# Reductions in driver speed using posted feedback of speeding information: Social comparison or implied surveillance?

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*Reducing driver speed has an essential role to play in traffic safety. This study measured the effect of a roadside sign, in a 50 km/h zone, that displayed one of three messages:*

1. *The average speed at that site: this message was designed to induce "social comparison" whereby drivers may reduce their speed in order to comply with the behaviour of the majority.*
2. *"Your speed is being measured": this was intended to imply surveillance whereby drivers may reduce speed in order to avoid possible enforcement action.*
3. *A combination of both messages, to see if both together would have a greater effect than either alone.*

*The percentages of high (over 70 km/h) and moderate (61-70 km/h) speeders reduced at the site with all three messages. On the opposite side of the road, where the messages could not be seen, such speed reductions did not occur. The findings of the current study suggest that both social comparison and implied surveillance are mechanisms by which driver speed may be reduced. Signs that encourage social comparison by highlighting behavioural norms do, however, show particular promise because of their educative component. It is suggested that more emphasis should be placed on promoting appropriate behavioural norms in future road safety campaigns.*

Speeding drivers (those drivers travelling in excess of the legal speed limit or at an inappropriate speed for the road and traffic conditions) are a major cause of death and injury on New Zealand roads, contributing to over 30% of road crashes each year (Land Transport Safety Authority, 1999).

The reasons for speed choice are complex but, it has been suggested by Zaidel (1992), any attempt to understand driver behaviour should include the impact of the social traffic environment. While there has only been a small amount of research on social determinants of driver behaviour, there is evidence to suggest that drivers may be influenced by their knowledge of other people's opinions concerning speeding and their impression of what other drivers do. Subjective norms - defined as an individual's perception of social pressures to perform or not perform a specific behaviour - have been found to play a key role in the formation of intention to speed (Parker, Manstead, Stradling, Reason, & Baxter, 1992). However, behavioural norms, the perceived behaviour of a group of people, may be an even more important factor in explaining driver behaviour than subjective norms generated by family and friends who may not be present in the driving situation. The behavioural influence of other drivers has been established in a number of studies concerning speeding; for example, it has been found that the perceived speed of other drivers is important for speed choice (Åberg, Larsen, Glad, & Beilinsson, 1997).

Another potential social influence on driver behaviour is social comparison (Zaidel, 1992), where drivers use other drivers as a reference group, and assess their own position in the context of the behaviour of that group. Social comparison has been little explored in the speeding context, although in a study of drivers' speed choices in free-flowing traffic there was a tendency for following vehicles to travel at a similar speed to the lead vehicle (Connolly & Åberg, 1993). While this effect may be expected when the lead car is slow, the similarity in speed is not accounted for when the lead car is fast. The authors suggested, therefore, that a significant role in speed choice is played by drivers' comparisons of their own speed with the speed of drivers around them.

In making social comparisons, however, drivers may not be accurately assessing the speed of other vehicles. For example, Åberg et al. (1997) found that drivers, on average, estimated the speed of other drivers to be 8-10 km/h higher than the speed actually observed. In a New Zealand study, Walton and Bathurst (1998) found that 90% of drivers claimed to drive slower than the average driver in a 50 km/h zone. If drivers over-estimate other drivers' speed, they may feel pressured to drive at faster speeds even if other drivers in reality do not go so fast.

The tendency for drivers to over-estimate the speed of others suggests why speeding is so prevalent. If drivers perceive a driving misdemeanour to be commonly practised, they may view their own similar misdemeanours as "normal" driving behaviour (Manstead, Parker, Stradling, Reason, & Baxter, 1992). The perceived common practice of such behaviours may, in turn, lead to resistance to behaviour change.

**Posted feedback of speeding information**

There has been limited research into how perceptions of driving norms may be changed in order to improve driver performance; however, the use of public posting of speeding information, as reported by Van Houten and associates in a series of studies (Van Houten, Nau, & Marini, 1980; Van Houten & Nau, 1981, 1983; Van Houten et al., 1985), may be one mechanism by which drivers will change their ideas about what speed is "normal" and hence will change their speed choice.

The initial study reported by Van Houten et al. (1980) consisted of the use of a large roadside sign displaying the percentage of drivers not speeding (defined as travelling under 66 km/h in a 50 km/h zone) on a particular stretch of road during the previous day or week, as well as the highest percentage recorded to date (e.g. "Drivers not speeding yesterday 85%. Best record 85%"). The daily and weekly posting interventions produced decreases in the percentage of drivers travelling above the speed limit, with the largest effect being on higher speed drivers.

