EFFECTS OF VMS TECHNOLOGIES ON DRIVER BEHAVIOUR

Merja Penttinen, Virpi Anttila and Juha Luoma
Technical Research Centre of Finland
P.O. Box 1902, FIN-02044 VTT, Finland
tel. +358 9 456 4512
fax. +358 9 464 850
Email: Merja.Penttinen@vtt.fi

SUMMARY

This field study was designed to compare the effects of two technologies used in variable speed limit signs on (a) speed behaviour, (b) recall of signs, and (c) recognition of variability of a sign. The speed limit signs used fibre-optic technology and electromechanical technology equipped with a fluorescent retroreflective sheeting. Data was collected in two lighting conditions, daylight and night-time. The results showed that a variable speed limit sign with fibre-optic technology is more effective than an electromechanical sign. Although the overall speed data in daylight did not support this conclusion, the interview results suggest that the relatively strong effects of the electromechanical sign were limited to drivers passing the site less than weekly. In the dark, the more substantial effects of the fibre-optic sign were evident in greater effects on speed, and in the higher recall rate of the speed limit and variability of the sign.

INTRODUCTION

Luoma and Rämä (1998) compared the effects of two different technologies of variable speed limit signs on speed behaviour and recall of signs. Specifically, the speed limit signs were of fibre-optic and electromechanical technology. In comparison to a fixed sign, the variable legend of the electromechanical sign was produced by a revolving disc. The results showed that the fibre-optic sign decreased the mean speed of vehicles travelling in free-flow traffic situations by 3-4 km/h more than the electromechanical sign. In addition, 91% of the interviewed drivers recalled the sign when the fibre-optic sign was used, compared with only 72% when the electromechanical sign was used. The effectiveness of the fibre-optic sign was confirmed a year later, although the magnitude of the speed effect was a bit smaller (Rämä, Luoma and Harjula, 1999).

Currently, electromechanical speed limit signs can be equipped with fluorescent retroreflective sheeting. The fluorescent retroreflective sheeting increases the luminance of the sign, the contrast between the legend and its background, the visibility distance and the conspicuity of the sign, although these positive effects seem to be more evident in daylight than in night-time (e.g. Jenssen and Brekke, 1997; Jenssen, Brekke and Moen, 1998).

In Finland, variable message signs are one of the main applications for fluorescent retroreflective sheetings, and these signs are an option for fibre-optic signs. Therefore, this field study was designed to compare the effects of these two technologies used in variable speed limit signs on (a) speed behaviour, (b) recall of signs, and (c) recognition of variability of a sign. The experiments were performed in two lighting conditions, daylight and night-time.

METHOD

Site

The experimental site was located in southern Finland on an inter-urban road, with a fixed speed limit of 80 km/h. Variable speed limit signs of 60 km/h (during data collection) were erected 273 – 292 m before the intersection with a secondary road.

Before the intersection, drivers travelling on the highway had two lanes in each direction: one for vehicles driving through the intersection and turning right, and one for left-turning vehicles. At the site, the road pointed roughly north-eastwards. The road section before the site was straight and level. The intersection was followed first by a straight road section and then by a slight curve. After the curve was a bus stop, which was used for the interviewing the drivers.

Equipment

Figure 1 shows the signs used in the study. These were variable speed limit signs that are in normal use in Finland. The diameter of the red circle of each sign was 640 mm. The legend of the electromechanical sign was black and the background was yellow, while the colours of the fibre-optic sign were white and black. The variable legend of the electromechanical sign was produced by a revolving disc and the sign had a fluorescent retroreflective sheeting. The legends and red circle of the fibre-optic sign were formed by small lenses. The light was conducted to the lenses along optical fibres illuminated with a halogen lamp at the other end of the fibre bundle. The fibre-optic sign automatically adjusted its output level according to the ambient light (the appropriate maximum and minimum levels of brightness were adjusted subjectively).

Figure 1. Schematic representation of (left) the electromechanical sign and (right) the fibre-optic sign.

The speed data were collected by two pairs of detector loops, the first pair located approximately 900 m before the signs and the second pair 32 m before the intersection.

Procedure

The stimulus condition was always changed after 1 hour to match the lighting and traffic conditions. This was done either by covering the electromechanical sign or by turning off the fibre-optic sign. This made the signs inconspicuous, i.e. nothing more than a dark grey board.

The driver interview was conducted at the bus stop, approximately 1.6 km after passing the signs. The drivers were stopped by a person wearing a luminous vest. Because of the curve, the drivers were not able to see him before the intersection. The delay between passing the signs and the interview was less than 2 minutes.

First, the driver was shown a picture of the intersection he or she has just passed. The picture showed the intersection from the viewpoint of the approaching driver, and there were no speed limit signs in the picture. The driver was asked what the speed limit was at that intersection. Second, the driver was asked to describe the appearance of the speed limit sign. He or she was also asked if the speed limit sign differed from a conventional speed limit sign.

The data were collected on Tuesdays through Thursdays, daylight data between 09:00 and 15:00 and night-time data between 21:00 and 23:00. The night-time data collection began at least 1 hour after sunset. The experiment was conducted in good weather and road surface conditions; i.e. there was no active precipitation or water on the road surface.

RESULTS

Driving speed

The main analysis of driving speed focused on the mean speed before and after the sign by vehicle category (cars/vans and trucks/buses). Only vehicles travelling in free-flow traffic situations (with a minimum headway of 5 s between the actual vehicle and the vehicle ahead) were included in the analysis. The data of the second speed measurements included only vehicles with a minimum speed of 50 km/h. This selection was aimed at excluding vehicles turning right, which were driving in the same lane as vehicles going straight on.

In daylight there was no statistically significant speed difference by type of sign in each vehicle category, either before the speed limit sign or after it. After the sign, the mean speed of cars and vans was 70.1 km/h for the fibre-optic sign, and 71.0 km/h for the electromechanical sign. The corresponding mean speeds of trucks and buses were 72.6 km/h and 72.9 km/h, respectively.

In the dark the fibre-optic sign cut the mean speed of cars and vans more (3.9 km/h) than the electromechanical sign (Figure 2). Specifically, there was no statistically significant speed difference by type of sign in each vehicle category before the sign. After the sign, however, the mean speed of cars and vans was lower for the fibre-optic sign than for the electromechanical sign, $t(741) = 4.53$, $p < 0.001$. The corresponding difference for trucks and buses was not statistically significant.

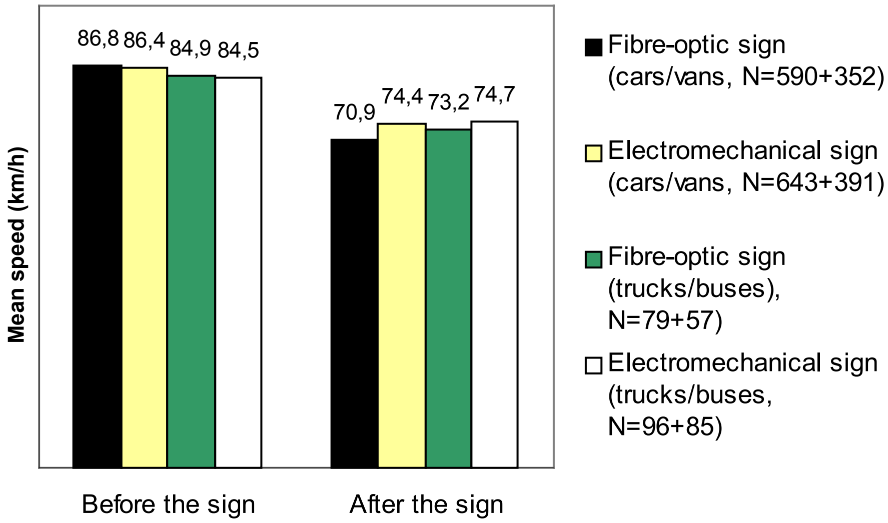

Figure 2. Mean speed of vehicles travelling in a free-flow traffic situation before and after the sign, by vehicle category in the dark. 'N' indicates the number of vehicles before and after the sign.

The results concerning the proportions of vehicles exceeding the posted speed limit by more than 5 km/h showed that in the dark vehicles exceeded the speed limit more frequently when the electromechanical sign was applied (78.4%) than when the fibre-optic sign was applied (68.7%), $\chi^2(1) = 10.6$, $p < 0.01$. *In daylight* there was no statistically significant difference between the two signs, although the percentage of drivers exceeding the speed limit tended to be higher when the electromechanical sign was used (70.2%) than when the fibre-optic sign was used (65.8%).

Driver interviews

Totally 669 drivers were interviewed (155 to 186 drivers in each sign and lighting condition). Seventy-seven percent of the drivers interviewed in daylight were men. Their ages ranged from 18 to 81 years (mean 46 years). Eighty-five percent of the drivers drove a car and 15% a van. Seventy-three percent of the drivers interviewed in night-time were men. Their ages ranged from 18 to 72 years (mean 41 years). Ninety percent of the drivers drove a car and 10% a van. The vehicle kilometrage of drivers during the last year and the driver's frequency of passing the site are shown in Table 3. The driver characteristics in the two lighting conditions were somewhat different. Specifically, the drivers were younger in night-time than in daylight, $t(664) = 5.01$, $p < 0.001$; they had passed the test site more frequently, $\chi^2(3) = 34.38$, $p < 0.001$; and there were more drivers driving a car, $\chi^2(1) = 4.35$, $p < 0.05$.

In daylight 81.2% of the drivers recalled the speed limit when the fibre-optic sign was used, compared with 77.9% when the electromechanical sign was used (not significant). However, drivers passing the site weekly or more frequently were more likely to recall the speed limit when the fibre-optic sign was used, $\chi^2(1) = 3.88$, $p < 0.05$ (see Figure 3). The effects of other background variables on recall of the speed limit were not significant.

Table 3. Vehicle kilometrage of drivers during the last year and driver's frequency of passing the site.

	Percentage of drivers	
	Daylight (N=347)	Night-time (N=319)
Vehicle kilometrage during the last year		
Less than 10,000 km	17%	14%
10,000 - 19,999 km	29%	23%
20,000 - 49,999 km	42%	50%
50,000 km or more	12%	13%
Frequency of passing the site		
Daily	21%	41%
Weekly	31%	28%
Monthly	38%	23%
Less than monthly	10%	8%

In night-time 73.9% of the drivers recalled the speed limit when the fibre-optic sign was used, compared with only 56.8% when the fixed speed limit sign was used, χ^2 (1) = 10.4, $p < 0.01$. No effect of background variables on recall of the speed limit was found to be significant.

