
		Center of curve	55/50	49.698	49.360	49.376	–0.34 (*p* = 0.0516)	**–0.32 (*p* = 0.048)**
	Southbound	At Curve Warning sign	55	56.190	55.460	55.843	**–0.73 (*p* << 0.01)**	**–0.35 (*p* = 0.0372)**
		Center of curve	55/50	48.696	48.559	49.198	–0.14 (*p* = 0.372)	**0.50 (*p* = 0.001)**

Table 2. Change in mean speed for all vehicles for Iowa. (Continued)

SIGN		LOCATION	POSTED/ ADVISORY SPEED (MPH)	BEFORE MEAN SPEED (MPH)	INITIAL-AFTER MEAN SPEED (MPH)	SECOND-AFTER MEAN SPEED (MPH)	INITIAL-AFTER CHANGE IN SPEED (MPH)	SECOND-AFTER CHANGE IN SPEED (MPH)
STOP-sign beacon	Northbound	Upstream	55	52.483	52.275	50.299	–0.21 (p = 0.491)	**–2.18 (p << 0.01)**
		Near intersection	55	39.801	38.681	41.270	**–1.12 (p << 0.01)**	**1.47 (p << 0.01)**
	Southbound	Upstream	55	57.476	57.016	56.916	**–0.46 (p = 0.0384)**	**–0.56 (p = 0.0168)**
		Near intersection	55	42.145	39.501	40.213	**–2.64 (p << 0.01)**	**–1.93 (p << 0.01)**
STOP-sign flags	Northbound	Upstream	35	28.464	28.544	28.318	0.08 (p = 0.634)	–0.15 (p = 0.364)
		Near intersection	35	31.652	31.313	31.183	**–0.34 (p = 0.004)**	**–0.47 (p << 0.01)**
Speed Limit flag	Northbound	Upstream	55	55.746	53.911	53.383	**–1.84 (p << 0.01)**	**–2.36 (p << 0.01)**
		Downstream of speed limit sign	35	36.665	36.384	34.426	–0.28 (p = 0.268)	**–2.24 (p << 0.01)**
	Southbound	Upstream	55	45.584	46.581	40.751	**1.0 (p << 0.01)**	**–4.83 (p << 0.01)**
		Downstream of Speed Limit sign	35	35.450	36.314	32.022	**0.86 (p << 0.01)**	**–3.43 (p << 0.01)**

Mean Speeds for Large (Heavy) Vehicles

When looking at changes in mean speed for heavy vehicles, the research team observed only a few statistically significant decreases. For northbound traffic on the curve with flashing beacons on the Curve Warning sign, the research team found the mean speed of heavy vehicles to be almost 2 mph slower (compared to 1.5 mph slower upstream) in the first after period at the center of the curve ($p < 0.01$) and 1.55 mph slower for the second after period ($p < 0.01$).

Large decreases in mean speed for heavy vehicles were also seen for the southbound approach on the intersection with the STOP-sign beacon. Mean speeds near the intersection decreased 3.12 mph in the first after period ($p = 0.0180$) and 3.78 mph in the second after period ($p = 0.004$). However, northbound traffic at this intersection saw a 2.54-mph increase in mean speed near the intersection for heavy vehicles in the second after period ($p < 0.01$).

85th-Percentile Speeds

The research team also analyzed changes in 85th-percentile speed, and the results are shown in table 3. As the speed-collection equipment only provided the speed to the nearest mile per hour, results are reported as changes to the nearest mile per hour. A negative value corresponds to a decrease in 85th-percentile speed once the treatment was installed. At the site with the beacon added to the Curve Warning sign, there were changes in the 85th-percentile speed ranging from a 1-mph increase to a 2-mph decrease.

The STOP-sign beacon saw decreases in 85th-percentile speed near the intersection for the southbound approach. All vehicles reduced 85th-percentile speed by 3 mph and 2 mph for the two after periods, while heavy vehicles reduced their 85th-percentile speeds by 7 mph and 5 mph in the two after periods, respectively.

The research team observed almost no change near the intersection for the STOP-sign flag site, and they saw only minor changes upstream.

