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The effect of different delineator post configurations on driver speed in night-time traffic: A driving simulator study

Sara Nygårdhs[a,b,*], Sven-Olof Lundkvist[a], Jan Andersson[a], Nils Dahlbäck[b]

[a] The Swedish National Road and Transport Research Institute (VTI), SE-581 95 Linköping, Sweden
[b] Department of Computer and Information Science, Linköping University, SE-581 83 Linköping, Sweden

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ABSTRACT

The aim of the study was to investigate how different delineator post configurations affect driver speed in night-time traffic. In addition, the potential speed effect of introducing a secondary task was investigated. The study was carried out in a car simulator on a road stretch including straight road sections as well as curves with different radii. Fourteen drivers participated in the study and the results show that absence of delineator posts leads to reduced speed. However, provided that there are delineator posts continuously present along the road, the overall driver speed is basically the same, regardless of the spacing between the delineator posts. The results also imply that to reduce driver speed in curves with small radius, using more compact spacing of posts in these curves as compared to in curves with a larger radius, could be a potential strategy. Additionally, the speed reducing effect of a secondary task was only prevailing where the task was initiated.

1. Introduction

Road accidents are a cause for concern in all countries and vehicle speed is a factor strongly contributing to the outcomes of these accidents on the road network. The road authorities often strive to fulfil sometimes conflicting goals of driver safety, accessibility, comfort and others. Road delineator posts are examples of available road equipment measures that can be used in order to fulfil the goals of the road authorities. In the Nordic countries, the aim of delineator posts is to provide drivers with visual guidance in night-time traffic for increased comfort and accessibility (Lundkvist, 2012). Their effect on traffic safety has however been discussed.

1.1. Driver behavioural theory

A field experiment on Finnish two-lane rural roads showed that introduction of delineator posts increased driving speeds as well as the number of injury accidents in darkness on roads with low geometric standard (Kallberg, 1993). This finding is in agreement with the risk homeostasis theory by Wilde (2001), which states that:

In any ongoing activity, people continuously check the amount of risk they feel they are exposed to. They compare this with the amount of risk they are willing to accept, and try to reduce any difference between the two to zero. Thus, if the level of subjectively experienced risk is lower than is acceptable, people tend to engage in actions that increase their exposure to risk. If, however, the level of subjectively experienced risk is higher than is acceptable, they make an attempt to exercise greater caution. (Wilde, 2001, p.5).

This theory by Wilde can be interpreted as when driving a car, measures meant to help the driver drive more safely, may in fact lead to increased speed in order for the driver to maintain the same experienced amount of risk he or she is willing to accept.

The zero-risk theory, presented by Näätänen and Summala (1976) and explained more in detail by Summala (1986), describes a situation where a driver is maintaining a certain safety margin. The driver's subjective speed variance is smaller compared to the objective variance, both in the driver's own performance and in the environmental conditions (Summala, 1986). Summala does not have high hopes for changing driver behaviour and suggests speed regulation as a necessary condition for efficient traffic safety work. He writes that:

The key for the effective safety countermeasures is thus to prevent drivers from changing their behavior in response to system

* Corresponding author at: Corresponding author at: The Swedish National Road and Transport Research Institute, Human-Vehicle-Transport System Interaction, Olaus Magnus väg 35, SE-58195 Linköping, Sweden. Tel.: +46 13 204330.
E-mail addresses: sara.nygardhs@vti.se (S. Nygårdhs), sven-olof.lundkvist@vti.se (S.-O. Lundkvist), jan.andersson@vti.se (J. Andersson), nils.dahlback@liu.se (N. Dahlbäck).

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modifications—i.e. to prevent drivers from satisfying their motives. (Summala, 1986, p.15)

This is in contrast to Wilde, since the risk homeostasis theory assumes that drivers continuously check the amount of risk they feel they are exposed to and adapt to it, while the zero-risk theory, on the other hand, implicates that drivers normally do not feel exposed to any risk.

Like Summala, Fuller (2005) argues that risk of collision is generally not relevant in the decision-making loop when driving. Instead, Fuller proposes task difficulty homeostasis as a subgoal when driving and risk homeostasis, in the sense of risk regarding feelings of risk, as being a special case of the former. According to Fuller, there is an inverse relation between driving task difficulty and the difference between driver capability and driving task demand. Although there are many factors determining task demand, such as environmental factors (e.g. visibility, road alignment, road marking and curve radii), other road users and operational features of the vehicle (e.g. information display), choice of speed is considered to be a factor over which the driver has immediate control (Fuller, 2005).

