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Field Evaluation of Methods for Enhancing Sign Conspicuity

Erin Kissner
Toxcel, LLC
erin.kissner@toxcel.com

Bryan Katz
Toxcel, LLC
bryan.katz@toxcel.com

Steve Jackson
Toxcel, LLC
steve.jackson@toxcel.com

Pamela Passarge
Toxcel, LLC
pamela.kryschtal@toxcel.com

INTRODUCTION

The 2009 Manual on Uniform Traffic Control Devices (MUTCD) outlines various strategies to enhance the conspicuity of traffic signs, defined as a traffic sign's ability to stand out and attract attention. Improving sign conspicuity is believed to directly and indirectly impact safety by promoting compliance, reducing speeds, and decreasing accidents. However, despite these enhancements, there is a lack of comprehensive research on their actual effectiveness on driver behavior. This study aims to fill that gap by evaluating the effectiveness of these conspicuity treatments, focusing on methods currently endorsed by the MUTCD rather than exploring novel treatments.

To conduct this evaluation, the research team reviewed existing literature and practices, consulting with members of the Traffic Control Devices Pooled Fund Study (TCD PFS) to identify which MUTCD treatments were being effectively utilized across states. Given that conspicuity, especially retroreflectivity, cannot be effectively replicated in laboratory settings, the researchers employed field experiments to gather data. They utilized a two-part approach, combining observational field data and eye-tracking studies, to assess how these conspicuity treatments influence driver behavior. This methodology allowed for a nuanced understanding of whether these enhancements lead to increased attention to signs and subsequent changes in driving behavior.

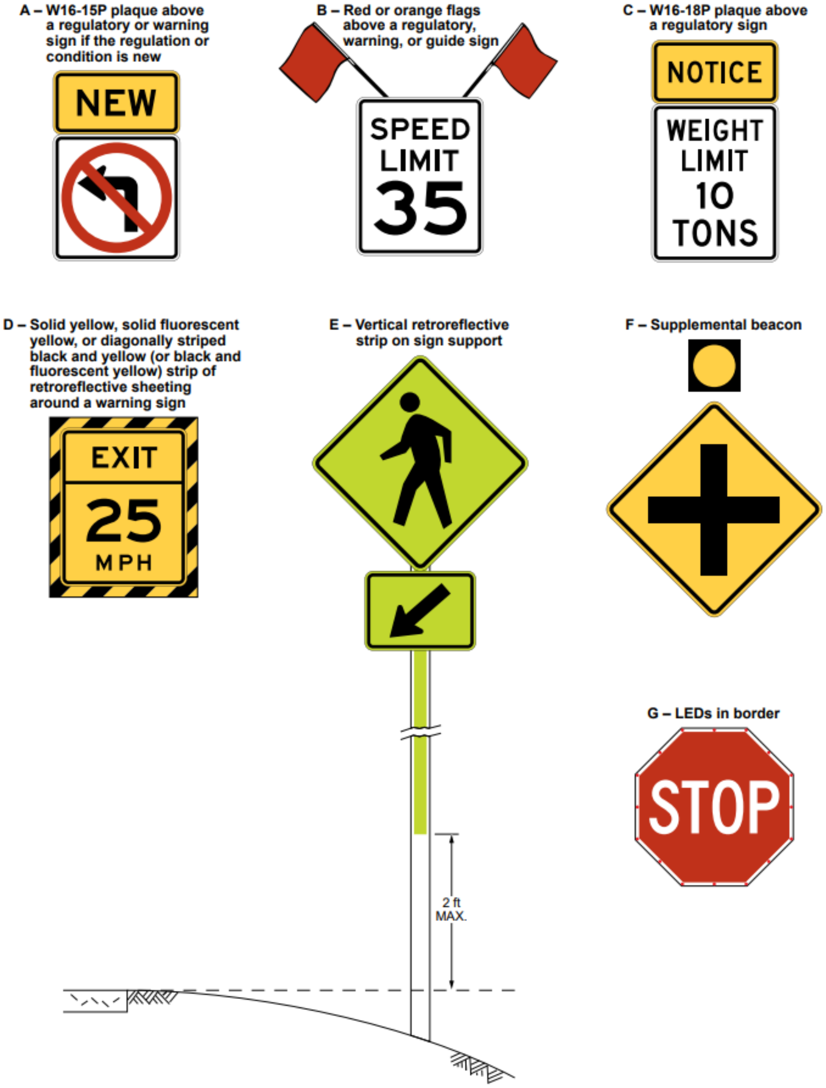

Figure 1: 11th Edition MUTCD Figure 2A-1. Examples of Enhanced Conspicuity for Signs

LITERATURE REVIEW

Enhancing the conspicuity of traffic signs is essential for improving road safety. Various studies have explored the effectiveness of materials and designs aimed at increasing sign visibility. This literature review examines these approaches and their implications for traffic sign conspicuity.