The tangent section with Speed Limit flags saw decreases in 85th-percentile speed for the southbound approach in the second after period. These decreases were 5 and 4 mph slower for all vehicles and heavy vehicles upstream and 4 and 2 mph for the downstream, respectively. This decrease in speed may have been a result of drivers being more cautious in winter, even with dry pavement. Overall, however, 85th-percentile speeds downstream of the treatments saw minor decreases or increases relative to the changes seen upstream.

Table 3. Change in 85th-percentile speed for Iowa.

SIGN	APPROACH	LOCATION	CHANGE INITIAL-AFTER, ALL (MPH)	CHANGE INITIAL-AFTER, HEAVY (MPH)	CHANGE SECOND-AFTER, ALL (MPH)	CHANGE SECOND-AFTER, HEAVY (MPH)
Flashing beacon on Curve Warning sign	Northbound	At Curve Warning sign	–1	–1	–1	1
Flashing beacon on Curve Warning sign	Northbound	Center of curve	–1	–2	–1	–2
Flashing beacon on Curve Warning sign	Southbound	At Curve Warning sign	–1	0	–1	0
Flashing beacon on Curve Warning sign	Southbound	Center of curve	0	0	1	1
STOP-sign beacon	Northbound	Upstream	0	1	–3	–2
STOP-sign beacon	Northbound	Near intersection	–1	–2	1	3
STOP-sign beacon	Southbound	Upstream	–1	0	–1	–2
STOP-sign beacon	Southbound	Near intersection	–3	–7	–2	–5
STOP-sign flag	Northbound	Upstream	0	–2	1	0
STOP-sign flag	Northbound	Near intersection	0	–1	0	0
Speed Limit flags	Northbound	Upstream	–1	–1	–1	0
Speed Limit flags	Northbound	Downstream of Speed Limit sign	–1	0	–2	–1

Table 3. Change in 85th-percentile speed for Iowa. (Continued)						
SIGN	APPROACH	LOCATION	CHANGE INITIAL-AFTER, ALL (MPH)	CHANGE INITIAL-AFTER, HEAVY (MPH)	CHANGE SECOND-AFTER, ALL (MPH)	CHANGE SECOND-AFTER, HEAVY (MPH)
Speed Limit flags	Southbound	Upstream	1	0	–5	–4
Speed Limit flags	Southbound	Downstream of Speed Limit sign	1	1	–4	–2

NEW HAMPSHIRE OBSERVATIONAL FIELD DATA COLLECTION

Method

Table 4 describes the signs, conspicuity treatments, and data-collection devices used in New Hampshire. The research team used speed radar devices at all Speed-Limit-sign locations to evaluate average driver speeds. The research team also used cameras at all other sign locations.

Table 4. Summary of data collection placement and equipment for New Hampshire.

SIGN	CONSPICUITY TREATMENT	DATA COLLECTION DEVICE	DATA COLLECTED
Railroad signing	Add yellow retroreflective strip (westbound direction only)	Camera	Count of vehicles stopped on tracks
SPEED LIMIT 30	Add additional sign in the median on a U-channel sign support duplicating the size and message of the existing Speed Limit sign.	Speed radar devices	Driver speeds
NO RIGHT TURN ON RED*	Add fluorescent-yellow rectangular header panel at the top of the sign with the word NOTICE	Camera	Count of vehicles that turned right on red
SPEED LIMIT 30	Add white retroreflective strip on signpost	Speed radar devices	Driver speeds
Pedestrian warning sign with RRFB	Add yellow retroreflective strip on both sides of both signposts (four strips total)	Two cameras	Count of vehicles that did and did not stop properly for pedestrians at ramps and in crosswalks
Pedestrian warning sign without RRFB	Add yellow retroreflective strip on both sides of both signposts (four strips total)	Two cameras	Count of vehicles that did and did not stop properly for pedestrians at ramps and in crosswalks

Note: The standard MUTCD sign to prohibit all turns on a red signal indication is the “NO TURN ON RED” sign.
RRFB = rectangular rapid-flashing beacon.

Figure 11 through figure 18 show some examples of signs before and after the conspicuity treatments were applied.

Figure 11. Photo. Before treatment: retroreflective 2.5-inch yellow strip.

Source: FHWA.