What seems to be a common main factor in the theories described by Wilde, Fuller and Summala and Näätänen is driver speed. Therefore, measuring driver speed is significant when investigating how different road equipment measures affect driver behaviour. One measure with the aim to facilitate driver guidance is using road delineator posts.

1.2. Night-time traffic and delineator posts

The human vision deteriorates as the amount of light decreases, which impairs both visual acuity and contrast sensitivity (Fors and Lundkvist, 2009). Since drivers essentially need visual information to carry out their driving task, the amount of available information decreases as the light level is reduced.

Bella and Calvi (2013) compared driving with different road designs during daytime and night-time visual conditions using a driving simulator. They conclude that it is not satisfactory to base speed analysis of tangent-curve transitions only on daytime driving conditions, because potential critical road situations that were identified during night-time driving were not identified from the simulated daytime driving. In order to minimize speed differentials during the night it is suggested to aim at speed reducing measures before entering a curve and also to increase the perception and visibility of the curve.

Since the main task of delineator posts is to provide visual guidance in darkness, i.e. at night-time conditions, they could possibly be used as such a visibility measure that Bella and Calvi recommend.

In a previous driving simulator study, the effect of road marking visibility and presence of delineator posts on a rural two-lane road with posted speed limit of 90 km/h was studied (Ihs, 2006). It was found that delineator posts (with a spacing of 50 m) on this kind of road increased driver speed approximately 2–10 km/h in night-time conditions, depending on road marking visibility. Presence of delineator posts affected driver speed more if the road marking visibility was poor.

Zador et al. (1987) studied short- and long-term effects of different curve delineation treatments on driver speed on existing two-lane roads in situ. They found that presence of delineator posts along the outside of curves increased night-time speeds in curves by about 2 km/h. These short-term results were not contradicted by long-term measurements.

Blaauw (1985) tested different configurations of raised pavement markers and delineator posts in darkness on straight road sections and curves with 1000 m radius and 200 m radius, respectively. The study was carried out in the field with constant speed and driver determined visual occlusion. The results showed that drivers observed the road less frequently if the delineator posts were located 1.5 m from the driver lane as opposed to 3.5 m. In addition, all drivers observed the configurations at small curves more often than at large curves, and more seldom at the straight road stretches.

Another attempt to compare different retroreflective delineation treatments in curves was conducted as an instrumented car study on a test track (Jenkins, 1991). For small curves with a radius of 125 m it was concluded that drivers entered the curve faster and tended to brake harder in the curve if there were delineator posts compared to if there were raised pavements markers present. Other research on driving and overtaking in horizontal curves for right-hand traffic in general (based on a field test with an instrumented vehicle) implies that speed is higher in curves to the right than to the left (Othman et al., 2010).

As the use of in-vehicle devices become more common (Jacobson and Gostin, 2010), it is of interest to study whether or not there is a relationship between visual distraction and different delineator post configurations. Although there is no general definition of driver distraction at present, Young and Regan (2007) found in a research review on the subject, that drivers tend to engage in various compensatory strategies in order to maintain an acceptable level of driving performance while interacting with in-vehicle devices. Some of the compensatory strategies mentioned were reducing speed or not using in-vehicle devices at all during driving. In a simulator study by Haigney et al. (2000) it seemed that drivers tried to compensate increased cognitive workload (in the form of mobile phone use) by reducing speed. It was however found that increased cognitive workload was still the case and the authors predicted that drivers would be less able to handle emergency situations or other sudden increases in driving task demands.

1.3. Aim and predictions

In order to find out how different delineator post configurations affect driver speed, a simulator experiment was carried out. The aim of this study was to investigate the effects of delineator post configurations on speed in darkness. Existing delineator post configurations were tested along with baseline and best practice configurations. The delineator post spacing differed depending on curve radius for the chosen configurations. According to the maxmincon principle, where the range of values of research variables should be wide, horizontal curves with large radius (1000 m) and small radius (250 m) were used, in both the left and right direction. Using a car simulator also affords for a controlled environment where all the participants experience the exact same road, environmental conditions and visual cues outside of the car. For the purpose of examining the possible influence of distraction during driving, a distraction task was used. The distraction task was operationalized through a visual in-car device, previously used in the same simulator by e.g. Kircher and Ahlström (2012). By this, possible interactions of visual distraction with delineator post configuration could be observed.

In accordance with the theory and previous references above the following predictions can be made:

- Presence of delineator posts lead to increased driver speed compared to absence of delineator posts on the whole road stretch (Ihs, 2006) and in curves (Zador et al., 1987).
- Given that there are delineator posts present continuously on the road, driver speed is dependent on the spacing between them (Fuller, 2005).
- Drivers reduce their speed in connection to a secondary task (Haigney et al., 2000).

From the predictions made above, an additional prediction can be made: