Thames Valley Safer Roads Partnership
Research Report

University of Reading
Damian Poulter and Frank McKenna

March, 2005

Contents

Executive Summary

A series of experiments have been conducted in conjunction with the Thames Valley Safer Roads Partnership, police, and local council authorities over one year. The aim of the research has been to address key issues regarding driver behaviour in the presence of speed control devices. Research has assessed how effective different devices deployed in the region are in reducing vehicle speeds, primarily on 30mph speed limit roads. The focus has been on both enforced methods (e.g. fixed/mobile camera), and un-enforced methods (e.g. roadside feedback).

Where previous research on safety cameras has used indirect self-report measures (e.g. Corbett, 1995), or as single case-studies on roads of varying speed limits (e.g. Kennan, 2002; 2004), there has been no rigorous scientific examination of speed behaviour around safety cameras on 30mph roads. This research has investigated speeds in both the enforced and un-enforced direction at camera sites, the behaviour of different speeding groups on approach to camera sites, time of day effects, and speeds at loaded camera housing versus unloaded camera housing, as well as speed and close following behaviour around mobile camera sites. The research has also been extended to investigate the speed reduction effect of roadside feedback, as well as its effect on close following.

<u>Fixed cameras: Driving behaviour</u>

Research conducted on speed behaviour around seven safety cameras indicated that there is an average reduction in mean speed of 4.95mph (-18.9%) from 300m before to at the fixed camera in the enforced direction. Speeds 300m after fixed cameras were also 1.2mph (-4.6%) lower than 300m before speeds on average. In the un-enforced direction there was an increase in speeds of 0.9mph (+3.5%) from 300m before to at camera sites, with speeds 300m after the camera site 1.6mph (+ 6.1%) higher than 300m before.

<u>Fixed cameras: Speed groups</u>

Further analysis of the data revealed that fixed cameras have a significant speed reduction effect on the target population (drivers in excess of the 30mph speed limit on approach at 300m before the camera), as well as those drivers driving within the

speed limit. The effect is most marked on vehicles that are approaching at speeds between 31-35mph (- 6.4mph), with speeds 300m after the camera still considerably less than at 300m before the camera for this speed group (- 4.9mph). For the high speed group approaching at 41+mph, there is a smaller significant reduction in speed (- 2.1mph), but mean speed 300m after the camera return to the same level as 300m before the camera for this speed group (+ 0.3mph). However, during night hours the 41+ speed group reduce their speed by 6.1mph from 300m before to at the camera.

Fixed cameras: Time of day

Time of day analysis revealed that there is a greater speed reduction effect of 8.2mph (-26.6%) due to fixed cameras during night hours, compared to the speed reduction effect of 4.9mph (-18.1%) during off-peak, and 4.6mph (-18.5%) during peak hours. The speed reduction during night hours is at least 8% greater than during peak and off-peak hours, which is interesting when considering that average speeds are comparatively higher at night.

Fixed cameras: Loaded vs. unloaded

A final analysis on fixed safety cameras was conducted on the effect of enforcement. Speeds at two unloaded cameras during off-peak hours were compared with speeds at two loaded cameras during off-peak hours. Results provided evidence that drivers reduce speed regardless of whether enforcement is conducted at the camera site, and thus future installation of fixed safety cameras would not necessarily require them to be loaded in order to have the equivalent speed reduction effect, although there may be limits to this effect. The data has implications for decommissioned safety cameras, as the results indicate that these cameras do still produce a change in speed behaviour.

Mobile cameras: Driving behaviour

For mobile cameras, average speed is 5.3mph (-16.5%) lower during mobile enforcement compared to the day before, and over 7mph (-18.8%) lower than the hours before enforcement. There is a net reduction in mean speed of 5.35mph (-17%) from 300m before to at the fixed camera compared to the day before mobile enforcement, and a net reduction of 7.43mph (-23.5%) from 300m before to at the fixed camera compared to the day after mobile enforcement, which is at least equivalent to the speed reduction effect of fixed cameras. However, the speed reduction effect of mobile cameras persisted 300m after the mobile camera, with a reduction of 4.2mph (-10.8%) in mean speed at 300m after the mobile camera compared to the day before, and a reduction of 5.4mph (-13.5%) in mean speed at 300m after the mobile camera compared to the day after.