Figure 12. Photo. After treatment: retroreflective 2.5-inch yellow strip.

Source: FHWA.

Figure 13. Photo. Before treatment: sign without header panel.

Source: FHWA.

Figure 14. Photo. After treatment: fluorescent-yellow NOTICE header panel.

Source: FHWA.

Figure 15. Photo. Before treatment: sign without retroreflective white strip.

Source: FHWA.

Figure 16. Photo. After treatment: sign with retroreflective white strip.

Source: FHWA.

Figure 17. Photo. Before treatment: Railroad Crossing sign without retroreflective 2.5-inch yellow strip.

Source: FHWA.

Figure 18. Photo. After treatment: Railroad Crossing sign with retroreflective 2.5-inch yellow strip.

Source: FHWA.

For both the before- and after-data collection periods, the research team collected data on a Friday and a Saturday. These days were selected, in coordination with New Hampshire DOT, to capture both a weekday and a weekend day during which there would be more traffic. The locations of the treatments were along routes that are heavily traveled by tourists; therefore, in many cases, drivers would likely be seeing the signs for the first time.

Data Analysis and Results

Railroad Signing

The research team added a yellow retroreflective strip to the signpost in the westbound direction. For the railroad crossing data, the research team determined noncompliance by considering the number of vehicles that were stopped on the tracks, given the queue was long enough to reach the railroad crossing. Data analysis indicated that noncompliance was significantly lower after the treatments were installed than before they were installed ($p\_before = 0.54$, $p\_after = 0.37$, chi-squared = 6.44, degrees of freedom (df) = 1, $p = 0.01$).

No Right Turn on Red

The research team added a fluorescent-yellow NOTICE panel to the top of the sign. There was no statistically significant difference in the number of vehicles turning on red before or after the treatment was installed.

Pedestrian Warning Sign with RRFB

The research team added a yellow retroreflective strip to both sides of the signposts. There were no statistically significant differences in the number of vehicles that failed to stop for pedestrians at ramps (waiting to cross) or pedestrians in crosswalks after treatments were installed compared to before treatments were installed.

Pedestrians at ramps are the pedestrians who were waiting to cross, i.e., not in the crosswalk.

Pedestrian Warning Sign without RRFB

The research team added a yellow retroreflective strip to both sides of both signposts. The proportion of vehicles that failed to stop for pedestrians at ramps was statistically significantly higher after treatment installation than before ($p\_before = 0.57$, $p\_after = 0.66$, chi-squared = 3.88, $df = 1$, $p = 0.05$). The proportion of vehicles failing to stop for pedestrians in the crosswalk was statistically no different after treatment relative to before ($p\_before = 0.34$, $p\_after = 0.28$, chi-squared = 0.32, $df = 1$, $p = 0.57$).

Speed Limit signing

As described in table 5, three Speed Limit signs received conspicuity treatments:

- SPEED LIMIT 30—NH–112 Eastbound—added retroreflective white strip to signpost.
- SPEED LIMIT 30—NH–112 Eastbound by I–93 overpass—added sign in median to match the existing sign.
- SPEED LIMIT 35—Route 3 Northbound—increased sign size to one size larger using MUTCD dimensions.

The research team compared mean speeds before and immediately after treatment installations. There were no significant differences in speeds before and after treatment installation for any of the three locations (table 5). There were also no significant changes in 85th-percentile speeds before and after the treatment installation for any of the locations, as shown in table 6.

Table 5. Change in mean speeds (mph) for all vehicles for New Hampshire.

SIGN	BEFORE MEAN SPEED (MPH)	INITIAL-AFTER MEAN SPEED (MPH)	CHANGE IN SPEED, BEFORE TO FIRST-AFTER DIFFERENCE (MPH)	CHANGE IN SPEED, BEFORE TO FIRST-AFTER (*P*-VALUE)	CHANGE IN SPEED, BEFORE TO FIRST-AFTER (COHEN'S *D* [SE])
SPEED LIMIT 30—add sign and oversize	36.02	37.00	0.98	1.00	0.18 (0.02)
SPEED LIMIT 30—add retroreflective white strip	39.16	39.53	0.37	1.00	0.08 (0.03)
SPEED LIMIT 35—increase sign size	39.53	39.73	0.20	0.97	0.05 (0.02)

SE = standard error.
Note: The *p*-value corresponds to *t*-test with one-sided alternative hypothesis. Small values suggest that speeds fell over time, and large values suggest that speeds did not fall over time.