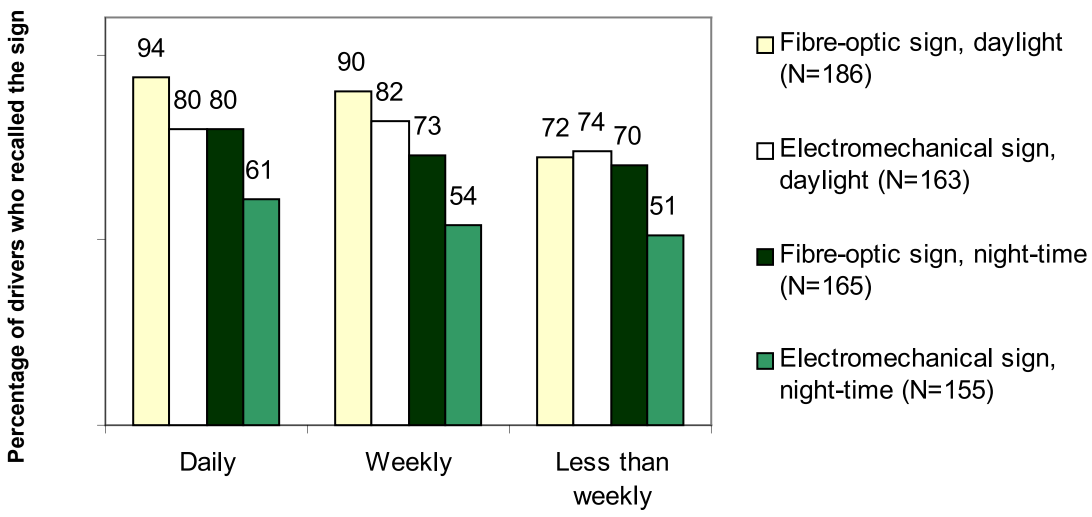

Figure 4. Recall of the sign by type of sign, lighting conditions and frequency of passing the site. 'N' indicates the number of vehicles before and after the sign.

The drivers were also asked to describe the appearance of the sign and whether they had noticed any difference compared to a conventional speed limit sign. In daylight the fibre-optic sign resulted more frequently (69.5%) than the electromechanical sign (56.7%) in responses 'variable message sign', $\chi^2(1) = 4.92$ $p < 0.05$. The corresponding percentages for night-time were 63.9% and 33.0%, respectively ($\chi^2(1) = 19.63$, $p < 0.001$).

DISCUSSION

According to the results, in daylight there was no statistically significant difference in the effects on speed of the two signs for vehicles travelling in free-flow traffic, although there was a slight tendency to greater speed reductions (-0.2 to -0.6 km/h) with the fibre-optic sign. In the dark, however, the fibre-optic sign cut the mean speed of cars and vans travelling in free-flow traffic significantly more (3.9 km/h) than the electromechanical sign. Also, the speed limit was less frequently exceeded by more than 5 km/h when the fibre-optic sign was used.

The results of driver interviews showed that drivers recalled the fibre-optic sign more frequently than they did the electromechanical sign. In the dark, the recall rate for the fibre-optic sign was 73.9% compared with 56.8% for the electromechanical sign. A similar pattern was evident in daylight, but only for drivers passing the site weekly or more frequently. A high level of brightness seemed to be the most frequently recalled feature, except for the electromechanical sign in the dark, when drivers most frequently indicated that the sign was a conventional one. In both lighting conditions, drivers passing the fibre-optic sign more frequently than drivers passing the electromechanical sign recognised the sign as variable.

The main implication of this study is that a variable speed limit sign with fibre-optic technology is more effective than an electromechanical sign equipped with fluorescent retroreflective sheeting. Although the overall speed data in daylight did not support this conclusion, the interview results suggest that the relatively strong effects of the electromechanical sign were limited to drivers passing the site less than weekly. In the dark, the more substantial effects of the fibre-optic sign were evident in greater effects on speed, and in the higher recall rate of the speed limit and variability of the sign.

Although the present results do show evidence of some advantages of fibre-optic sign over electromechanical sign equipped with fluorescent retroreflective sheeting, the data have their own limitations. For example, the circumstances of the study only covered a single application and location (i.e. speed limit sign at the intersection of a secondary road). Consequently, the results cannot be generalised to all traffic environments or circumstances and more research is needed to study the effects of sign technology on driver behaviour.

ACKNOWLEDGEMENT

Appreciation is extended to the Finnish National Road Administration (Finnra) for their support of this study.

REFERENCES

Jenssen, G.D. and Brekke, B. (1997). *A study of the visibility and effectiveness of fluoresent retroreflective traffic control signing in work zone applications*. Paper presented at the International Conference on Traffic Safety on Two Continents (Lisbon, Portugal, September, 22-24, 1997).

Jenssen, G.D., Brekke, B. and Moen, T. (1998). *Field evaluation of the effect of fluorescent retroreflective traffic control devices on driver attention and behavior*. Paper presented at the

77th Annual Meeting of Transportation Research Board (Washington, D.C., January 11-15, 1998).

Luoma, J. and Rämä, P. (1998). Effects of variable speed limits on speed behaviour and recall of signs. *Traffic Engineering + Control, 39*, 234-237.

Rämä, P., Luoma, J. and Harjula, V. (1999). Distraction due to variable speed limits. *Traffic Engineering + Control, 41*, 428-430.