Mobile cameras: Close following

One counter argument to traffic calming devices is that while speeds might be reduced, so may the gap between cars, thus counteracting the safety benefit of speed reduction. Analysis of time gaps between vehicles, however, revealed a dual safety effect of mobile cameras. Comparison of vehicles travelling at less than three second gaps behind the vehicle in front revealed that the mean time between vehicles at the camera site *increased* by 6.7% during mobile enforcement compared to the day before and day after enforcement. Therefore, while the visible distance between vehicles reduces during enforcement, the time gap between vehicles actually increases because of reduced speed, allowing drivers more time to react.

Roadside feedback: Driving behaviour

There is relatively little research into the effect of roadside feedback despite their widespread use by local authorities to reduce speed. A series of experiments were conducted on the effect of presenting drivers with interactive feedback of their speed using Speed Indication Devices (SID), adopting the same temporal and spatial methodology as the safety camera experiments. Results consistently indicate that current use of SID to provide drivers' with individual feedback regarding their speed (accompanied by a smiley/sad face) leads to a significant 5.9mph (-16.6%) reduction in average vehicle speeds from the hours before to the hours during SID deployment, as well as a significant 7.0mph (- 19.2%) reduction in average vehicle speeds from the day before to the day of SID deployment. This reduction is localised, with speed returning to pre-deployment levels immediately after SID is removed. However, when examining the spatial effect of SID there is a net reduction in mean speed of 5.6mph (- 18%) from 300m before SID to at the SID on the day of deployment compared to the day before deployment, with speeds remaining 2.6mph lower 300m further down the road on the day SID is present compared to the day before. This evidence provides support for the continued use of SID as a low cost tool for management of speed limits that can be deployed at high-speed sites without the need for enforcement.

Roadside feedback: Close following

As with mobile cameras, there is a potential counter effect of roadside feedback in reducing the inter-vehicular time gap when reducing speeds. Data collected from one of the roadside feedback experiments revealed that SID has an enhanced safety component over and above the speed reduction effect. Comparison of vehicles travelling at less than three second gaps behind the vehicle in front revealed that the mean time between vehicles at the SID site increased by 4.5% during SID deployment compared to the day before and day after SID deployment, which is slightly less than the increase in time found during mobile enforcement.

Roadside feedback: Attitudes to speed and to roadside feedback

Surveys were conducted in both urban and rural communities in order to assess people's attitude to speeding and speed related issues. Results showed that people rated speeding motorists as the problem of greatest concern compared to other issues such as antisocial behaviour, vandalism, and burglary. With regards to people's knowledge of roadside feedback devices, the majority of respondents (81.9%) knew that SID is simply a feedback device, and that if a vehicle drove past it exceeding the speed limit the driver would not receive a fine and/or points on their licence. When considered in light of behavioural data already reported, it would appear that drivers slow down for roadside feedback devices despite knowing that no police enforcement is involved. The survey then assessed motivational components for adjusting speed at SID, with respondents agreeing that they would slow down for SID if they were exceeding the speed limit, that others would expect them to slow down, and that they would slow down because they ought to, and not for fear of police detection. Finally, social acceptability of roadside feedback devices was also assessed across two surveys. In the first survey, the majority of respondents (77.3%) stated that there should be an increase in the use of SID. In the second survey, an almost identical proportion of respondents (77.9%) advocated an increase in SID. In addition, this survey also assessed the social acceptability of safety cameras, with one third of respondents (32.9%) stating that there should be an increase in safety cameras, with only one quarter of respondents (25.2%) stating there should be a decrease in safety cameras.

Proposed research

Our completed work is now being used, with the help of others, to produce a good practice guide on speed feedback devices. However many gaps in our understanding of speed behaviour remain. We have planned and in some cases are part way through studies designed to clarify the behaviour of drivers in the presence of speed control\feedback devices. We have planned the following studies:

Close following at fixed camera

We have planned a study designed to examine close following around fixed speed camera sites. We have shown an increase in time gaps at both mobile camera and roadside feedback sites, but importantly an investigation of time gaps between vehicles has yet to be done at fixed camera sites.

Cumulative speed reduction at fixed camera sites

Analysis of speed trends at several fixed camera sites is planned, in order to examine any cumulative speed reduction effect created by fixed cameras over the years. Data collected at fixed camera sites can be compared with data collected at sites where no enforcement has been conducted, in order to compare the relative trend in mean speeds at the different locations over the years.

Replication of mobile camera research

We have planned further research on the speed reduction effect of mobile cameras at multiple sites in order to be confident that any effect can be generalised, and is not simply site-specific.

Speed Awareness Course

A longitudinal investigation into the effects of education on the consequences of speeding (attendance at speed awareness course), compared to the effects of punishing speeding (fine and points on licence), in planned on recidivism rates, as well as comparison of attitudes and reported behaviour to speed and speeding issues by the two groups.

Roadside feedback

- The roadside feedback experiments have mainly examined short-term deployment of roadside feedback but future work is required on long-term deployment of roadside feedback as an alternative, cost efficient method of traffic calming. We have identified the sites and have the co-operation of various groups to track the effects over time. At this point in time it is not known whether there are large effects as the device is introduced which then diminish over time. With a knowledge of the time course the effectiveness of the speed control devices can be maximised.
- Roadside feedback is presented to the driver in many different ways. For example, sometimes the feedback is associated with the presence of a road safety officer and sometimes not. We have a planned study to assess the magnitude of the effect of the presence of the road safety officer.
- The effect of individual interactive roadside feedback for drivers compared to more traditional static signs and generic roadside feedback signs (e.g. flashing speed roundel) is necessary in order to determine whether individualising feedback has a greater speed reduction effect than traditional roadside traffic calming methods. This study has now been planned.
- Work is required into identifying the motivating factors for drivers to reduce speed in response to individual roadside feedback. Drivers are presented with varying messages that include positive reinforcement, negative reinforcement, and a combination of both. We have planned a study to asses the relative contributions of each part of the message.
- We are currently halfway through a study looking at attitudes to speeding and observed speeding in a rural and urban community. We have completed Phase 1 in which we have assessed speeding attitudes and measured on-road speed behaviour. Following the intervention of speed feedback devices in the neighbourhoods we plan to re-sample attitudes and observed speed behaviour.

Fixed safety cameras

Introduction

Research on fixed safety cameras has focussed on their impact on both accident reduction and speed reduction effects. A recent evaluation of the national safety camera programme (Gains, Heydecker, Shrewsbury, and Robertson (2004) revealed an average speed reduction across sites of 2.4mph (7%), as well as a 40% reduction in people killed or seriously injured (KSI) at safety camera sites. Mountain and Hirst's (2004) research found that the introduction of safety cameras at 62 sites on 30mph roads lead to 34% reduction in KSIs, and a 4.4mph (-13.4%) reduction in speed at camera sites. Both studies demonstrated the significant safety effect of fixed cameras on speeds and accident statistics by comparing data before and after the introduction of safety cameras. However, no examination was made of driver behaviour directly around the camera sites (e.g. approach and departure speeds).

Non-peer reviewed reports have shown that fixed camera sites can reduce mean speed by between 4-7kph, as well as speed variance (Kronberg and Nilsson, 2000). Stradling and Campbell (2002) monitored the percentage of drivers speeding during the gradual installation of a safety camera on five 30mph roads. They found that 64% of drivers were exceeding the posted 30mph limit before the camera was installed, reducing to 37% when the camera housing was installed but before it was operational, and further reducing to 23% when the camera began operating.

In relation to behaviour around camera sites, Keenan's (2002) analysis on driving speed around safety cameras using hand held radars, showed that there was a significant difference between speeds 500m before camera site and speeds at the camera site. However, speeds returned to pre-camera levels 500m after camera sites, demonstrating a localised speed reduction effect. Analysis of accident data at the four safety camera sites showed that accidents increased from before to after camera installation at three sites. Keenan concluded that safety cameras do not automatically imply an improvement in driving behaviour, and could create new problems such as erratic braking and acceleration profiles, as well as an increase in accident rates.

In a follow up article (Keenan, 2004), further analysis was conducted on speed behaviour at one of the sites in the 2002 study where the safety camera was now painted bright yellow to make it highly overt to drivers. Results showed that the number of drivers violating the 40mph speed limit had reduced before, at, and after the new yellow cameras compared to speeds recorded when the camera was grey. However, the 85^{th} percentile at 500m before the camera increased by 2mph, with the author suggesting that faster drivers are anticipating the exact location of enforcement to a greater degree. 85^{th} percentile speeds at the camera site, and 500m after the camera reduced by 2mph and 1mph respectively. In conclusion, the author states that violation rates have fallen since the introduction of highly visible yellow cameras, but anticipation of the exact location has increased by faster drivers, although evidence from the 500m after camera data collection point suggests that yellow camera housing has extended the influence of the camera in reducing speeds. It should be noted that Keenan's (ibid.) research was conducted on three 40mph and one 60mph road rather than 30mph roads.

To date there has been no deeper investigation of driving behaviour around fixed safety cameras on 30mph speed limit roads. The following studies look first at the overall effect of safety cameras on reducing speed, and go on to analyse the data in terms of drivers above and below the speed limit 300m before the safety camera, as well as comparing the behaviour of different speeding groups on approach to camera sites, and the effect of the time of day (peak, off-peak, night) on speed behaviour. Finally, two sites were selected for further data collection with hand-held radars, and speed behaviour at these two sites was compared with data collected from two unloaded fixed safety cameras in order to investigate the effect of enforcement on speeds at camera sites.

Experiment 1A: Spatial effect of safety cameras

Research was conducted on driving behaviour 300m before a fixed safety camera, at the safety camera, and 300m after the safety camera on 30mph roads. The aims were to investigate whether driving speed was reduced from before the camera to the camera position, and whether any speed reduction effect persisted beyond the safety camera.

Method

There were 10 initial sites monitored for speed in the research. However, for the purpose of this study three sites were excluded from the final analysis, two due to higher speed limits (one 40mph, and one 50mph speed limit site), and one site that was in close proximity to a speed limit change and led to higher speeds at the 300m before camera location, and thus exaggerating the speed reduction effect.

Table 1.1 Loading frequency, offences detected, and average daily total for all seven fixed safety cameras (30mph limit) from 2002 to 2004

Camera	Loading frequency	Offences detected	Average daily total
536	44	1189	27.02
664	71	605	8.52
688	49	785	16.02
804	89	3443	38.69
826	106	2392	22.57
909	25	174	6.96
910	62	2590	41.77

All speed measurements were taken using Speed Detection Radars (SDR), with one positioned 300m before the camera, one positioned at the camera, and one positioned 300m after the camera. All data was 'binned', with speeds from 5 to 70mph recorded in 14 bins, as well as mean speed being calculated by the SDR. Due to the nature of the data, individual speeds were not recorded, and thus could not be used for analysis. Instead the mean speed of each bin was calculated, and used as the speed for each of the data points recorded in that bin, with the assumption that individual speeds were normally distributed around the mean speed of each bin.

A between-subjects design was employed, as there was a small variation in number of speeds recorded before, at, and after the camera, making it impossible to track individual drivers across the three measurement points. Analysis was conducted on speeds recorded in the enforcement direction, as well as speeds in the un-enforced direction, which served as a control condition.