Table 6. 85th-percentile speeds for New Hampshire.

SIGN	STATISTIC	BEFORE	FIRST-AFTER
Speed Limit—add sign and oversize (SPEED LIMIT 30)	Q85	41.00	42.00
Speed Limit—add sign and oversize (SPEED LIMIT 30)	SD	5.74	4.95
Speed Limit—add retroreflective white strip (SPEED LIMIT 30)	Q85	44.00	44.00
Speed Limit—add retroreflective white strip (SPEED LIMIT 30)	SD	4.32	4.73
Speed Limit—increase sign size (SPEED LIMIT 35)	Q85	44.00	44.00
Speed Limit—increase sign size (SPEED LIMIT 35)	SD	4.37	4.50

Q85 = 85th-percentile speeds; SD = standard deviation.

The research team also examined mean speeds by vehicle classification (e.g., small, medium, large). However, there were no significant differences in average speeds before and after treatment installation by vehicle size, and there was a limited number of small vehicles observed during the study periods.

VIRGINIA OBSERVATIONAL FIELD DATA COLLECTION

Method

In Virginia, the research team installed conspicuity treatments on six different signs, as described in table 7.

Table 7. Summary of data collection placement and equipment for Virginia.

SIGN	CONSPICUITY TREATMENT	DATA COLLECTION DEVICE	DATA COLLECTED
STOP	Add red retroreflective strip on signpost	Camera	Count of vehicles that did and did not come to a complete stop
Curve Warning sign with 50-mph advisory speed plaque (duplicate signs on both sides of road)*	Replace sign with oversized sign (increased to 48×48 inches) for both sides of the road	Speed radar devices	Driver speeds
SPEED LIMIT 45 (duplicate signs on both sides of road)*	Add fluorescent yellow NOTICE header panel on both signs**	Speed radar devices	Driver speeds
SPEED LIMIT 45 (duplicate signs on both sides of road)*	Replace sign with increased size (increased to 48×60)	Speed radar devices	Driver speeds
SPEED LIMIT 55 (duplicate signs on both sides of road)*	Add white retroreflective strip on post	Speed radar devices	Driver speeds
Curve Warning sign with advisory speed (40 mph)	Replace sign with oversized sign (increased to 36×36)	Speed radar devices	Driver speeds

*Duplicate signs were already in place before the study began.
**The NOTICE header panels are not compliant with the MUTCD. The MUTCD only allows for a header panel that is the full width of the sign.

Figure 19 through figure 21 show examples of signs before and after treatments were installed.

Figure 19. Photo. After treatment: oversized sign.

Source: FHWA.

Figure 20. Photo. After treatment: red retroreflective strip.

Source: FHWA.

Figure 21. Photo. After treatment: fluorescent yellow NOTICE header panel.

Source: FHWA.

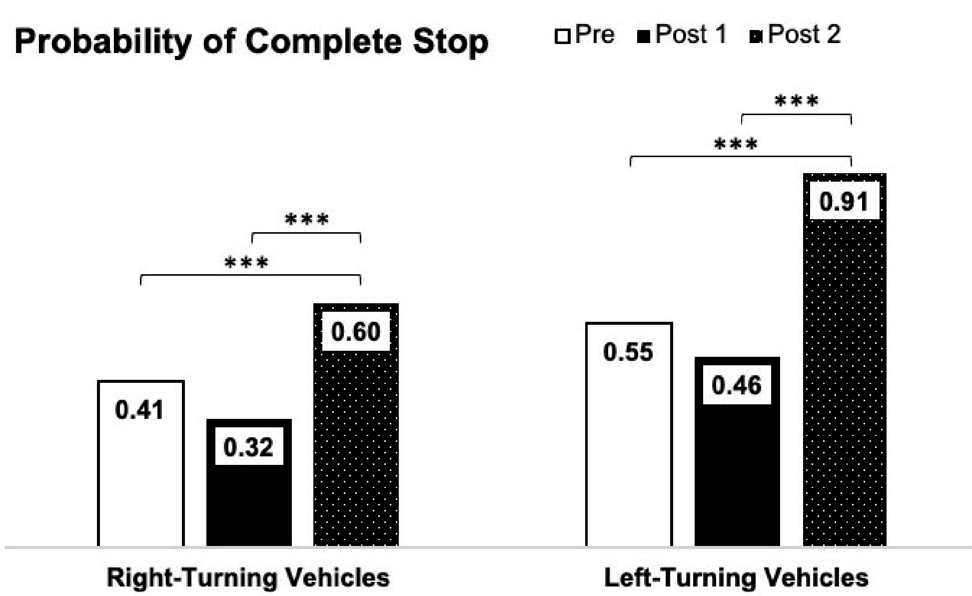
Note: The NOTICE header panels shown in figure 21 are not compliant with the MUTCD. The MUTCD allows for only a header panel that is the full width of the sign.

