

# COMPREHENSION OF WARNING AND REGULATORY SIGNS FOR SPEED

Bryan J. Katz

Gabriel K. Rousseau, Ph.D.

Davey L. Warren

**Abstract.** When signs or other traffic control devices are used, it is essential that drivers understand the message and know how to take action appropriate to the situation. Failures in sign comprehension could increase driving hazards. The present research investigated comprehension for several types of speed management signs including animal presence warnings involving a flashing beacon, regulatory and advisory warnings, and variable speed limit signs with text and animation. The goal of this study was to determine if people make any problematic inferences from these types of signs. There were 103 participants in this research study. Participants viewed the signs, described what the signs meant, and then completed a comprehension task in which statements about each sign were presented and participants indicated whether the statement was true of the sign. The results from the comprehension task are described in this paper. Findings indicated that: (1) many participants failed to recognize that a hazard may still exist when the beacon attached to the animal presence sign is off, (2) many people thought that an advisory speed on a warning sign is an enforceable, legal speed limit, and (3) the variable speed limit sign was understood with either a text message or with animation. The most critical problem found in this study involved the animal presence signs. Further research is recommended to study better techniques to communicate the dynamic nature of the animal hazard to drivers.

## BACKGROUND

In 2001, almost 13,000 people died in vehicle crashes where speed was a contributing factor. This number represents about one-third of all fatal crashes in 2001, and this proportion has held steady for the past decade according to a 2002 National Highway Transportation Safety Administration report. If vehicle-related fatalities and injuries are to be reduced, then researchers and engineers must develop and implement effective speed management countermeasures. The purpose of this research project was to examine one aspect of speed management: driver comprehension of warning and regulatory signs. Speed management is a complicated issue and involves many factors including law enforcement, roadway design, environmental conditions, and visibility to name only several. In many situations, regulatory and warning signs may be the primary technique used to influence driver behavior and alert drivers that the roadway may require reduced speeds. Driver compliance with speed signs will depend at least in part on whether the drivers understand the sign, and although comprehension is not a *sufficient* condition to achieve driver compliance, it is a *necessary* condition. This research project investigated driver comprehension for three different types of speed signs including animal presence signs, variable speed limit signs, and regulatory/warning signs.

### *Animal Presence Signs*

Animal presence signs typically involve a deer (or other large animal) symbol and are placed to warn drivers that animals may be on or near the roadway. Roughly 100 people are killed each year by crashes involving large animals (Khattack, 2002). To the degree that vehicle speeds can be reduced in areas where deer and other large animals might be present, fatalities and injuries should be reduced. The Manual on Uniform Traffic Control Devices (MUTCD) includes an animal crossing warning sign (W11-3) and it is used to inform drivers that an unexpected deer hazard could occur. This sign is limited in its ability to encourage drivers to slow down because it is a generalized warning (i.e., the sign looks the same whether deer are present or not).

New warning techniques could help increase driver compliance with animal crossing signs. Several locales (e.g., see Gordon and Anderson, 2001) have tested sensors that detect a large animal in the area and then actuate a beacon attached to the warning sign. This technique provides the driver with a more situation-specific warning to slow down and be alert. The critical question is how drivers interpret a sign when the beacon is not flashing. Gordon and Anderson examined driver compliance with a warning sign stating, “Deer On Road When Lights Are Flashing” and only found a significant decrease in vehicle speed when the beacon was flashing and a lifelike deer statue was present on the roadway ahead. Most importantly, they found essentially no speed reduction when the beacon was off and no deer were present.

Gordon and Anderson did not test any other warning sign messages, but their message might encourage drivers to ignore the warning when the beacon is not flashing. Thus, does this warning message indicate that no deer have been detected and there is no need for caution when not flashing? Or do drivers recognize that a hazard still exists? If drivers interpret the sign to mean that caution is not needed (as implied by the Gordon and Anderson results), then signs with a non-flashing beacon could increase driver risk. One way to limit such misinterpretations is to develop a warning message that signifies a continued hazard even when the beacon is off. Part of this experiment involved comparing different animal presence sign configurations to determine how best to limit misunderstandings by drivers. Figure 1 presents the four animal presence signs used in this experiment.