Results:

A total of 162,422 vehicle speeds in the enforced direction, and 172,352 vehicle speeds in the un-enforced direction, were recorded at the seven camera sites, making a total of 334,774 vehicle speeds recorded.

Results in Table 1.2 show that mean speed in the enforced direction reduced by 4.95mph from 300m before to at camera, with only a small increase in speed from at camera to 300m after. Variance was also reduced at camera, as well as a drop in 85th percentile speed of 4.5mph. However, variance at 300m after camera increases to above the variance at 300m before camera, and 85th percentile also increases back to the same speed at 300m before camera.

Table 1.2 Descriptive statistics for speed before, at, and after cameras in both the enforced and un-enforced direction

Time	n	*M*	*SD*	variance	85th %
Enforced direction					
300m before	52462	26.20	8.02	64.32	33.50
At Camera	54366	21.26	7.80	60.82	29.00
300m after	55594	25.00	8.28	68.57	33.50
Un-enforced direction					
300m before	57249	25.76	8.20	67.20	33.50
At Camera	59036	26.65	7.53	56.65	33.50
300m after	56067	27.33	7.87	61.87	33.50

For the un-enforced direction there was a steady increase in speed of 0.89mph from 300m before the camera to at the camera, with a further increase of 0.68mph from at camera to 300m after the camera. 85th percentile speed remains static at 33.50mph across all three locations.

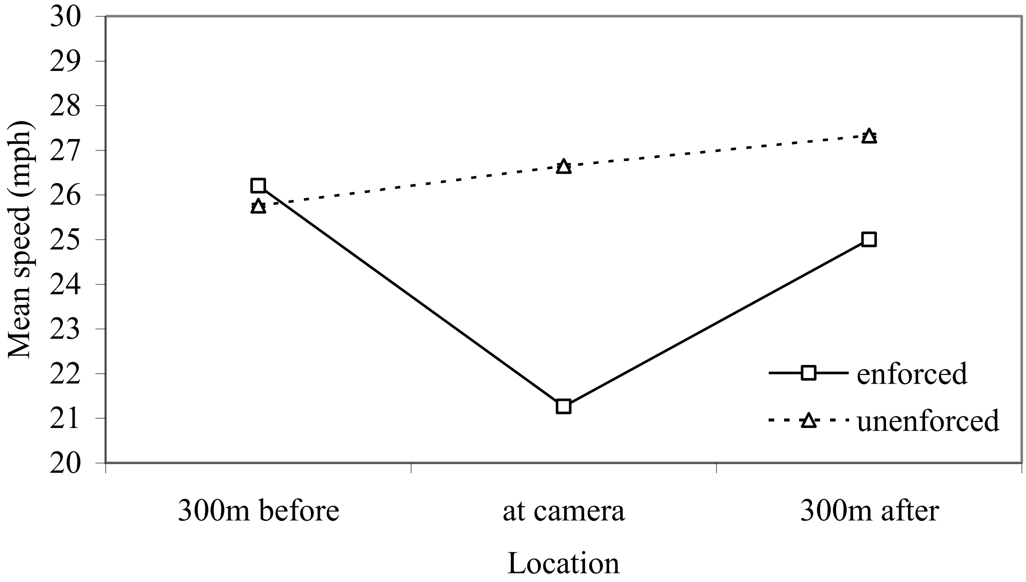

Figure 1.1 Mean speed 300m before, at, and 300m after camera for all drivers in the enforced and un-enforced direction