Data Analysis and Results

Stopping Data

For the STOP sign, the research team used a camera to count the number of vehicles that did and did not come to a complete stop before and after the red retroreflective strip was installed on the signpost. The research team observed this behavior for drivers who turned right from the STOP signs and drivers who turned left. As shown in figure 22, there was not a statistically significant change in complete stops in the initial after period, after which the second after period shows significantly increased rates of complete stops for each turning direction.

Figure 22. Graph. Probability of a complete stop by data collection period—Virginia.



Source: FHWA.

***Statistically significant difference at the $p = 0.01$ level.

There were two limitations to the stopping data. First, there was variation in the data collection days for the before, initial-after, and second after-data collection periods. The research team collected data for the following:

- Before treatment installation on a Friday, Saturday, and Sunday.
- Initial after period on a Wednesday, Thursday, and Friday.
- Second after period on a Monday, Tuesday, and Wednesday.

It is possible that different traffic volumes (e.g., on weekdays versus weekends) could have influenced stopping behavior. For example, drivers may have been more likely to come to a complete stop if there were higher volumes of cross-traffic during that time. This observation is also related to the second limitation for these data: because of the positioning of the camera, the research team was unable to capture whether any cross traffic was present when vehicles were at the STOP sign. Therefore, the research team was unable to determine if drivers were choosing to come to complete stops or if they were required to stop because of cross traffic.

Speed Data

The research team compared mean speeds before and after treatment installation. Table 8 shows the results for the five signs for which the research team collected speed data. A negative value corresponds to a decrease in speed after the installation of the treatments, and a positive value corresponds to an increase in speed after the installation of the treatments. The *p*-value is also listed, and numbers in bold indicate a statistically significant change in speed at a 95-percent level of significance. There were some significant, but small, decreases in speeds after treatments were installed. The research team observed the largest initial speed decrease for the oversized Curve Warning sign; mean speeds were approximately 1.5 mph slower in the initial after period compared to the before period. However, in the second after period, speeds returned to what they had been during the before period. For the Speed Limit sign with the fluorescent yellow NOTICE panel, mean speeds decreased by 0.46 mph in the initial after period and by 1.39 mph in the second after period, compared to the time before the treatments were installed. For the increased size of Speed Limit sign, mean speeds decreased by approximately 0.94 mph in the second after period compared to the time before treatments were installed. The Speed Limit sign with the white retroreflective strip and the second oversized Curve Warning sign saw reductions in mean speeds of 0.47 mph (initial-after) and 0.54 mph (second-after), respectively.

Table 8. Change in mean speeds for all vehicles for Virginia.

