Evaluation of Perceptual Countermeasure Treatments

Thanuja Gunatillake, Michael Tziotis, Jemima Macaulay (ARRB TR)
Brian Fildes, Stuart Godley (MUARC)

ABSTRACT

Perceptual countermeasures is a term given to a class of road treatments which are intended to induce drivers to reduce travel speeds by altering driver perception of speed, risk or comfort. They are generally low cost treatments which rely on painted markings or other forms of delineation.

ARRB Transport Research, in conjunction with the Monash University Accident Research Centre (MUARC), is currently trialing two perceptual countermeasure treatments for the Australian Transport Safety Bureau (ATSB) in association with the Roads and Traffic Authority of NSW and VicRoads. The trials mark the final of a four phase project investigating perceptual countermeasure treatments and their applicability in Australia. Based on the findings of a comprehensive literature review and simulation studies, two perceptual countermeasure treatments were selected for trial. The first treatment consists of enhanced lateral guide post spacing with ascending heights around a curve. The second treatment is a peripheral transverse line (occurring on the edges but not in the centre of the travelling lane), placed at regular intervals over 400m on the approach to an intersection. Each treatment is currently being trialed in Victoria and New South Wales. In Victoria, the treatments are also being investigated during night time driving conditions.

The present paper outlines the key findings of the first three stages, and how they have input into the design and conduct of the fourth and final stage, currently in progress. It reports the progress of the fourth stage and discusses the implications of the investigation for road safety in Australia.

1 INTRODUCTION

Speed or speeding has long been recognised as a major factor in the occurrence and severity of road crashes. Overseas studies have identified excessive speed as a contributing factor in approximately 37% of all fatal road crashes, whilst Australian investigations have estimated speed to be a contributory factor in approximately 30% of all fatal crashes. The cost of these road crashes is high, both in terms of personal loss and cost to the community. Nationally, these crashes have been estimated to cost up to 1 billion dollars per annum, with Victoria bearing approximately $260 million per annum and NSW, 470 million dollars per annum.

The implementation of enforcement, education/ publicity and engineering programs has assisted in reducing the incidence and severity of speed related crashes across Australia. However, supplementary measures are required to more effectively control speeding and discourage unsafe driver behaviours, particularly at hazardous road locations.

In order to identify future directions for research in this area, Fildes and Lee (1993) facilitated discussions with leading experts from across Australia. A key finding of these discussions was the need to develop low cost perceptual countermeasures designed to reduce driver speeds on the road.

Based on the findings of this investigation, the Federal Office of Road Safety (FORS) (now the Australian Transport and Safety Bureau (ATSB)) and the Roads and Traffic Authority (RTA) of NSW commissioned Monash University Accident Research Centre (MUARC) and ARRB Transport Research (TR) to explore the types, uses and proven benefits of various perceptual countermeasures, to evaluate their effectiveness in a simulated driving environment and to trial a selection of these countermeasures on the Australian road network in an attempt to identify the most effective and feasible options for Australian road authorities.

2 Study Outline and Status

The evaluation of perceptual countermeasures or Perceptual Safety Treatments (PST), conducted jointly by ARRB TR and MUARC, commenced in 1993 in the form of a four phase research program. The four discrete phases, to be conducted over a period of over seven years, were as follows:

Phase 1 – Literature Review
Phase 2 – Validation of Behaviour in Driver Simulator

Phase 3 – Simulator Modelling of Driver Responses to Perceptual Treatments
Phase 4 – On-road Trials of Perceptual Treatments

To date, the first three phases have been completed. The fourth stage commenced in 1999/2000 and is due for completion in June 2002. Through the completion of this four phase research program, the following publications have been/ will be generated:

I. **Perceptual Countermeasures: Literature Review.** CR4/94 (FORS and RTA NSW), BN Fildes and JR Jarvis, November 1994. (Completed)
II. **Perceptual Countermeasures: Simulator Validation Study** CR 169 (FORS) and RR 1/97 (RTA NSW), Fildes, BN, Godley, S., Triggs, T and Jarvis, JR, April 1997
III. **Perceptual Countermeasures: Experimental research**, Report CR182, Godley S., Fildes B., Triggs T & Brown L. (1999), Australian Transport Safety Bureau, Commonwealth Department of Transport and Regional Services, Canberra. (Completed)
IV. **Perceptual Countermeasures: Trialing of Perceptual Safety Treatments** (Final phase of major study, to be completed 2001)

The present paper outlines the key findings of the first three stages, and how they have input into the design and conduct of the fourth and final stage, currently in progress.

3 Perceptual countermeasures evaluation

Perceptual countermeasures are a class of road and roadside treatments designed, through their visual effect, to induce motorists to reduce their travel speeds by altering their perception of speed, risk or comfort. They are generally low cost treatments which rely on painted road surface markings or other forms of delineation. The primary application of these treatments are at hazardous locations where the crash history has identified excessive driver speeds as a major contributing factor. The present investigation seeks to investigate the range of perceptual countermeasure options available, their effectiveness and the feasibility of their implementation in an Australian context.

3.1 Phase 1: Literature review

A comprehensive literature review was conducted in 1993/1994, with the objective of providing an overview of recent perceptual countermeasure developments against excessive speeding and the requirements for, and directions of, future research. The review sought to highlight both existing and potential treatments that have been developed and trialed both locally and overseas, in order to outline a program of research for further development or refining of suitable treatments for implementation and evaluation on Australian roads for their speed reduction potential. Visits were also made to a number of prominent research organisations in Europe to assess, first hand, the types of treatments in development and their potential relevance to Australia. A number of promising road and roadside treatments were subsequently identified, with seeming speed and crash reduction potential. The review identified a need for a a more systematic development, implementation and evaluation plan. The primary outcome of the review was the development of a research plan including a laboratory research program, followed by on-road demonstration trials to ensure that the speed and crash benefits of the more successful of these measures would be implemented and thoroughly evaluated on the road.

The most promising treatments identified through the literature review, to be adopted in the detailed research program are listed below. These treatments were selected based on their relatively low cost and their potential as an additional road safety countermeasure.

- Edgeline and centreline treatments
    - Herringbone Pattern: A reducing herringbone pattern on the edge and centreline of the road
    - Chequered pattern: Alternative edge and centreline treatment
    - TNO Centreline and edgeline treatment: Low contrast perceptual (rumble) treatment
    - Edgeline comb and hatching effects
    - Centreline (median) treatments: including widening of median to reduce lane width
    - RPMS's versus line treatments
    - Curve enhancements: including innovative novel post spacings and variable delineator height as well as road treatments to the edge line as well as transverse lines in the approach zone

- Transverse road markings and rumble effects
- Special application treatments
    - Osaka bridge treatment: Painted thermoplastic large road chevrons and broken centre and edgelines
    - Close following chevrons: chevrons at 40 metre intervals on highways to help drivers choose a more safe following distance

3.2 Phase 2: Validation of behaviour in Driving Simulator

A study was undertaken to demonstrate whether the MUARC driving simulator (developed by the Transport Accident Commission TAC) was a valid environment for testing of perceptual countermeasures. The simulator employs the latest silicon graphics projections and provides a 180 degree front view as well as a rear image. The simulator also provides 'a sense of 'road feel' through positive feedback dampers under the car and a quadraphonic sound system. This phase of the study was a precursor to a full experimental program aimed at evaluating a range of low cost road treatments as a counter measure to excessive speeding. The driving performance of a sample of drivers in an instrumented test vehicle on-road was compared with that of a similar group in the driving simulator at sites with and without transverse rumble line treatments. Performance measures included speed profiles, braking characteristics, deceleration and lane discipline. Differences were examined statistically between treated and control sites on the road and in the simulator. Results showed that speed and braking responses were correlated for most sites and that lateral placement results were similar for curves. The major conclusions drawn from the study were:

1 The TAC driving simulator held at MUARC was a suitable test environment for evaluating perceptual countermeasures
1. Transverse lines on suburban roads appeared to have a positive effect on speed
2. If transverse lines have an auditory and vibration effects as well as their visual effect, they are likely to have an even larger effect than a visual effect alone.

