Interaction between Speed Choice and Road Environment

Abstract
This project aimed to identify the most effective, low-cost speed-reducing measures for a selection of urban and rural environments. The overall project approach consisted of three sequential steps:

- Stage 1 – a review of speed-reduction treatments;
- Stage 2 – applying expert judgement to the information gathered in Stage 1 to design a range of treatments for each of the problem areas and road types; and
- Stage 3 – simulator experiments to identify the most promising treatments.

Main findings
The review outlined the state-of-the-art speed-reducing measures, focusing on engineering design. This involved consultation of the current research literature, analysis of existing data and a survey of local authorities in the UK. One of the main conclusions here was that the methods that local authorities use to evaluate and report the success of interventions should be standardised and the results made easily accessible by other authorities. Twenty different speed treatments were then evaluated using a high-fidelity driving simulator:

- Treatments generally achieved better results if there was a reason for drivers to slow down (e.g. a sharp bend or a junction) or clearly defined change of speed limit (e.g. a village entry).
- Physical treatments, including those that featured sensory feedback, achieved the lowest spot speed on urban roads, while rural roads were found to be amenable to peripheral hatching and vehicle-activated signs. Hazard marker posts at rural bends were also found to be successful in lowering speeds.
- Peripheral hatching achieved superior results compared to central hatching, presumably due to the fact that drivers were guided towards the centre of the carriageway, thus affecting their safety margin.
- Treatments with high contrast in relation to their environmental setting also played a role in capturing drivers’ attention and hence facilitating speed perception.

The best-performing treatments for each road layout were then evaluated for their persistence, by repeating each treatment at three locations. Most of the treatments tested were durable, with the exception of pedestrian refuges on urban straight roads and warning signs with an advisory speed on rural lanes.
Background

Environmental cues such as road markings, surface characteristics, roadside furniture and landscaping all provide the driver with an indication of the appropriate speed for a particular stretch of road. Better use could be made of road markings and other environmental features, to provide drivers with feedback about their speed. This research project sought to understand the environmental cues important to speed choice and identify the features of the road and roadside that could be modified affordably to encourage the choice of appropriate speeds.

Research findings

Current practice in scheme evaluation

A survey was distributed to local authorities, and discussion groups were run with experts, to establish how speed reducing schemes are currently evaluated. This consultation revealed that robust monitoring of speed interventions is not carried out in all circumstances, often due to a lack of resources. Where monitoring was taking place, the results were generally not being shared with other local authorities in a consistent manner. The MOLASSES (Monitoring Of Local Authority Safety SchemES) database only holds accident numbers, and no speed data are included. Improvements to this monitoring procedure are currently being undertaken.

Short-term treatment efficacy

The first behavioural study in this project evaluated the short-term effects of a number of low-cost speed reducing treatments in the University of Leeds Driving Simulator, Figure 1.

The study considered schemes appropriate for rural and urban road environments (identified by literature review and consultation with an expert panel composed of road safety practitioners) and which addressed the most prevalent speed-related accidents. Seven road scenarios (see Table 1) were modelled with road markings, widths and signs conforming to current UK legislation.

A total of 20 speed-reducing treatments were developed, representing various types suitable for implementation on each road scenario. In order to accommodate all scenarios and all treatments, 45 road sections were modelled and used to develop three separate routes. Each route took approximately 25 minutes to drive and incorporated urban and rural scenarios. Using a within-subjects design allowed a direct comparison between a driver’s baseline speed and their speed at each of the treatments.

<table>
<thead>
<tr>
<th>Road layout</th>
<th>Treatment</th>
<th>Speed reduction (baseline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban straight</td>
<td>Pedestrian refuges</td>
<td>-2% (+3%)</td>
</tr>
<tr>
<td>Urban junction</td>
<td>Raised rumble strips</td>
<td>-5% (-1%)</td>
</tr>
<tr>
<td>Rural straight</td>
<td>Coloured peripheral hatching</td>
<td>-4% (-1%)</td>
</tr>
<tr>
<td>Rural junction</td>
<td>VAS with SLOW DOWN</td>
<td>-14% (-8%)</td>
</tr>
<tr>
<td>Rural bend</td>
<td>Hazard marker posts</td>
<td>-44% (-37%)</td>
</tr>
<tr>
<td>Village entry</td>
<td>Countdown signs</td>
<td>-35% (-26%)</td>
</tr>
<tr>
<td>Rural lane</td>
<td>Advisory speed limit</td>
<td>-15% (-10%)</td>
</tr>
</tbody>
</table>

Table 1: Comparison of treatment effects (Study 1)

Treatments generally achieved superior results if there was a reason for drivers to slow down, e.g. a potential conflict spot ahead (a sharp bend or a junction) or a clearly defined change of speed limit (e.g. village entry). This could explain the relatively small effect of treatments on the straight sections of roads. Physical treatments (in this case, pedestrian refuges) achieved the lowest spot speed on urban straight roads, suggesting that the presence of physical objects amends drivers’ safety margin and hence their choice of speed.

Peripheral hatching achieved superior results compared to central hatching, presumably due to the fact that drivers were guided towards the centre.
of the carriageway, again amending drivers’ safety margin and speed choice.

The provision of sensory feedback appears valuable for speed reduction, demonstrated by the different results achieved for raised and flat rumble strips. Contrast also plays a role in capturing drivers’ attention and hence facilitates speed perception. This effect was demonstrated by coloured hatching achieving superior results, compared to hatching without coloured surface. This effect was demonstrated across both rural and urban environments. This phenomenon is also evidenced by signs with a yellow backing board, particularly in the rural environment. Presumably this is because the urban scene is generally more cluttered and hence the contrast effect is diminished.

Vehicle activated signs (VAS) demonstrated impressive results across various road layouts. They were consistently superior to static signs, suggesting that the alerting mechanism contributes to speed perception. In addition, warning signs that provide an advisory speed limit achieved better results than warning messages such as ‘Reduce speed now’ or ‘Slow down’ appended to the sign.

Advanced warning (e.g. VAS) generally achieved superior results compared to late warning (e.g. rumble strips) treatments and resulted in a smoother speed reduction over distance. Repeated warnings (e.g. countdown signs) also demonstrated their value. However, for sharp bends, treatments that guide the drivers through the bend achieved superior results compared to advanced warning with respect to the actual speed at curve apex, where loss of control is most likely to occur.

**Long-term treatment efficacy**

The most successful treatments from Study 1 (see Table 1) were used in the second driving simulator study, designed to test the durability of the speed reductions. Again, a completely within-subjects design was used, and each driver encountered each treatment three times (and also drove through three corresponding baseline sections of the same length).

Most of the successful treatments demonstrated persistence over time (see Table 2). The only exceptions were pedestrian refuges on urban straight roads and warning signs with advisory speed limit on rural lanes.

**Conclusions**

The results of the review and consultation suggest that the methods that local authorities use to evaluate and report the success of interventions should be standardised. The results should be made easily accessible to other local authorities.

Using a driving simulator has allowed a robust comparison of 20 diverse speed-reducing treatments. Each of the drivers encountered all the treatments, one of the most effective ways of controlling for extraneous variables.

Overall, the results suggest that treatments which have different underlying mechanisms (informative, alerting etc.) are differentially effective in urban and rural settings. Relatively straight sections of road are known to encourage higher speeds and, in both urban and rural sections of road, the treatments produced only small speed reductions – in the order of 2–4%. Pedestrian refuges and coloured peripheral hatching were the most successful treatments in urban and rural straight roads respectively.

On approach to junctions, alerting treatments were the most effective. Vehicle activated signs and rumble strips proved effective countermeasures at urban junctions, while in rural environments signs are the best option. Both static and vehicle activated signs were effective in lowering speed around rural junctions, achieving double the speed reduction compared to the urban junction scenario.
The top-performing bend treatments appear to be those that provide the driver with guidance regarding the appropriate curve negotiation speed. Informing drivers explicitly (using an advisory speed sign), or implicitly (using chevrons or hazard marker posts) appears to work similarly well. These treatments provide drivers with sufficient time in order to make the requisite speed changes, a feature associated also with the most effective treatment at a village entry. Here, countdown signs worked well, suggesting that early and continual reminders are necessary.

The second study demonstrated that most of the top-performing treatments were durable over a short time period, particularly raised rumble strips (urban junctions), hazard marker posts (rural bend) and countdown signs (village entry).

**Future directions**

Further methodological work should be undertaken to define the appropriate measurement variables to allow for the comparison of a wide range of schemes. Driving simulation has the benefit of providing a controlled environment in which to test schemes – efforts should be made to develop tools that allow quick and easy modelling of real-world problem sites. Validation of the simulator study should be undertaken, where increased visual clutter and, for example, pedestrian movements may impact further on driver behaviour. A small pilot site using the suggested treatments and roadside measurements would allow this.

**About the project**

This project employed a state-of-the-art driving simulator to undertake a robust comparison of a wide range of low-cost speed reducing treatments across a variety of road types.