SIGN	POSTED/ ADVISORY SPEED (MPH)	BEFORE MEAN SPEED (MPH)	INITIAL-AFTER MEAN SPEED (MPH)	SECOND-AFTER MEAN SPEED (MPH)	CHANGE IN SPEED, BEFORE TO INITIAL-AFTER (MPH)	CHANGE IN SPEED, INITIAL-AFTER TO SECOND-AFTER (MPH)	CHANGE IN SPEED, BEFORE TO SECOND-AFTER (MPH)
Used oversized Curve Warning sign (1)	55/40	54.8	53.3	55.23	**–1.50 (p < 0.01)**	1.58 (p = 1.00)	0.08 (p = 0.87)
Added yellow NOTICE header to Speed Limit sign	45	50.89	50.44	49.7	**–0.46 (p < 0.01)**	**–0.93 (p < 0.01)**	**–1.39 (p < 0.01)**
Increased Speed Limit sign size	45	49.68	49.78	49.12	0.10 (p = 0.94)	**–1.04 (p < 0.01)**	**–0.94 (p < 0.01)**
Added white retroreflective strip on Speed Limit sign	55	58.31	57.84	59.14	**–0.47 (p < 0.01)**	1.07 (p = 1.00)	0.60 (p = 1.00)
Used oversized Curve Warning sign (2)	55/40	45.73	—	45.19	—	—	**–0.54 (p = 0.05)**

—No data.
Note: The *p*-value corresponds to *t*-test with one-sided alternative hypothesis. Small values suggest that speeds fell over time, and large values suggest that speeds did not fall over time.

Table 9. 85th-percentile speeds for Virginia.

SIGN	STATISTIC	BEFORE	INITIAL-AFTER	SECOND-AFTER
Used oversized Curve Warning sign (1)	Q85	61.00	60.00	61.00
Used oversized Curve Warning sign (1)	SD	7.27	7.80	7.13
Added yellow NOTICE header to Speed Limit sign	Q85	56.00	56.00	55.00
Added yellow NOTICE header to Speed Limit sign	SD	5.60	5.70	5.44
Increased Speed Limit sign size	Q85	54.00	54.00	54.00
Increased Speed Limit sign size	SD	4.66	4.66	4.69
Added white retroreflective strip to Speed Limit sign	Q85	63.00	63.00	64.00
Added white retroreflective strip to Speed Limit sign	SD	5.36	5.57	5.14
Used oversized Curve Warning sign (2)	Q85	53.00	—	51.00
Used oversized Curve Warning sign (2)	SD	8.79	—	6.91

—No data.

Mean speeds were also examined by vehicle classification (small, medium, large); however, there were no significant differences in average speeds before and after treatment installation by vehicle size, and the research team observed a limited number of small vehicles during the study periods. The conspicuity treatments used in Virginia only minimally reduced vehicles speeds.

EYE-TRACKING FIELD STUDY, VIRGINIA

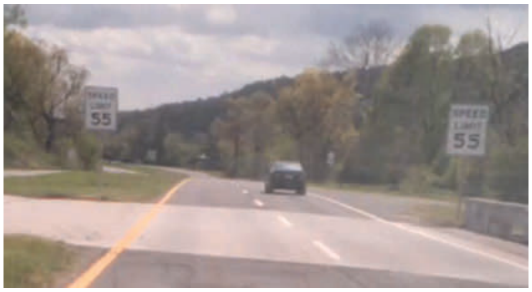
Method

Sixty-three participants took turns driving a field research vehicle along a predetermined, 24-mi route in Elliston, VA. Of the 63 participants, 28 were female, and 35 were male. Participants ranged in age from 18 to 69 yr (mean = 25 yr). The field research vehicle was a medium-size, sports utility vehicle. Each participant was fitted with a head-mounted, mobile eye-tracking system—appearing much like a pair of glasses—which was used to collect visual-attention data. After the glasses were calibrated, each participant completed a practice drive before starting on the test route. A researcher was always present in the vehicle with each participant. During the test drive, participants were given verbal navigational directions to follow along the route and were instructed to drive as they normally would despite the new elements (e.g., different car, headset, additional passenger, etc.). The research team installed three sign treatments along the test route:

- Sign 1—a duplicate SPEED LIMIT 55 sign.
- Sign 2—fluorescent yellow NOTICE header panels on two SPEED LIMIT 45 signs.
- Sign 3—white retroreflective strip on SPEED LIMIT 55 signpost.

The research team also used these signs and treatments in an observational portion of the data collection for Virginia. Figure 23 through figure 25 display the three treatments. A single SPEED LIMIT 55 sign was used as a control.

Figure 23. Photo. Conspicuity treatment: duplicate signs.



Source: FHWA.

Figure 24. Photo. Conspicuity treatment: fluorescent yellow NOTICE header panels.

Source: FHWA.

Figure 25. Photo. Conspicuity treatment: white retroreflective strip on signpost.

Source: FHWA.

Data Analysis and Results

The research team analyzed data from 48 participants. The team manually recorded glances to each sign and the speedometer (while each sign was visible) for each participant, and the team also recorded critical variables such as the presence of leading vehicles and weather variables. The team fit a full Poisson regression model to both glances to each sign and to glances to the speedometer, and it used stepwise selection to remove variables that did not significantly affect the models.

The results indicated that participants looked at sign 1 (duplicate signs) and sign 2 (fluorescent yellow NOTICE headers) more often than the control signs. Participants also looked at the speedometer more often while signs 1 and 2 were visible, compared to the control sign. Sign 3 (white retroreflective strip on signpost) did not yield statistically significant results for the number of glances to the sign or the speedometer.

The research team found age and gender to be influential variables. Older participants made fewer glances toward the signs than younger participants. The research team examined age as a continuous variable, so higher ages led to fewer glances to the sign. Male participants looked at the speedometer fewer times than female participants. Also, the presence of a leading vehicle was associated with fewer glances to the signs and even fewer glances to the speedometer.

DISCUSSION

In general, conspicuity treatments applied to Speed Limit signs tended to reduce driver speeds only minimally and, in some cases, did not reduce speeds at all. The eye-tracking results indicated that participants looked at sign 1 (duplicate signs) and sign 2 (fluorescent yellow NOTICE headers) more often than the control signs. Participants also looked at the speedometer more often while signs 1 and 2 were visible compared to the control sign. Sign 3 (white retroreflective strip added to the signpost) did not yield statistically significant results for the number of glances to the sign or the speedometer. These results, in conjunction with the observational results, suggest that even if conspicuity treatments may increase conspicuity of Speed Limit signs, the signs may not cause drivers to change their speeds.

For Curve Warning signs, there were minimal mean-speed decreases when beacons or oversized signs were used. In one case of oversized signs, there was a very slight increase in speed by the second after period. There were small decreases in mean speeds near STOP signs when flags or beacons were used.

Although results were generally mixed, treatments such as adding white retroreflective strips, duplicating signs, or increasing the size of signs may not have an effect on mean driver speeds, whereas other treatments such as beacons, flags, and fluorescent NOTICE header panels may impact driver speeds. It should be noted, however, that these findings come from three different States and in locations that all have different environmental and traffic factors to consider, which could influence driver speeds as well.

The findings regarding stopping and turning behavior were also mixed. The application of yellow retroreflective strips on railroad signing in New Hampshire resulted in an increase in compliance. Yellow retroreflective strips on pedestrian warning signs made no difference in stopping behavior at ramps or at crosswalks in most cases, but they led to a slight decrease in drivers stopping for pedestrians at ramps at one location. The yellow fluorescent NOTICE header panel on a NO RIGHT TURN ON RED sign in New Hampshire did not result in any change in turning behavior. The red retroreflective strip on a STOP sign in Virginia did not result in a significant change in complete stops initially but was followed by a significant increase in complete stops during the second after period.

Most of the sites chosen were familiar to drivers, and the treatments were used to enhance signs with regulations or warnings that already existed. Therefore, although people may have been more apt to look at the signs, the drivers did not find it necessary to change their behaviors. Because the eye-tracking data indicated that some treatments resulted in increased glances at the enhanced conspicuity measures, it is very likely that conspicuity enhancements for signs that are important for unfamiliar motorists, signs that notify drivers of new regulations, or signs that warn of new conditions might result in changes in driver behavior.

A more comprehensive approach looking at more installations of similar treatments may be useful in determining differences between various enhanced conspicuity treatments.

REFERENCES

Federal Highway Administration. 2009. *Manual on Uniform Traffic Control Devices*. Washington, DC: Federal Highway Administration.

Researchers—This study was conducted by Bryan Katz (0000-0003-2813-8098) and Erin Kissner of toXcel, as well as Shauna Hallmark of Iowa State University as part of Vanasse Hangen Brustlin Inc.'s contract DTFH6116D00040L.

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