3.3 Phase 3: Simulator modelling of driver responses to perceptual treatments

A number of participants were recruited to 'drive' the simulator and a total of seven human factor experiments were conducted to test systematically a range of the most promising PCMS identified in the initial literature review. These included:

- Transverse road markings
- Lane edge and herringbone treatments
- Centreline and other edge treatments
- Several enhanced curvature treatments

A number of these treatments appeared effective at reducing travel speed, including:

- Full width transverse lines
- Peripheral transverse lines and lane edge herringbone treatments
- Hatched median (especially with a lane width narrower than 3 metres), with or without intermittent gravel edgelines
- Enhanced post spacings (possibly with ascending post heights) for road curves

In identifying the mots promising of these treatments, it is noted that the selection of perceptual countermeasures for use on the road needs to take account of not only their potential speed reduction benefits but also the practical realities that exist at sites requiring treatment and the likely costs, benefits and maintenance needs. The third phase of the project also identified the need to evaluate the effects of the more promising of these countermeasures on the road itself, both in their immediate and in the long term. These findings were input into the design of Phase 4: 'On road trials and evaluation'

4 Phase 4: On Road trials of perceptual countermeasures

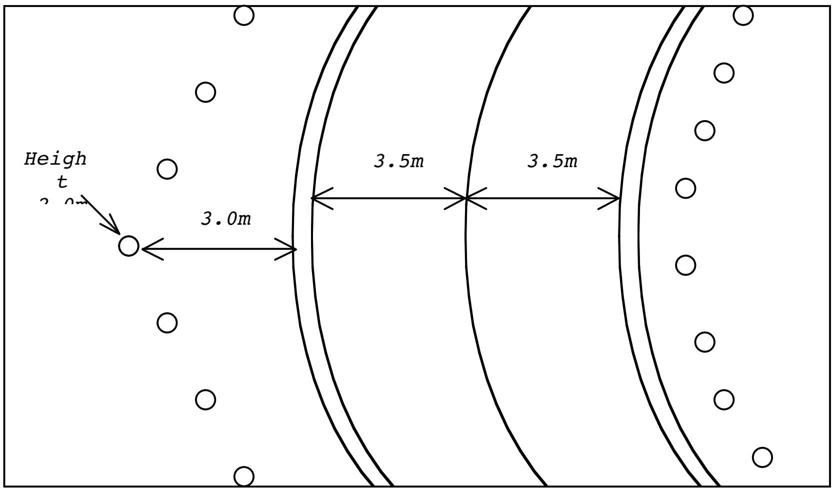
4.1 Treatments selected for trial

Facilitated by two workshops, consultations were held between the research team and a number of relevant traffic engineers, service people and representatives of the funding agencies to overview the findings from the research conducted in stages 1 to 3 and to select appropriate treatments for the Stage 4 research program. Two treatments were selected, one midblock treatment and one intersection treatment.

4.1.1 Curve Treatment

The first treatment consists of enhanced lateral guide post spacing with ascending heights around a curve. To the approaching motorist, the configuration and ascending height of the guideposts makes the curve appear sharper than it is, inducing the driver to negotiate the curve at a lower speed. The technical specifications of the curve treatment are shown below.