Public posting ("posted feedback") of speeding information in the driving environment has since been applied to other settings and populations with promising results (Phillips & Maisey, 1989; Ragnarsson & Bjorgvinsson, 1991; Roqué & Roberts, 1989; Van Houten & Nau, 1981, 1983; Van Houten et al., 1985).

Although posted feedback of speeding information appears to be effective in controlling speed, it is not clear why this should be so. Among the explanations proposed have been that the feedback sign may imply continuing surveillance, or that the feedback sign may introduce a social comparison factor (Van Houten et al., 1980; Van Houten & Nau, 1983). Using similar posted feedback messages to those employed by Van Houten and associates, Groeger and Chapman (1997) conducted a series of experiments in a simulated setting in order to explore these explanations further. Interestingly, they also found that the posted information was effective in reducing speeding, but only where the majority of other drivers present were complying with the posted feedback information. In other words, drivers may treat the posted information with scepticism if the behaviour of other drivers suggests the posted information is untrue. It was also found that, although drivers might become more law-abiding with regard to a particular offence, they did not become more law-abiding in general. The authors concluded, therefore, that posted feedback does not invoke a significant threat of surveillance as when the posted information relates to one violation, there is no observable tendency to become more law-abiding with respect to other violations.

Social comparison looks a very promising mechanism that potentially could be incorporated into the range of practical strategies currently used to encourage drivers to reduce speed. The primary purpose of the current study was, therefore, to attempt to induce social comparison by informing drivers of the average speed of drivers along a particular road. If behavioural norms are an influence on driver behaviour, it was anticipated that drivers deviating from the posted "normal" driving speed would moderate their behaviour to comply with the behaviour of the majority.

The implied surveillance explanation is also of interest as, contrary to previous research findings (e.g. Galizio, Jackson, & Steele, 1979), this suggests that driver speed may be reduced with the threat of surveillance which is not supported by visible police enforcement. A second sign-based condition was, therefore, incorporated which simply advised drivers their speed was being measured.

It may well be that there are a number of mechanisms of behaviour change at work in the effective use of posted feedback to reduce driver speed. In a third condition, both types of information were combined to determine if this would be more successful than either used alone.

## Method

### *The site*

The site chosen for the study was located in Waitakere City, which lies in the western part of the greater Auckland metropolitan area. Specifically, the target site comprised the section of Parrs Cross Road which runs from Seymour Road to West Coast Road, which has a legal speed limit of 50 km/h. Parrs Cross Road is a busy two-lane urban road (one lane in each direction), leading from a semi-urban area to a small suburban retail development surrounded by a residential area. At the target section, the road is bordered by a park on its eastern side and there is a large retail outlet for a local orchard, together with some residential development, on its western side. On average approximately 11,500 vehicles are driven along this section of road each day in each direction.

This particular section of road was selected for the study for several reasons: historical speed data revealed that a high proportion of drivers travelled in excess of the legal speed limit; there was only one entry/exit point, at the very beginning of the target section (with little impact on traffic flow) so that all drivers whose speeds would be measured must have passed the feedback sign; the presence of little other signage in the area to distract drivers' attention away from the feedback sign; and speed measurement equipment was already installed at this site. The sign was erected on the eastern side of the road; the western side of the road was used as a control site.

### *Speed measurement equipment*

Vehicle speeds were monitored using inductive loop detectors ("loops") which were buried under the roadway. The loop detectors were connected to a "classifier" which recorded the total number of vehicles that crossed the loops during each hourly period together with the speed of each vehicle. All single vehicle speed measurements were aggregated and categorised into ten speed categories: 0-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100, 101-110, and over 110 km/h.

The loops were calibrated for accuracy when first installed, two months prior to the commencement of the current study. Re-calibration normally occurs on an annual check of the equipment or earlier if a fault develops with the hardware. Re-calibration was therefore not undertaken during the course of the current study.

### *Feedback signs*

The first feedback sign was constructed from reflective aluminium and measured 1.6 m high by 2.2 m wide. The sign was placed approximately 3.7 m from the side of the roadway at its closest point, and its bottom edge was 2.6 m above the ground. The sign was white with a 5 cm wide black border and 15 cm high black reflective lettering. This feedback sign indicated the average speed of drivers at the measurement point along the experimental site ("Average Driver Speed Here __ km/h"). A pocket was included on the face of the sign so that the average driver speed could be displayed by inserting appropriately numbered digits into the pocket. An error that did occur was the inclusion of the digits "50" on the sign face where the digits panel was located. This meant that if no digits were slotted into the panel, the average driver speed read "50 km/h".

Two logos were incorporated into the sign: the logo of the local council, and another created as a brand for ACC' s "Down with Speed" injury prevention programme.

The second sign was similar in design to the first; however, this time drivers were told that speed measurement was taking place, and information could also be given about average driver speed. The wording concerning average speed was shortened, however, to accommodate the longer message in total ("Your speed is being measured. Average speed __ km/h"). A panel was constructed which could be bolted to the lower portion of the sign, to cover the second part of the sign wording, so that the sign simply read "Your speed is being measured". The error that occurred in the first sign was inadvertently retained, so that when the panel was bolted on, a "50" figure was incorporated into the sign where the speed digit panel was. However, it was assumed that drivers would see this as a speed limit sign, rather than an indication of actual driver behaviour.

The feedback sign was installed 60 m before the loops. Drivers approaching from the main road (Parrs Cross Road) could see the sign for approximately 150 m and thus these drivers had approximately 210 m in which to respond to the feedback sign before their speed was measured. Drivers approaching from the only side road (Seymour Road) had 120 m between seeing the sign and speed measurement taking place, however, generally the drivers approaching from this direction need to wait at this junction in order to give way. Informal observation of the site reveals that approximately 90% of vehicles travelling along the target site approach from the main road. Street lighting overhead ensured the feedback sign was visible at night.

While the back of the feedback sign was visible to drivers travelling in the opposite direction, along the control site, no wording on the sign could be seen by these drivers.

## General procedure

Vehicle speeds were monitored continuously throughout each 24 hour period forming part of an intervention phase. The length of the intervention phases and the time between each phase were dictated by the delay in obtaining data from the contractor and the construction time of the signs. Speed measurement was sometimes interrupted during the longer intervention phases, and re-started at a later date. This ensured speed measurements were available at the commencement of a phase and also later on in the phase, to determine if a gradual rather than an immediate change in driver speed occurred.

While it was intended to post an accurate reflection of average driver speed on the feedback sign, it was important that the initial posted average speed should not be so low that it might be treated with scepticism by drivers. Therefore, it was decided to strategically select from the range of daily means available from both sides of the road.

**Experimental design**

The study consisted of four experimental phases: (a) *Baseline*, (b) *Posted feedback of average driver speed*, (c) *Surveillance information*, and (d) *Surveillance information and posted feedback of average driver speed*.

***Baseline***

During this phase, the feedback sign had not yet been erected, and vehicle speeds were recorded daily using the apparatus and procedure outlined above. Due to a delay in construction of the first feedback sign, this phase lasted almost three months, with four data collection periods during this time (lasting 7, 7, 14 and 5 days respectively).

***Posted feedback of average driver speed***

Prior to the commencement of this phase the first feedback sign (referred to as "the average speed sign") was erected. The initial average speed posted was 54 km/h (the mean speed at the control site) as the mean speed at the intervention site was considered too low (52 km/h). In fact, due to delays in organising a contractor to perform the service of inserting the digits on the feedback sign, the average speed on the sign initially (incorrectly) read "50 km/h". This speed was displayed for 10 days, until the contractor inserted the digits so that the speed now read "54 km/h".

After nearly two weeks of data had been collected (over a three week period) with the "54 km/h" speed displayed, the speed on the sign was changed to "53 km/h" to determine if displaying a lower average speed would have a greater impact on driver speed. The sign was left in place, with the 53 km/h average speed displayed, for eight weeks to ascertain if there was a cumulative effect on driver speed reduction with increased exposure to the sign.

Speed measurements were obtained for the entire period when the "50 km/h" speed was displayed (apart from a one day interval due to the classifier battery being replaced), and for varying length periods throughout the 54 km/h and 53 km/h conditions. This amounted to 35 days of data in total for this phase.

***Surveillance information***

Prior to the commencement of this phase, the first feedback sign was dismantled and the second sign was erected at the same site. The second feedback sign was installed with its lower portion covered with the specially designed panel, so that the sign read "Your speed is being measured". As the digits comprising the number "50" had been incorporated into the design, these figures were also displayed on the sign. This sign is referred to as "the surveillance information sign".

During this phase vehicle speeds were measured as before, for 15 consecutive days.

***Surveillance information and posted feedback of average driver speed***

At the commencement of this phase the panel covering the average speed information was removed to display the full wording of the second feedback sign. This sign is referred to as "the combined feedback sign".

As the previously posted average driver speed of "53 km/h" had been displayed for nearly two months, it was a concern that drivers might habituate to the presence of the sign if the same speed was showing in this phase. Analysis of the data from the *Surveillance information* phase had revealed the daily average speed at the experimental site was 51-52 km/h. The higher average speed was adopted for displaying on the sign, thus the full sign wording read, "Your speed is being measured. Average speed 52 km/h".

Vehicle speeds were measured as before, for a period of 10 days. Unfortunately, when the data were downloaded, it was discovered that a hardware fault in the classifier had occurred and thus the data collected to date in this phase were unusable. The classifier was changed and data collection re-commenced. Speed measurements were taken for six days, followed by a two day break while the data were checked and the classifier battery re-charged. Collection of data continued for another 10 days, making a total of 16 days of data in this phase.

## Results

### Analysis of data

In total, data for 99 days were available for analysis.

In order to examine the effect of the experimental interventions on driver speed, the following sets of analyses were computed on the number of drivers travelling within the 10km/h speed bands each day:

(i) the percentage of drivers travelling at or below 50 km/h (those travelling within the speed limit);
(ii) the percentage of drivers travelling between 51 and 60 km/h (the low speeders);
(iii) the percentage of drivers travelling between 61 and 70 km/h (the moderate speeders); and
(iv) the percentage of drivers travelling over 70 km/h (the high speeders).

### Main findings

Table 1 shows the mean percentage of drivers travelling within each speed category during each experimental condition, together with the percentage change relative to the baseline phase. Relative percentage decreases are preceded by "-" and relative percentage increases are preceded by "+". The figures in brackets show what each percentage decrease or increase means in vehicle numbers. The corresponding results from the control site are also shown.

***Experimental site***

*Baseline*: During the baseline phase, on average 62.71% of drivers exceeded the speed limit each day. Very few drivers (on average just over half a percent, or approximately 65 vehicles daily) travelled > 70 km/h, and virtually all of these drivers travelled under 81 km/h. The mean percentage of drivers travelling between 61-70 km/h was 8.69% (approximately 1,000 vehicles), the mean percentage travelling between 51-60 km/h was 53.46% (6,135 vehicles), and the mean percentage travelling within the speed limit was 37.29% (4,280 vehicles).

*Posted feedback of average driver speed*: Table 1 shows the mean percentage of drivers travelling within each speed category for each of the speeds displayed on the average speed sign, and also gives a combined mean percentage calculated over all three average speed conditions. It can be seen that, relative to the baseline phase, the mean percentage of drivers travelling > 70 km/h decreased by 10.5% on average during this phase to 0.50%, and the mean percentage of drivers travelling in the 61-70 km/h speed category decreased by 14% to 7.49%. Drivers complying with the speed limit increased by 6% to 39.55%. During all three average speed conditions the percentage of drivers travelling in the > 70 km/h and 61-70 km/h speed categories at the experimental site was lower than during the baseline phase.

*Surveillance information*: In this phase the mean percentage of drivers travelling > 70 km/h decreased by 14.5% relative to the baseline phase to 0.48%, and drivers travelling between 61-70 km/h decreased by 19.5% to 6.99%. There was a 3.5% increase in drivers complying with the speed limit.

*Surveillance information and posted feedback of average driver speed:* During this phase the mean percentage of drivers travelling > 70 km/h reduced by 19.5% relative to the baseline phase to 0.45%, and the mean percentage of drivers travelling between 61-70 km/h reduced by 15.5% to 7.35%. There was a 2% increase in drivers complying with the speed limit.

| Driver speed (km/h) | Baseline | Posted feedback of average driver speed<br>Speed displayed on average speed sign<br>50 km/h | 54 km/h | 53 km/h | Combined results for all three average speed conditions | % change (change in vehicle nos.) | Surveillance Information | % change (change in vehicle nos.) | Surveillance information and posted feedback of average driver speed | % change (change in vehicle nos.) |
|---|---|---|---|---|---|---|---|---|---|---|
| > 70 | **0.56 (65)** | **0.47** | **0.52** | **0.52** | **0.50** | **- 10.5 (- 7)** | **0.48** | **- 14.5 (- 9)** | **0.45** | **- 19.5 (- 13)** |
| | *0.99 (110)* | *0.94* | *1.03* | *1.04* | *1.00* | *+ 1 (+ 1)* | *1.09* | *+ 10 (+ 11)* | *0.91* | *- 8 (- 9)* |
| 61 - 70 | **8.69 (1000)** | **7.34** | **7.27** | **7.85** | **7.49** | **- 14 (- 140)** | **6.99** | **- 19.5 (- 195)** | **7.35** | **- 15.5 (- 155)** |
| | *13.70 (1550)* | *13.78* | *13.27* | *14.63* | *13.88* | *+ 1.5 (+ 20)* | *14.51* | *+ 6 (+ 90)* | *13.35* | *- 2.5 (- 40)* |
| 51 - 60 | **53.46 (6135)** | **53.05** | **51.36** | **53.14** | **52.45** | **- 2 (- 115)** | **54.01** | **+ 1 (+ 60)** | **54.20** | **+ 1.5 (+ 90)** |
| | *62.64 (7100)* | *61.79* | *61.10* | *63.11* | *61.98* | *- 1 (- 70)* | *64.06* | *+ 2.5 (+ 170)* | *63.69* | *+ 1.5 (+ 120)* |
| ≤ 50 | **37.29 (4280)** | **39.15** | **40.84** | **38.49** | **39.55** | **+ 6 (+ 255)** | **38.52** | **+ 3.5 (+ 140)** | **38.01** | **+ 2 (+ 85)** |
| | *22.67 (2570)* | *23.50* | *24.61* | *21.22* | *23.13* | *+ 2 (+ 50)* | *20.34* | *- 10.5 (- 270)* | *22.05* | *- 2.5 (- 70)* |

Notes: The mean number of vehicles indicated for each speed category in the baseline phase is rounded to the nearest 5 vehicles.
% changes are rounded to the nearest 0.5%, and accordingly the reduction or increase in vehicle numbers during each experimental phase is approximate.
% changes for each experimental phase are calculated on the basis of mean percentages of drivers within each speed category and each percentage change is independent of the others, thus will not total "0" if summed.

**Table 1: Mean percentage of drivers travelling within each speed category during each experimental condition and the percentage change/change in vehicle numbers during each experimental phase relative to the baseline phase (control site results are shown in italics).**

***Control site***
At the control site, during the baseline phase, on average 77.33% of drivers exceeded the speed limit each day. Just under 1% of drivers (approximately 110 vehicles) travelled > 70 km/h, and most of these drivers travelled under 81 km/h. The mean percentage of drivers travelling between 61-70 km/h was 13.70% (approximately 1,550 vehicles), the mean percentage travelling between 51-60 km/h was 62.64% (7,100 vehicles), and the mean percentage travelling within the speed limit was 22.67% (2,570 vehicles). A larger percentage of drivers travelled in the higher speed categories and less drivers complied with the speed limit, therefore, than at the experimental site.

Table 1 shows that during the *Posted feedback of average driver speed* and *Surveillance information* phases there were small increases, relative to the baseline phase, in the mean percentages of drivers travelling > 70 km/h and between 61-70 km/h (ranging from + 1% to + 10%). During the *Surveillance information and posted feedback of average driver speed* phase, there was an 8% decrease in drivers travelling > 70 km/h and a 2.5% decrease in drivers travelling 61-70 km/h relative to the baseline phase.

***Changes in mean speed/traffic volume/weather conditions***
Although daily mean speeds decreased occasionally during the study at both the experimental and control sites (apparently caused by traffic build-ups during peak hours), there was no consistent change in overall mean speed during any particular experimental phase. Traffic volume also remained at a similar level throughout the entire period of the study. All experimental phases had a similar number of dry and light and heavy rain days, suggesting that weather conditions did not confound the results in the current study.

**Influence of traffic volume on driver speed**
Traffic volume is generally considered to have an effect on traffic speed, because at lower traffic densities drivers are less restricted by other traffic and are consequently generally able to drive at faster speeds. In the current study there was a considerable difference in traffic volume at both the experimental and control sites on work days (Monday-Friday excluding public holidays) compared to non-work days (Saturdays, Sundays, and public holidays). On work days, the average daily traffic volume along the experimental site was approximately 12,700 vehicles; on non-work days, the average traffic volume was 9,500 vehicles. Morning and afternoon peak hour traffic on work days contributed to much of this difference. Likewise, on work and non-work days, daytime traffic was much heavier than nighttime traffic.

Thus, in order to establish whether speed reductions were affected by the type or time of day, analyses were conducted of the daily percentages of drivers travelling within each of the four speed categories on work days/non-work days and during the daytime/nighttime. Daytime was defined as 0701 to 1900 hours and nighttime as 1901 to 0700 hours. These hours were chosen because the raw data automatically supplied a daily breakdown of the traffic volume and the number of drivers travelling within each speed category for each of these 12 hour periods, and thus analysis of the data could easily be accomplished. In addition, peak hour traffic would occur during the hours designated as "daytime" hours and off-peak traffic would occur during "nighttime" hours.

As the results concerning the high and moderate speeders were similar, and due to the small number of vehicles travelling in the > 70 km/h speed category, the results from the high and moderate speed categories were combined. Thus the data reported here relate to drivers travelling > 60 km/h.

As can be seen from Table 2, at the experimental site there was a reduction in the mean percentage of drivers travelling > 60 km/h on work days, and on non-work days and nights, during each experimental phase relative to the baseline phase. The largest percentage reductions generally occurred on non-work days. On work nights there were only minor variations in the mean percentage of high and moderate speeders during each experimental phase relative to the baseline phase.

At the control site there were increases in the mean percentage of drivers travelling > 60 km/h on work days and nights during each experimental phase relative to the baseline phase. On non-work days there were reductions in the mean percentage of drivers during each experimental phase, although these changes were generally substantially smaller than those occurring at the experimental site. Only minor percentage changes occurred on non-work nights.

| | | **Percentage change in drivers travelling > 60 km/h** | | | | | |
|---|---|---|---|---|---|---|---|
| *Type/time of day* | | *Experimental site* | | | *Control site* | | |
| | | Posted feedback of average driver speed | Surveillance Information | Surveillance information and posted feedback of average driver speed | Posted feedback of average driver speed | Surveillance Information | Surveillance information and posted feedback of average driver speed |
| **Work** | *Day* | - 8 | - 17 | - 10.5 | + 5.5 | + 11.5 | + 3.5 |
| | *Night* | - 1.5 | + 2 | 0 | + 8.5 | + 20.5 | + 3.5 |
| **Non-work** | *Day* | - 26 | - 33 | - 19 | - 13 | - 6 | - 15.5 |
| | *Night* | - 10.5 | - 10.5 | - 24 | - 5 | + 1.5 | - 2 |

**Table 2: Percentage change in the mean percentage of drivers travelling > 60 km/h on work/non-work days and during the daytime/nighttime during each experimental phase relative to the corresponding type/time of day in the baseline phase.**

## Discussion

The aim of the current study was to use posted feedback to determine the effect social comparison processes and surveillance information may have on driver speed, and to investigate whether either of these mechanisms may have been responsible for reductions in driver speed in previous posted feedback studies. As speed reductions occurred at the experimental site with the feedback signs in place but reductions did not generally occur at the control site, this would suggest that it was the presence of the feedback signs that affected driver speed at the experimental site, rather than extraneous variables. The findings from this study, therefore, suggest that both social comparison and surveillance information may influence driver speed.

The basis of the social comparison explanation is that drivers supposedly compare their driving behaviour with other drivers and adapt their behaviour if it appears to deviate from the norm.

Given that the percentage of speeding drivers did reduce in the presence of the average speed sign, it seems possible that drivers did use the average speed information against which to compare their own driving speed, and, in some cases, to adjust their speed if they noticed some disparity. The fact that the largest percentage decreases occurred in the mean percentages of high and moderate speeders during this phase lends strength to this argument.

It could, of course, be argued that, as speed measurements were taken and publicly posted, drivers may have assumed their driving behaviour was under surveillance in this phase, and thus they slowed down in anticipation of possible enforcement action. However, the average driver speed displayed on the sign was changed at very infrequent intervals, which would indicate little human involvement in the speed measurement process. This suggestion also seems unlikely given that the average speed sign was present for almost three months, with no additional ticketing of drivers.

The results from the *Surveillance information* phase demonstrate that overtly advising drivers their speed is being measured also reduces driver speed, suggesting that an active police presence is not necessarily required to support the threat of enforcement. As might be expected if drivers are responding to a perceived risk of police enforcement, speed reductions in the current study occurred in only the high and moderate speeders. Drivers in New Zealand do not get ticketed for speeding unless they travel 10 km/h or more over the speed limit, thus those drivers travelling in the 51-60 km/h speed category may not reduce speed under threat of possible enforcement. The research literature, however, suggests that in order for surveillance to be effective in reducing speeding, there needs to be a high perceived risk amongst drivers that enforcement action will follow speeding behaviour (Zaal, 1994). At first glance, it seems unlikely that, in the current study, drivers would have assessed the risk of apprehension as high, in view of the lack of additional enforcement activity. Nevertheless, drivers would have been unsure of the form any potential enforcement would take, such as a police patrol vehicle or a mobile speed camera operating from a police vehicle (both reasonably visible means of enforcement), or a fixed speed camera (which may be substantially less visible). The latter possibility in particular may have encouraged drivers to perceive the risk of enforcement action as relatively high and to therefore adopt a more cautious approach than normal to their speed choice.

It could be argued that if drivers perceived a real risk of enforcement action, they could take avoidance action by choosing an alternative route by which to reach their destination. As traffic volume did not change, it appears this avoidance strategy was not used. Although avoidance tactics in relation to drink-driving enforcement are known to occur, anecdotal evidence suggests that the issue of convenience tends to outweigh the benefits for drivers travelling out of their way to avoid speed enforcement.

The addition of information concerning average driver speed did not, in general, increase the efficacy of the surveillance information sign. Instead, there was a slightly reduced effect during this phase than occurred with the surveillance information message alone. Perhaps the addition of the information concerning average speed may have made drivers realise that the purpose of the sign was not to warn them of local enforcement activity, but simply to give them information, with no resulting consequences if they were speeding. Another possibility is that the two parts of the combined feedback message required greater cognitive processing than either of the previous messages. Drivers may, therefore, have reduced speed once they were beyond the speed measurement site.

By aggregating 24-hour data, some higher speed reduction effects at certain times of the day may be "averaged down" over a longer timeframe to more modest effects. In this study, the analysis of the data into daytime and nighttime hours revealed that the feedback signs, in general, had more effect on speeders during the day than at night. Although the feedback signs may have been less visible at night, this seems unlikely given that the signs were made of reflective materials and there was street lighting overhead. Nevertheless, it has to be considered as a possibility that some difference in visibility of the signs at night either caused drivers not to react to the feedback signs or to react more slowly than during the day, in which case drivers may not have reduced speed until they had passed the speed measurement site. Alternatively, it may be that darkness gives drivers a degree of anonymity that may not be present in the daytime. During the *Posted feedback of average driver speed* phase, drivers may have felt they were less likely to be observed at night, or that other drivers were less able to determine their driving speed and thus less likely to make negative judgements about their driving. During the *Surveillance information* phase, it is possible that drivers perceived enforcement to be more commonly carried out during the daytime than at night, although this seems unlikely given that police blitzes, especially for alcohol-impaired driving, traditionally occur at night.

The further analysis of the data also revealed that, during all experimental phases, the reductions in the mean percentages of drivers travelling > 60 km/h were greater on non-work days than on work days. A possible explanation for this finding is that commuters and other drivers have more time pressures during the working week than weekend drivers, whose driving trips are likely to be more leisure-oriented. Drivers on non-work days are also more likely to have passengers with them, particularly family members. There is some evidence that passengers may influence driver behaviour, including speed choice (e.g. Baxter, 1990). Another explanation is that, as found by Groeger and Chapman (1997), in the presence of posted speeding information, drivers may reduce speed but only if the drivers around them are complying with the posted information. Cialdini, Reno and Kallgren (1990) noted that people are most likely to act in norm-consistent ways when norms are made salient. In the driving environment, it is possible that faster drivers may be more noticeable than slower drivers because very often they are undertaking manoeuvres that bring them to the attention of other drivers. In the heavier traffic typical of work days, therefore, the behaviour of high speed drivers may have been more salient than the normative information contained on the average speed sign. In lighter traffic, on non-work days, it may be that, in the absence of other drivers on the road, any comparison of speed could only be made with the posted information.

Speeding drivers may be more resistant to reducing speed during peak traffic periods than at other times of the day, because they perceive issuing speeding tickets is more difficult during periods of high volume traffic (Vaa, 1997). In the context of the surveillance information sign, therefore, drivers may have perceived the likelihood of being apprehended for speeding as being less threatening, at least at certain times on work days, than on non-work days. This explanation does not seem sufficient, however, to account for the lower speed reduction effects at nighttime, when traffic volume was lower and thus the perceived risk of apprehension should presumably be relatively high.

The greater speed reductions seemingly occurring on non-work days should, in any event, be interpreted with caution. As there were considerably less non-work days than work days during all experimental phases, extraneous variables such as recreational activities that cause traffic to slow may have a larger effect than might occur when averaged over a greater number of days.

It is worth noting that the target site was not a particularly high speed site in relation to many other sites with documented speed problems, and thus there was possibly less potential to reduce speed at this site than at other sites. It should be recognised, however, that whereas there is room for larger speed reductions at sites with a larger proportion of high speed drivers, it is not known what effect displaying a higher average speed will have on drivers' speed reduction efforts. In addition, the speed bands were set at 10 km/h intervals in anticipation of a greater spread of drivers travelling at higher speeds at this site. However, this meant that small increases or decreases in speed by drivers were not necessarily reflected in the data. For example, if a driver was travelling over 60 km/h and reduced speed to 60 km/h or under in response to the feedback signs, this would be captured in the data for all conditions, even if that driver was influenced to differing degrees by the feedback signs. A better picture of speed reductions could have been obtained by dividing the 61-70 km/h and 51-60 km/h speed categories into a number of narrower speed bands.

Apart from social comparison and the surveillance threat operating in the driving environment, there are a number of other possible explanations for the reductions in driver speed in the current study and previous posted feedback studies. For example, in the current study, it is possible that, as the majority of drivers were approaching the experimental site from a semi-urban area, some drivers were unsure of the speed limit along the target site. Although the feedback sign did not specify the speed limit, it may have reminded drivers that in a residential area a speed limit of 50 km/h applies. It is also possible that the speeding information displayed on the feedback signs in previous posted feedback studies included a constituent which has yet to be identified but which may be necessary for maximum impact on driver speed. One such possibility is that the second part of the message "Best record __%" may have introduced a goal setting component. Goal setting is often combined with performance posting interventions in work settings to indicate what constitutes "good" performance (Nordstrom, Lorenzi & Hall, 1990). While goal setting is not traditionally incorporated into road safety interventions, it is suggested that further research is warranted into its potential as a means of fostering a community-wide road safety goal.

One explanation that could fit in with the social comparison and implied surveillance explanations for the effect of feedback signs on driver speed is that speed reductions occur because drivers take their foot off the accelerator as they approach the feedback sign, in order to check their speedometer. In the presence of the average speed sign, drivers may do this in order to compare their driving speed with that of other drivers. In the presence of the surveillance information sign, drivers may wish to ensure they are not driving more than 10 km/h over the speed limit, and thus are not in danger of being ticketed for speeding. In any event, speedometer-checking would not necessarily diminish the potential usefulness of posted feedback as a road safety intervention. Any intervention that encourages drivers to be aware of their speed should surely be encouraged.

A summary of possible explanations for the effect of feedback signs on driver speed is contained in Figure 1. Primary influences are those that appear most likely to have contributed to the speed reductions in the current study and in the previous posted feedback studies. Secondary influences are those that, although they may not appear to be the prime motivating factor in drivers reducing speed, they may influence the level of speed reductions achieved.

| **Posted feedback of: speeding information/ normative driver behaviour** | **Surveillance information** |
|---|---|
| *Suggested primary influences on driver speed* | |
| Social comparison of driver speed [1] ✧<br>Threat of enforcement action [2] | Threat of enforcement action |
| *Suggested secondary influences on driver speed* | |
| Goal setting [3] ✧<br>Reinforcement for improvement in driver behaviour [3] ✧ | |

Traffic volume/flow [4] ✧
Weather conditions †
Reminder of speed limit [5] ✧
Checking speedometer ✧

***Key***

1. May result in:
   - pressure to conform with majority behaviour
   - revised sense of comparative injury/enforcement risk
2. Possible but unlikely in the current study that the average speed sign alone indicated meaningful surveillance
3. Unlikely in the current study but a possible speed reducing factor in previous studies
4. May act as an influence in a number of ways:
   - drivers may be influenced by the speed of other drivers around them
   - a chain reaction may occur when one driver brakes and other drivers in a platoon follow suit
   - during periods of heavy traffic volume, drivers may perceive enforcement action unlikely
5. Previous studies suggest otherwise but cannot be discounted in the current study

✧ Warrants further investigation

† Discounted due to the findings in the current study

**Figure 1: Summary of possible explanations for the effect of feedback signs on driver speed.**

At present, little is known about how drivers gain their perceptions of what is "normal" in the driving environment. Drivers travel on many different roads with differing speed limits, so how do drivers build up a picture of normative driver behaviour? What are the motivations for drivers conforming to normative driver behaviour? Do drivers, as Rothengatter (1990) suggested, have an innate sense of wanting to do what other drivers do simply so they do not stand out from the crowd; in other words, do they have an internally driven sense of wanting to conform? Alternatively, are such motivations externally driven; for example, do drivers compare the level of injury risk they run by driving at a speed that is higher than the average, or the risk compared to the average driver of being detected for speeding which may result in a speeding ticket? As a large proportion of drivers involved in speed-related crashes are male drivers and young drivers, the differential influence of behavioural norms on different groups of drivers is of particular interest.

New Zealand road safety campaigns have traditionally highlighted the poor driving behaviours of a deviant minority, or have encouraged drivers to adopt safe driving practices without suggesting these behaviours are "normal". The speed reduction effects of posted feedback of average driver speed in the current study suggest the potential usefulness of publicity campaigns highlighting behavioural norms. An additional benefit is that such campaigns may make a valuable contribution to a change in public tolerance of speeding so that the public is less accepting of drivers who put other road users at risk due to deviant speeding behaviour.

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