One study by Gates and Hawkins conducted before-and-after evaluations of various high-conspicuity sign materials.[1] One key application was the addition of a 3-inch red microprismatic border around a Speed Limit sign at the entrance of a speed zone. The study reported approximately 2 mph decreases in mean and 85th percentile speed at the entry point to the speed zone, as well as 500 feet after entering the zone, for daytime passenger vehicles. The study also

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[1] Gates, T.J., and Hawkins, H.G., Effect of Higher-Conspicuity Warning and Regulatory Signs on Driver Behavior, Texas Transportation Institute, Project Summary Report 0-4271S, 2004.

found an 18.4 percent reduction in the number of vehicles exceeding the speed limit. Additionally, the study examined the installation of red flashing light-emitting diodes (LEDs) on STOP signs, which led to a 28.9 percent decrease in the number of vehicles not fully stopping at the sign.

According to the synthesis in Castro and Horberry's *The Human Factors of Transport Signs*, other studies have indicated that colored borders can enhance the visibility of traffic signs.[2] However, they caution that such borders should be used judiciously, particularly on warning signs, as they may reduce legibility if positioned too close to the text.[3] A separate study by Arnold and Lantz in Virginia assessed the effects of adding red flashing LEDs to STOP signs, yielding somewhat inconclusive results; while speeds did decrease slightly, the presence of additional measures like "Stop Ahead" signs and rumble strips likely influenced the outcomes.[4]

Further research has explored treatments such as increasing sign size and duplicating signs on the left side of the roadway. A case study by the FHWA in Winston-Salem, NC, showed a reduction in crashes and injuries from a combination of measures, including larger signs and added markings.[5] However, when multiple enhancements are made at the same time, it is difficult to determine which countermeasure (or combination of countermeasures) is responsible for the increased safety benefits, or if a single countermeasure could produce the same benefits on its own.

Similarly, Pour-Rouholamin et al. conducted a survey and discussed multiple case studies regarding WRONG WAY signs, DO NOT ENTER signs, and wrong way driving.[6] Participants in the survey represented sixteen states. One of the survey questions focused on conspicuity methods that states implement on WRONG WAY and DO NOT ENTER signs. The results revealed that over half of the respondents used specific treatments: adding a second identical sign on the left side of the roadway, increasing the sign size, and adding a retroreflective strip to the sign support. Additionally, nearly half of the states mounted their signs at the minimum height allowed by the MUTCD instead of the standard height. While the survey highlighted the impacts of these conspicuity treatments, the case studies offered deeper insights. For instance, Caltrans reported a significant drop in wrong way driving incidents by lowering sign mounting heights to align with vehicle headlights, reducing incidents from 50-60 per month to just 2-6 in some areas. Similarly, TexDOT observed a 30% reduction in incidents following the installation of WRONG WAY signs with flashing LED borders in a San Antonio study. The authors also referenced several other studies that implemented larger signs and placed identical signs on the left side of the road. Although these measures led to incident reductions, it's important to note that changes in driver behavior cannot be attributed to any single countermeasure, as multiple strategies were often employed together.

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[2] Castro, C., & Horberry, T. (2004). *The Human Factors of Transport Signs*. CRC Press.

[3] Young, S.L. (1991). Increasing the noticeability of warnings: effects of pictorial, color, signal icon and border. *Proc. Hum. Factor Soc. 35th Annu. Meet.* 580-584 San Francisco: Human Factors Society.

[4] Arnold, E. D., Jr., & Lantz, K. E., Jr. (2007). *Evaluation of Best Practices in Traffic Operations and Safety: Phase I: Flashing LED Stop Sign and Optical Speed Bars* (Rep. No. FHWA/VTRC 07-R34). Charlottesville, VA: VTRC

[5] Federal Highway Administration (FHWA), 2009. Stop Sign-Controlled Intersections: Enhanced Signs and Markings, A Winston-Salem Success Story. FHWA-SA-09-010.