Figure 1: Curve treatment



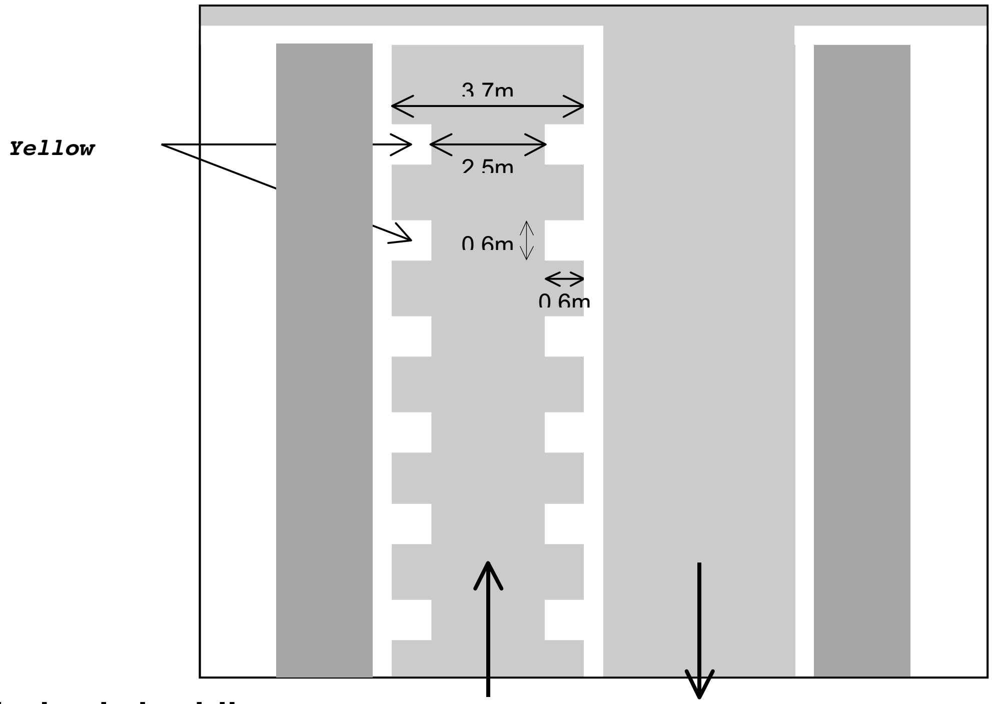
Treatment description

- Treatment to start/finish at the start/finish of curve.
- Guideposts around outside of curve to be spaced at half the normal spacing. The approximate radius of the curves will be need to be determined/estimated.
- Lateral placement of the guide posts to increase evenly from the usual offset (typically 1.2 m) at the start of the curve, to 3m at the centre of the curve, then reduce back to the usual offset at the end of the curve.
- The height of the guide posts to increase evenly from 1m (ie normal height) at the start of the curve, to 2m at the centre of the curve, then reduce back to 1m at the end of the curve.
- Guide posts to be standard timber or flexible posts, painted white etc.
- Two reflectors to be provided on each guide post – one approximately 50 mm from the top of post and one at 1m height.
- No changes to the guide posts on the inside of the curve.

4.1.2 Intersection Treatment: Peripheral transverse line treatment

The second treatment is a peripheral transverse line (occurring on the edges but not in the centre of the travelling lane), placed at regular intervals over 400m on the approach to an intersection. Such treatments are designed to encourage drivers to decelerate more rapidly than usual by influencing their perception. They can also encourage drivers to maintain a central position within the traffic lane. The technical specifications of the intersection treatment are shown below.

Figure 2: Peripheral transverse line treatment on approach to intersection



Treatment description

- Treatment to start approximately 435m from intersection, and to go over 400m (ie. nothing over 35m immediately prior to intersection).
- Peripheral transverse lines to be 600 mm wide, 600 mm long, with a 4.5m gap between parallel lines. Note that the distance between lines (across the lane) will vary depending on the lane width.
- Lines to be yellow paint (not long life).
- Where there is no existing centre line, a centre line will be installed with the treatment (standard 3m-9m dashed centre line) and must continue to intersection (may be solid for last 30m or so)

4.2 Study design

The evaluation of the midblock and intersection treatments at each site comprised the following tasks:

- making a number of observations, namely, braking distance, lateral displacement and speed (at varying points) at the treatment sites, and then comparing these observations and measurements to sites of similar geometric and geographic characteristics which were to remain untreated (ie control sites).