**Figure 1. Animal Presence Warning Signs.**

### *Regulatory/Warning Signs*

Drivers travel past numerous regulatory and warning speed signs almost every time they step into a vehicle. Despite the incredible degree of familiarity with these of signs, many drivers may not fully understand some of them (Stokes, Rys, and Russell, 1996). One question is whether drivers understand the difference between speeds posted on regulatory signs versus those posted on warning signs. According to the MUTCD, a warning sign should help:

...call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users.

Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations. (FHWA, 2000).

The present experiment compared comprehension levels for a regulatory speed limit sign with those for curve and winding road warning signs to determine if drivers recognize that the speed on a warning sign is a recommended safe speed on a roadway segment whereas the regulatory sign presents an enforceable legal speed limit.

### *Variable Speed Limit Signs*

Variable speed limit signs have been around for decades, but recent technological advances have increased their potential applications. One intriguing idea is that animated symbols could be used to inform drivers of roadway and traffic situations. For example, if traffic congestion exists ahead, a variable speed limit sign could display an appropriate speed as well as an animation of a series of cars braking (e.g., to represent congestion). The present experiment compared comprehension of variable speed limit signs with either an animated symbol or a text message.

### *Research Questions*

This study involved a focused examination of how participants interpreted several types of speed management signs (i.e., animal presence warning signs, regulatory versus advisory speed plaques, and variable message signs). Comprehension was assessed by

using two tasks: an open-ended question task in which participants viewed the signs and then provided their own definition for each one; and a comprehension task in which they saw the same signs again along with several statements (e.g., ‘It is legal to drive faster than 25 MPH on this road’) and checked which items were true of that sign. This paper focuses on the comprehension task because this part of the experiment allowed for an examination of specific interpretations and inferences concerning the signs.

The specific research questions in this experiment were:

1. Do participants interpret an animal presence sign with the flashing beacon off to mean that *no animals have been detected* or that *animals may still be present*?
2. Do participants understand the difference between a regulatory and an advisory speed limit?
3. Do participants understand the meaning of a variable message sign representing congestion ahead?

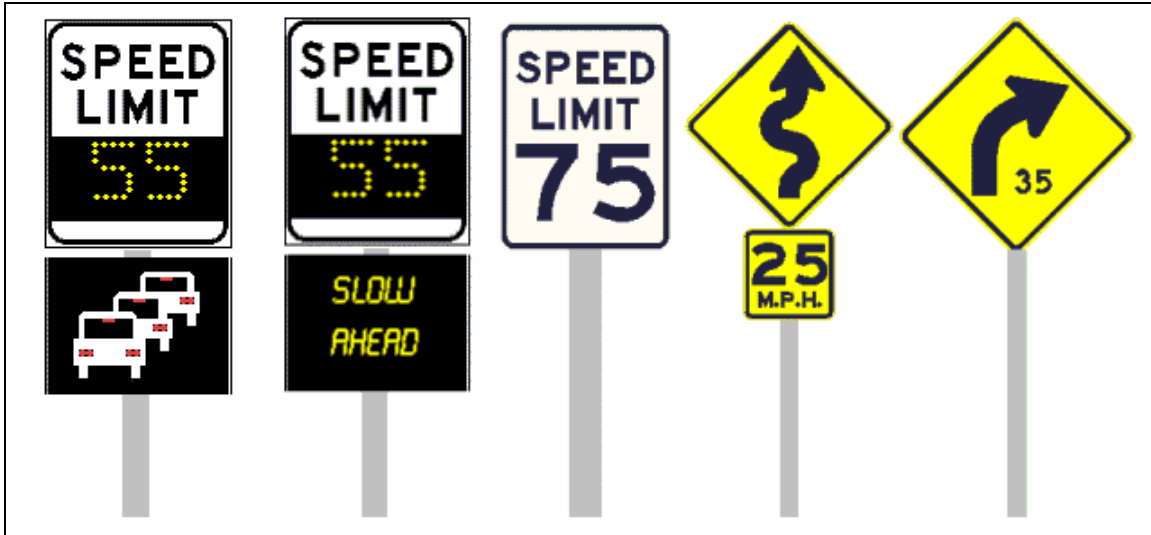
## **RESEARCH METHOD**

### *Participants*

There were 103 participants in this experiment and they ranged in age from 18 to 82 years old with an average age of 44. Testing occurred at Turner Fairbank Highway Research Center in McLean, Virginia and at the McLean Community Center. Participants received 15 dollars for their time.

### *Experimental Procedure*

Participants were first shown a series of eight signs on a computer screen (one of the signs was not related to this particular study) and asked to explain what the sign meant in their own words. The signs were presented with a blank background. The experimenter recorded participants’ responses for each sign. The signs used in the experiment are presented in Figure 1 and Figure 2. Several signs—the animal presence signs with a flashing beacon and the variable speed limit signs—were animated on the computer screen while participants viewed them. Each participant saw only one animal presence sign (Figure 1) in both its beacon on and off states, but saw all of the signs presented in Figure 2. The sign presentation order was counterbalanced to reduce the possibility of order effects confounding the results. For example, as a result of the counterbalancing technique, half of the participants first saw the animal presence sign with a flashing beacon and the other half first saw the sign with the beacon off.



**Figure 2. Variable Speed Limit, Regulatory, and Warning Signs.**





After completing the open-ended questions, participants viewed the same eight signs and chose which statements they thought were true from a list of statements corresponding to each sign. Participants could select multiple statements all signs except the animal presence signs. The comprehension questions were used to examine the types of inferences the participants drew from the signs.

## **RESULTS**

### *Animal Presence Signs*

The intended goal of animal presence signs is to ensure that drivers understand the potential for animals on or near the roadway. Table 1 presents the animal presence comprehension question data. Results demonstrated that almost all participants understood the animal presence sign with the flashing beacon on regardless of which placard message was used (see bottom row of Table 1, which contains the percentage sum for responses that indicated that deer could be present, with higher percentages meaning better comprehension). However, the symbol only sign and “Extra Caution When Flashing” signs were far better at warning drivers when the beacon was off that deer may still be on or near the roadway than the “Animal Detected When Flashing” and “When Flashing” sign configurations. These findings are supported by non-parametric tests—there were no significant differences among the signs when the flashing beacon, but there were significant differences when the beacon was off. For the “Use Extra Caution when Flashing” almost 90 percent of the participants understood that a hazard could still exist.

**Table 1. Percent Agreement with Statements for the Animal Presence Signs.**




								
	<b>Beacon</b>		<b>Beacon</b>		<b>Beacon</b>		<b>Beacon</b>	
	<b>On</b>	<b>Off</b>	<b>On</b>	<b>Off</b>	<b>On</b>	<b>Off</b>	<b>On</b>	<b>Off</b>
No deer are on or near the roadway*	0.0	19.2	0.0	42.3	0.0	8.0	0.0	37.5
Deer may be on or near the roadway	34.6	80.8	38.5	53.8	44.0	88.0	52.0	62.5
Deer are on or near the roadway	65.4	0.0	61.5	3.8	56.0	4.0	48.0	0.0
Sum for deer “may be” plus “are on” the roadway	100.0	80.8	100.0	57.6	100.0	88.4	96.2	62.5

\*Note: Participants were instructed to select only one statement for each sign.

*Regulatory Versus Warning Speed Signs*

Findings from the regulatory and warning sign questions revealed that, as would be expected, almost all participants understood that the regulatory speed limit sign displayed the maximum legal speed. However, about half of the participants also thought that speeds on warning signs were legal limits (see the first row and third rows of Table 2). The data show that participants held a different interpretation of speed warning signs than intended by the MUTCD. Interestingly, more participants thought that the posted speed on warning signs was a recommended safe speed compared to the regulatory sign.

**Table 2. Percent Agreement with Statements for the Regulatory and Warning Signs.**

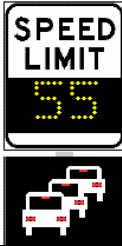
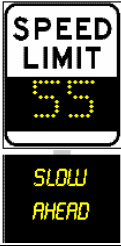
			
The maximum legal speed on this road segment is 75/25/35 MPH*	95.1	54.9	48.0
The recommended safe speed on this road segment is 75/25/35 MPH	23.5	78.4	81.4
It is legal to driver faster than 75/25/35 MPH on this road	2.9	11.8	9.8

\*Note: The speeds listed in the statements above varied for each sign according to the speed on the test sign. Participants could select more than one statement as true of a sign.

*Variable Speed Limit Signs*

Table 3 presents the results for the VSL signs. As can be seen in the table, comprehension both the symbol message and the text message were roughly comparable to each other. Based on the results from this experiment, the brake animation seems to be as well understood as the text message.

**Table 3. Percent Agreement with Statements for the Variable Speed Limit Signs.**

		
There is an accident ahead.*	15.7	21.6
Traffic ahead of you is traveling at 55 MPH.	22.5	19.6
The speed limit has been changed to 55 MPH due to congestion ahead.	84.3	76.5
There is a traffic jam 55 miles ahead of you.	4.9	3.9

\*Note: Participants could select more than one statement as true of a sign.

**DISCUSSION**

This experiment focused on comprehension of several types of warning and regulatory signs, and in particular, what types of inferences people draw from these of signs. Driver behavior may be the ultimate measure of a sign’s effectiveness, but drivers cannot be blamed if they do not understand a warning sign or, perhaps even worse, misinterpret it. In this study we found several misinterpretations of varying significance.

Roughly half of the participants thought that the speeds posted on warning signs are legal limits. The question becomes whether this interpretation could create hazardous driving situations. Given that most participants also thought that the warning signs provided a recommended safe travel speed there do not appear to be major safety concerns. Other researchers (e.g., Lyles, 1982; Chowdhury, Warren, Bissell, and Taori, 1998; Stokes, Rys, and Russell, 1996) have raised a variety of concerns with speed advisories, including overuse, accuracy in specifying appropriate speeds, and comprehension. Perhaps driver understanding of warning signs could be improved through education campaigns, or even better, through careful design and testing of new warning signing techniques.

The most troubling finding in this study was the high percentage of participants who thought there was no animal hazard when a sign’s beacon was off for the “Animal Detected When Flashing” and “When Flashing” placards. Clearly, if a beacon is to be used, a better sign and placard are needed to indicate that the when the beacon is off, a hazard could still exist. The present experiment’s “Use Extra Caution When Flashing

Placard” offers the most promise for the beacon off condition, with nearly 90 percent of the participants realizing that a hazard still exists. Almost every participant understood the sign variations when the beacon flashed, but as Gordon and Anderson’s (2001) research indicates, drivers may not adjust their driving speed even in this circumstance. The most powerful factor in getting drivers to slow down in their field study was to place a lifelike deer statue near the road. What is unknown from both the present study and that of Gordon and Anderson is whether drivers adapt their behavior in some less overt way. For instance, drivers may maintain their usual speed but may scan the roadside environment more frequently to prepare for a sudden stop.

Finally, the variable speed limit signs highlight the promise of using animated signs to communicate information to drivers. In fact, it may be possible to use animation such as was used for the variable speed limit sign to improve comprehension in other difficult signing situations, such as in wildlife crossings. Despite comprehension limitations found in the present study, through careful research and development, it will be possible to develop new techniques to warn drivers of hazards and, ultimately, reduce the number of fatalities and injuries that involved speeding.



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## AUTHORS

Bryan J. Katz  
Transportation Engineer  
Human Centered Systems Team, HRDS-07  
Science Applications International  
Corporation  
6300 Georgetown Pike  
McLean, VA 22101  
Phone: 202-493-3388  
Fax: 202-493-3390  
Email: [bryan.katz@fhwa.dot.gov](mailto:bryan.katz@fhwa.dot.gov)

Gabriel K. Rousseau, Ph.D.  
Research Psychologist  
Human Centered Systems Team, HRDS-07  
Office of Safety R&D  
Federal Highway Administration  
6300 Georgetown Pike  
McLean, VA 22101  
Phone: 202-493-3383  
Fax: 202-493-3374  
Email: [gabriel.rousseau@fhwa.dot.gov](mailto:gabriel.rousseau@fhwa.dot.gov)

Davey L. Warren  
Highway Safety Engineer  
Office of Safety, HSA-20  
Federal Highway Administration  
400 7<sup>th</sup> Street, SW  
Washington, DC 20590  
Phone: 202-366-4668  
Fax: 202-366-2249  
Email: [davey.warren@fhwa.dot.gov](mailto:davey.warren@fhwa.dot.gov)