[6] Pour-Rouholamin, M., Zhou, H., Shaw, J., & Tobias, P. (2015). Current Practices of Safety Countermeasures for Wrong-Way Driving Crashes. In Transportation Research Board 94th Annual Meeting.

Research into flashing beacons has also been conducted, with Janoff and Hill summarizing previous findings on their effectiveness. They noted that the presence of flashing beacons at curve warnings led to reduced speeds and fewer crashes related to loss of control.[7] A study by Pant et al. compared intersections with only STOP signs to those equipped with Intersection Control Beacons, finding speed reductions but no significant changes in compliance or crash rates.[8] An FHWA pooled fund study examined three types of flashing beacons and found an overall reduction in crashes, although sample sizes were insufficient to draw statistically significant conclusions for each type.[9] Notably, flashing beacons on stop signs showed potential for greater effectiveness, but a cost-benefit analysis indicated that actuated beacons might not be a worthwhile investment in most stop-controlled locations.

Table 1: Angle Crash Reduction (Srinivasan, 2007)

Group (# of Sites)	Estimate of Percent Reduction
Rural Sites in NC and SC (76)	15.7%
Suburban Sites in NC (14)	11.8%
Urban Sites in NC and SC (16)	-12.3%
Two-way stop in NC and SC (95)	12.7%
Two-way stop in SC (31)	-10.4%
Four-way stop in SC (11)	27.8%
Standard Overhead in NC and SC (84)	11.9%
Standard STOP sign mounted in NC and SC (5)	58.2%
All Standard in NC and SC (89)	13.3%
Actuated in NC (17)	14.0%

METHODOLOGY

The methodology for this research involved two key components: an observational field study conducted in Virginia and New Hampshire, and an eye-tracking study carried out in Virginia. In collaboration with State Departments of Transportation (DOTs), the research team focused on gathering observational data at selected high-traffic sign locations, implementing specific conspicuity treatments to assess their effects on driver behavior. Simultaneously, the eye-tracking study in Virginia provided insights into drivers' visual attention patterns in relation to these treatments. Together, these approaches aimed to evaluate the effectiveness of various enhancements to traffic sign visibility and compliance, offering a comprehensive understanding of their impact on road safety.

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[7] Janoff, M. S., & Hill, J. G. (1986). Effectiveness of Flashing Beacons in Reducing Accidents at a Hazardous Rural Curve (Abridgment). Traffic Control Device and Rail-Highway Crossings, (1069), 80-82 Transportation Research Board.

[8] Pant, P. D., Park, Y., Neti, S. V., & Hossain, A. B. (1999). Comparative Study of Rural Stop-Controlled and Beacon-Controlled Intersections. Traffic Control Device and Rail-Highway Crossings, (1692), 164-172 Washington, D.C.: Transportation Research Board.

[9] Srinivasan, R., Carter, D., Eccles, K., Persaud, B., Lefler, N., Lyon, C., & Amjadi, R. (2007). *Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections* (Rep. No. FHWA-HRT-08-044). Washington, DC: FHWA.

Observational Field Data Collection

The research team collaborated with two State DOTs in New Hampshire and Virginia to gather observational field data. These States were chosen based on their participation in the TCD PFS and their proximity to the research team, facilitating efficient travel to various research sites. The team worked closely with state officials to identify specific locations where enhanced conspicuity treatments could be applied, implementing only one treatment per sign location. Signs were selected in heavily traveled areas to ensure robust data collection, focusing on those designed to elicit specific driver behaviors (e.g., STOP signs, Speed Limit signs) for more quantifiable outcomes. While some signs were included at the request of the states due to problematic driver behavior, most were selected based on their strategic locations and proximity to other relevant signs.

To assess the impact of the treatments, the research team evaluated criteria such as driver speed, stopping behavior, and turning behavior at each sign location. They collected mean speed and 85th percentile speed data, classifying vehicles as small, medium, or large based on their length. In Virginia, the signs and treatments used for observational data were consistent with those in the accompanying eye-tracking study. The literature review indicated that novelty effects could influence results, prompting the team to establish 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). New Hampshire was an exception, with only before and initial-after data collection due to the need to remove treatments before winter tourist season. The timing of data collection varied among the States due to differences in tourism, weather patterns, and delays related to the COVID-19 pandemic, as well as variations in environmental factors and DOT availability for installation.