- collecting and analysing both pre and post-crash data at both treatment and control locations

The survey program is shown in Table 2 below:

Table 2 - On-road trial design

Site Group	*Location*	*Before-treatment* (3 months prior)	*After-treatment 1* (1-2 months after)	*After treatment 2* (12 months after)
First treatment	3 - Vic 3 - NSW	X_1	X_2	X_3
First control	3 - Vic 3 - NSW	C_1	C_2	C_3
Second treatment	3 - Vic 3 - NSW	X_4	X_5	X_6
Second control	3 - Vic 3 - NSW	C_4	C_5	C_6

This design will enable the effects of each treatment to be evaluated, both before and after installation, while controlling for traffic differences at the sites. The inclusion of two evaluation periods at 1-2 months and 12 months after installation will facilitate in distinguishing between short and long-term effects.

4.3 Site selection

Three trial treatment sites and three control sites in rural Victoria and in rural NSW were selected for each treatment, totalling twelve sites in each State. The selected sites exhibited accident histories where speed was considered to be a contributing factor in a high proportion of crashes. Candidate sites were inspected to determine the appropriateness of the site for perceptual countermeasure installation and the feasibility of positioning of the ARRB TR video trailer to make discrete observations. Control sites were selected on the basis of their similarity to the treatment sites in terms of horizontal and vertical alignment, cross section, traffic volume and traffic composition. The sites are listed in Table 1 below:

Table 1: Perceptual countermeasure trial sites in Victoria and New South Wales

Treatment description		Road	Site description
Curve (VIC)	Treatment	Gembrook Rd	S bound RH curve just past no. 605 (north of Harvie Rd)
	Control	Gembrook Rd	N bound RH curve just past no. 605 (north of Harvie Rd)
	Treatment	Harkaway Rd	S bound RH curve just past no. 186 (opposite 'Melrose')
	Control	Harkaway Rd	N bound RH curve just past Caserta Dr
	Treatment	Pakenham Rd	S bound RH curve north of Mann Rd (second curve south of no. 1005)
	Control	Pakenham Rd	S bound RH curve south of Paternoster Rd/Mt Burnett Rd (near rock wall)
Intersection (VIC)	Treatment	Ballarto Rd at Koo Wee Rup Rd	North leg
	Control	Ballarto Rd at Koo Wee Rup Rd	South leg
	Treatment	Bittern Dromana Rd at Balnarring Rd	East leg
	Control	Bittern Dromana Rd at Balnarring Rd	West leg
	Treatment	Myers Rd at Coolart Rd	West leg
	Control	Myers Rd at Coolart Rd	East leg
CURVE (NSW)	Treatment	Castleraegh Rd	SW bound LH cur ve near no. 460, past Springwood Rd (cnr private access road)
	Control	Castleraegh Rd	SW bound LH curve between Inalls Rd & Drift Rd
	Treatment	Scheyville Rd	E bound, LH curve past Dormitory Hill Rd
	Control	Scheyville Rd	E bound LH curve at Sydney Show Jumping Club
	Treatment	Henry Lawson Drive	W bound (outbd) first LH curve 600m after Clancy Rd
	Control	Henry Lawson Drive	E bound (citybd) first LH curve just past Boomerang Reserve on LHS, 800m east of River Rd
INTERSECTION (NSW)	Treatment	The Driftway at Londonberry Rd	West leg
	Control	The Driftway at Londonberry Rd	East leg
	Treatment	Old Stock Route Rd at Sanders Rd	North leg
	Control	Old Stock Route Rd at Sanders Rd	South leg
	Treatment	Smith Rd/Broos Rd at Oakville Rd/Stahls Rd	South leg
	Control	Smith Rd/Broos Rd at Oakville Rd/Stahls Rd	North leg

4.4 Performance Measurement

The site observations and measurements will be made using CAMDAS (Video Vehicle Detection System owned by ARRB Transport Research), for braking and lateral displacement observations, and a speed laser gun for speed measurements. This unit is ideally suited for this work as it enables discrete observations of traffic behaviour to be made, without influencing driver behaviour.

Video recording of all vehicles that transverse each treatment and control site for a one-day period was undertaken. This enabled the project team to generate a permanent performance record for analysis at a later time. A series of trials was also conducted at night, to identify differences in the effectiveness of each treatment under different light conditions and also to assess the magnitude of these differences where they existed.

4.4.1 Braking and Lateral Displacement

Observations for braking and lateral displacement of vehicles will be collected for 4-6 hour periods at each site (trial and control sites), prior to the application of the perceptual countermeasures. The "after" observations will be collected after an initial 4 week settling in period and again after 12 months.

4.4.2 Speed Measurement Profiles

To determine the effectiveness of the treatments in terms of vehicle speed reductions, speed measurements will be recorded and speed profiles (ie 85^{th} percentile and mean speed, and standard deviation), plotted at each treatment.

4.4.3 Crash Measurement

To supplement the differences in driver performance observed at each treatment site, crash data at each treatment and control site were collected to allow the project team to measure the reduction potential of each treatment. Site data from police accident records were obtained during the observation period from the appropriate authority. The crash records retrieved will predominantly be those of casualty crashes, a degree of non-injury crashes is also contained on these databases.

Where crash reduction trends are observed at the treated sites, it will then be possible to conduct a cost-benefit analysis of these findings to demonstrate the efficacy of more widespread use of these treatments.

5 Progress to date

At present, all pre-treatment data collection has been completed, both in New South Wales and Victoria, for both treatment and control sites. Treatments in NSW and Victoria have been installed by the respective road authorities at all sites except one. At those sites where treatments have been installed, all post treatment data collection has been completed. The data obtained from the before and after studies for these sites are presently under analysis to assess the short term effects of the treatment installations on driver behaviour.

A second and final series of data collection will be conducted in June 2001, to assess the long term effects of the treatments. The results of this final stage will qualify and quantify the degree to which the treatments have remained effective, after drivers have become more familiar with them or whether familiarity has led motorists to return to their pre-treatment behaviour. A final report, detailing the numerical results and conceptual findings of the pre and post treatment studies is due for publication in June 2002.

6 Future directions

The fourth and final stage of this project seeks to assess, through on road trials, the effectiveness of two of the most promising perceptual countermeasure treatments identified through literature review and simulation experiments, in an Australian context. Findings of the earlier stages of the current investigation have suggested that perceptual countermeasure treatments may be effective in improving driver speed and lane discipline behaviour. As a consequence, it is expected that this will result in a lowering of crash frequencies and severities where applied. In the longer term it is envisaged that the findings of studies of this type will lend to two initiatives:

- the identification of effective, low cost treatments which may be incorporated into standard design practice or mass action programs at locations where the risk of speed related crashes is high
- investigation of other types of perceptual countermeasure treatments to combat dangerous driver behaviours at a range of roadway alignments (eg curves, roundabouts) in order to identify those which are most cost effective and feasible for application in Australia.

7 References

- Fildes, BN, Jarvis JR (1994) ***Perceptual Countermeasures: Literature Review*.** CR4/94 FORS and RTA NSW, November 1994
- Fildes, BN, Godley, S., Triggs, T and Jarvis, JR (1997*) **Perceptual Countermeasures: Simulator Validation Study*** CR 169 (FORS) and RR 1/97 (RTA NSW), April 1997
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