New Hampshire Observational Field Data Collection

Table 2 outlines the signs, conspicuity treatments, and data collection devices utilized in New Hampshire. The research team employed speed radar devices at all Speed Limit sign locations to assess average driver speeds, while cameras were used at all other sign locations.

Table 2: 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 2 through Figure 9 show some examples of signs before and after the conspicuity treatments were applied.

Figure 2. Photo. Before and After treatment: retroreflective 2.5-inch yellow strip.

Figure 3. Photo. Before and After treatment: header panel.

Figure 4. Photo. Before and After treatment: retroreflective white strip.

Figure 5. Photo. Before and After treatment: retroreflective 2.5-inch yellow strip.

During both the before- and after-data collection periods, the research team gathered data on a Friday and Saturday. These days were chosen in collaboration with the New Hampshire DOT to ensure that both a weekday and a weekend day with higher traffic volumes were included. The treatment locations were along routes frequented by tourists, meaning many drivers would likely encounter the signs for the first time.

Virginia Observational Field Data Collection

In Virginia, the research team applied conspicuity treatments to six different signs, as outlined in Table 3.

Table 3: 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 10 through Figure 12 show examples of signs before and after treatments were installed (Note: The NOTICE header panels shown in Figure 12 are not compliant with the MUTCD. The MUTCD allows for only a header panel that is the full width of the sign).

Figure 6. Photo. After treatment: oversized sign.

Figure 7. Photo. After treatment: red retroreflective strip.

Figure 8. Photo. After treatment: fluorescent yellow NOTICE header panel.

Eye Tracking 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.

Virginia Eye Tracking Study

Sixty-three participants drove a field research vehicle along a predetermined 24-mi route in Elliston, VA. Among them, 28 were female and 35 were male, with ages ranging from 18 to 69 years (mean age = 25). The field research vehicle was a medium-sized sports utility vehicle. Each participant wore a head-mounted, mobile eye-tracking system that resembled a pair of glasses to collect visual-attention data. After calibrating the glasses, each participant completed a practice drive before starting the test route. A researcher was always present in the vehicle with them. During the test drive, participants received verbal navigational instructions and were told to drive as they normally would, despite the new elements (e.g., different vehicle, headset, additional passenger). 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 13 through Figure 15 display the three treatments. A single SPEED LIMIT 55 sign was used as a control.

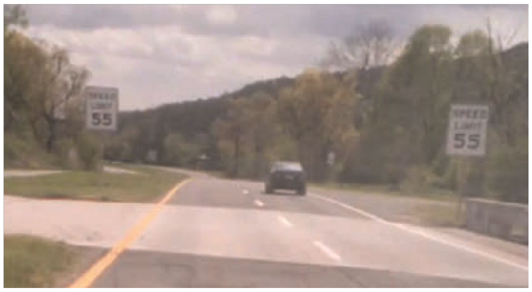

Figure 9. Photo. Conspicuity treatment: duplicate signs.

Figure 10. Photo. Conspicuity treatment : fluorescent yellow NOTICE header panels.

Figure 11. Photo. Conspicuity treatment: white retroreflective strip on signpost.

RESULTS

This section presents the results from the observational field studies conducted in New Hampshire and Virginia, along with findings from the eye-tracking study performed in Virginia. The outcomes highlight the effectiveness of various conspicuity treatments on driver behavior and compliance at selected traffic sign locations, providing insights into their impact on road safety. Each study component details specific interventions and their associated effects, offering a comprehensive overview of the research findings.

New Hampshire Observational Field Data Collection

The following presents the results of the observational field data collection in New Hampshire, organized by specific traffic sign categories.

Railroad Signing

The research team applied a yellow retroreflective strip to the signpost facing westbound. To assess noncompliance at the railroad crossing, the team counted the number of vehicles that were stopped on the tracks, provided that the queue was long enough to extend to the crossing. Data analysis showed that noncompliance significantly decreased after the treatments were installed compared to before (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 placed a fluorescent yellow NOTICE panel at the top of the sign. However, there was no statistically significant change in the number of vehicles making right turns on red before and after the treatment was implemented.

Pedestrian Warning Sign with RRFB

The research team applied a yellow retroreflective strip to both sides of the signposts. However, there were no statistically significant differences in the number of vehicles that did not stop for pedestrians at ramps (pedestrians who were waiting to cross, i.e., not in the crosswalk) or for pedestrians in crosswalks after the treatments were installed compared to before.

Pedestrian Warning Sign without RRFB

The research team applied a yellow retroreflective strip to both sides of the signposts. The proportion of vehicles that failed to stop for pedestrians at ramps was statistically significantly higher after the installation of the treatments compared to before (p_before = 0.57, p_after = 0.66, chi-squared = 3.88, df = 1, p = 0.05). In contrast, the proportion of vehicles not stopping for pedestrians in the crosswalk showed no statistically significant difference after the treatment was implemented (p_before = 0.34, p_after = 0.28, chi-squared = 0.32, df = 1, p = 0.57).

Speed Limit Signing

The research team compared mean speeds before and immediately after treatment installations. Three Speed Limit signs received conspicuity treatments, as listed below:

- 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.

There were no significant differences in speeds before and after the installation of treatments at any of the three locations (Table 4). Additionally, the 85th-percentile speeds showed no significant changes before and after treatment installation at any of the sites (Table 5).

Table 4. 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 5. Change in Mean Speeds (mph) for All Vehicles 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

Sign	Statistic	Before	First-After
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 analyzed mean speeds by vehicle classification (e.g., small, medium, large). However, there were no significant differences in average speeds before and after the installation of treatments based on vehicle size, and the number of small vehicles observed during the study periods was limited.

Virginia Observational Field Data Collection

The following subsection outlines the results of the observational field data collection in Virginia, including the stopping data and speed data.

Stopping Data

For the STOP sign, the research team utilized a camera to record the number of vehicles that came to a complete stop versus those that did not, both before and after the installation of the red retroreflective strip on the signpost. They focused on observing drivers making right and left turns at the STOP signs. As illustrated in Figure 16, there was no statistically significant change in the rate of complete stops during the initial-after period; however, the second-after period showed a significant increase in complete stops for both turning directions.

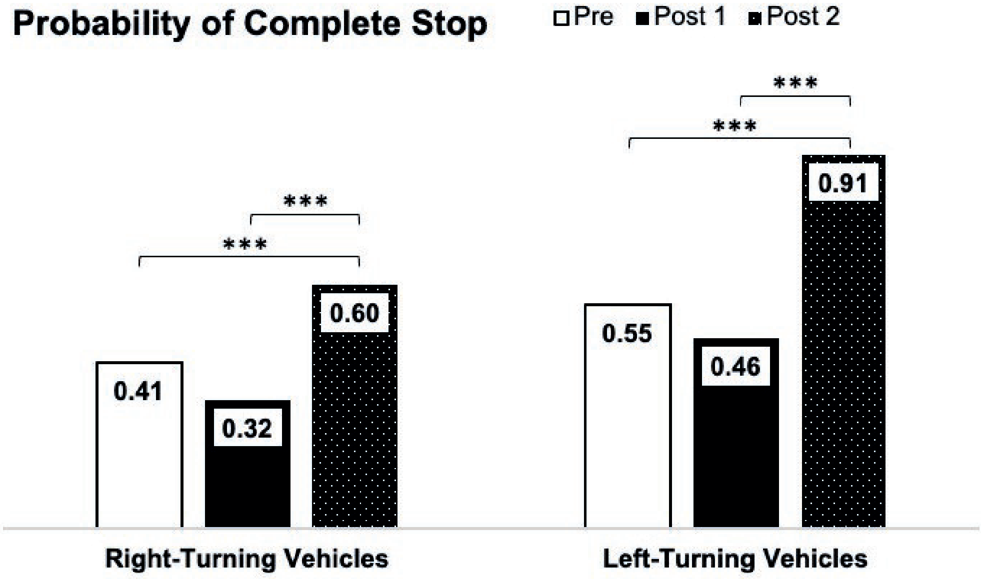

Figure 12. Graph. Probability of a complete stop by data collection period—Virginia.

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

Two limitations affected the stopping data. First, there was variability in the data collection days across the before, initial-after, and second-after 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.

Variations in traffic volume (e.g., weekdays versus weekends) may have affected stopping behavior. For instance, drivers might have been more inclined to come to a complete stop when there was a higher volume of cross traffic. This ties into the second limitation of the data: due to the camera's positioning, the research team could not determine whether any cross traffic was present when vehicles approached the STOP sign. As a result, they were unable to ascertain whether drivers chose to stop or were compelled to do so because of cross traffic.

Speed Data

The research team compared mean speeds before and after the installation of treatments. Table 6 presents the results for the five signs for which speed data was collected. A negative value indicates a decrease in speed after treatment installation, while a positive value signifies an increase. The table also includes p-values, with bold numbers denoting statistically significant changes at a 95-percent confidence level.

There were some notable but small decreases in speeds following treatment installation. The most significant initial speed reduction was observed for the oversized Curve Warning sign, where 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 levels seen before the treatments were applied.

For the Speed Limit sign featuring 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 pre-treatment speeds. The larger Speed Limit sign showed a mean speed reduction of about 0.94 mph in the second-after period relative to before treatment installation. Additionally, the Speed Limit sign with the white retroreflective strip and the second oversized Curve Warning sign experienced mean speed reductions of 0.47 mph (initial-after) and 0.54 mph (second-after), respectively.

Table 6. 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 o 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	45	50.89	50.44	49.7	**–0.46** **($p < 0.01$)**	**–0.93** **($p < 0.01$)**	**–1.39** **($p < 0.01$)**

Sign	**Posted/ Advisory Speed (mph)**	**Before Mean Speed (mph)**	**Initial-After Mean Speed (mph)**	**Second-After Mean Speed (mph)**	**Change in Speed, Before o Initial-After (Mph)**	**Change in Speed, Initial-After to Second-After mph)**	**Change in Speed, Before to Second-After (mph)**
Speed Limit sign							
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.

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Table 7. 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 analyzed based on vehicle classification (small, medium, large). However, no significant differences in average speeds before and after treatment installation were found based on vehicle size, and the research team noted a limited number of small vehicles during the study periods. The conspicuity treatments implemented in Virginia resulted in only minimal reductions in vehicle speeds.

Virginia Eye Tracking

The research team analyzed data from 48 participants, manually recording glances at each sign and the speedometer whenever the signs were visible. They also noted critical variables, such as the presence of leading vehicles and weather conditions. A full Poisson regression model was fitted to both the glances at each sign and the glances at the speedometer, using stepwise selection to eliminate variables that did not significantly impact the models.

The results showed that participants looked at Sign 1 (duplicate signs) and Sign 2 (fluorescent yellow NOTICE headers) more frequently than the control signs. Additionally, they glanced at the speedometer more often when Signs 1 and 2 were visible compared to the control sign. Sign

3 (white retroreflective strip on the signpost) did not yield statistically significant results for the number of glances at the sign or the speedometer.

The research team identified age and gender as influential variables. Older participants made fewer glances at the signs compared to younger participants, with age considered as a continuous variable indicating that higher ages led to fewer glances tto the sign. Male participants looked at the speedometer less often than female participants. Furthermore, the presence of a leading vehicle was associated with fewer glances to the signs and even fewer glances to the speedometer.

CONCLUSION

Overall, the study found that conspicuity treatments applied to Speed Limit signs generally resulted in only minimal reductions in driver speeds. Eye-tracking data showed that participants looked more frequently at signs with duplicate displays and fluorescent yellow NOTICE headers compared to control signs. Additionally, drivers paid more attention to their speedometers when these conspicuity treatments were present. However, the addition of white retroreflective strips to signposts did not produce statistically significant results in terms of glance frequency or speedometer attention. These findings suggest that while conspicuity enhancements might improve visibility, they do not necessarily lead to changes in driving speed.

For Curve Warning signs, using oversized signs resulted in only minimal reductions in mean speeds, with one oversized sign even associated with a slight speed increase. Treatments like white retroreflective strips, sign duplication, and increased sign sizes appeared ineffective in altering mean speeds, while fluorescent NOTICE headers showed more promise. It’s important to note that these findings were derived from different states with varying environmental and traffic conditions, which could influence driver behavior.

Regarding stopping and turning behaviors, results were also varied. Yellow retroreflective strips on railroad signs in New Hampshire increased compliance, while their use on pedestrian warning signs had little effect overall, except for a slight decrease in stopping at ramps in one location. The fluorescent yellow NOTICE header on a NO RIGHT TURN ON RED sign did not change turning behavior, and a red retroreflective strip on a STOP sign in Virginia showed no immediate effect on complete stops but resulted in a significant increase during a later observation period. Given that most sites were familiar to drivers, the enhancements might have drawn attention without prompting behavioral changes. This suggests that conspicuity improvements could be more effective for unfamiliar signs or those introducing new regulations. A broader examination of various treatments and installations could provide deeper insights into their impacts on driver behavior.