Enforced direction

A Levene's test for equality of error variance revealed that was a highly significant difference in variance from 300m before, at, and 300m after the camera ($F(2,162419) = 578.04$, $p < 0.01$), with the least variance seen at the camera, and the most variance seen 300m after the camera. Therefore, it would appear that 300m after the camera some drivers continue to drive at a reduced speed, whereas others are accelerating. A one-way ANOVA (Position: 300m before, at camera, 300m after) was conducted on vehicle speed in the enforced direction. Results show that there was a significant main effect of Position on speed ($F(2,162419) = 5544.11$, $p < 0.01$). Post-hoc Bonferroni pairwise comparisons revealed that across sites there was a significant reduction in mean speeds of 4.95mph from 300m before camera to at the camera ($p < 0.01$). Mean speed across sites between at camera and 300m after camera increased significantly by 3.74mph ($p < 0.01$). However, the mean speed 300m after the camera was still

1.20mph less than 300m before the camera, which represents a statistically significant reduction in speed ($p < 0.01$). Mean speeds in the enforced and un-enforced direction are illustrated in Figure 1.2.

Un-enforced direction

A one-way ANOVA (Position: 300m before, at camera, 300m after) was conducted on vehicle speeds in the un-enforced direction. There was a significant main effect of Position on speed ($F(2,172349) = 565.33$, $p < 0.01$). Post-hoc Bonferroni pairwise comparisons revealed a significant increase in mean speed of 0.89mph from 300m before to at the camera site ($p < 0.01$), and a significant increase in mean speed of 0.68mph between at camera and 300m and 300m after the camera. Overall there was a significant increase in mean speed between 300m before and 300m after the safety camera of 1.57mph ($p < 0.001$).

Conclusion

Results revealed that safety cameras significantly *reduce* mean speed by 4.95mph, as well as variance and 85^{th} percentile speed, compared with a significant *increase* in mean speed for vehicles travelling in the un-enforced direction. The speed reduction effect is persistent 300m beyond the cameras, with speeds over 1mph lower than the 300m before speeds on average. The speed reduction of almost 5mph is a significant reduction when considering government literature stating that a reduction of 1mph leads to a 5% reduction in accidents (DfT, 2004).

Experiment 1B: Spatial effect of safety cameras on speed violators

A second analysis was conducted on the proportion of drivers exceeding the speed limit. Only speeds above 30mph at 300m before the safety camera were included for analysis. The proportion of drivers exceeding the speed limit compared to all drivers at this time point was then calculated, and the same proportion of speeds recorded at the camera and 300m after the camera were selected for analysis. This was to investigate the effect of safety cameras on their target population (those travelling above the speed limit). At 300m before the safety camera 18452 vehicles (35.17%) were exceeding the speed limit. Therefore only the top 35.17% of drivers at the camera, and 300m after the camera were added to the analysis.

Results

Results for drivers exceeding the speed limit at 300m before the camera, and the same proportion of drivers at camera, and 300m after the camera can be seen in Table 1.3. For this subset, mean speed reduces by 5.47mph between 300m before and at the camera. However, interestingly the variance increases substantially from before to at the camera. While mean speed increases from at the camera to 300m after the camera by 1.79mph, the variance increases further. A Levene's test for equality of error variance found that there was a significant difference in variance across the three measurement points ($F(2,57533) = 997.84$, $p < 0.01$).

Table 1.3 Descriptive statistics for speed before, at, and after cameras for drivers over 30mph at 300m before the camera

Time	*n*	*M*	*SD*	variance
300m before	18452	34.77	5.33	28.45
At Camera	19392	29.30	8.07	65.05
300m after	19692	31.09	8.67	75.19

A one-way ANOVA (Position: 300m before, at camera, 300m after) was conducted on vehicle speed. Results show that there was a highly significant main effect of Position on speed ($F(2,57533) = 2574.21$, $p < 0.01$). Pairwise Bonferroni comparisons revealed that there was a significant reduction of 5.47mph in mean speed from 300m before the camera to at the camera ($p < 0.01$), with a significant increase in speed of 1.79mph from at the camera to 300m after the camera ($p < 0.01$). Mean speed 300m after the camera was still highly significantly lower than mean speed 300m before the camera by 3.68mph ($p < 0.01$). These results are illustrated in Figure 1.2 below.

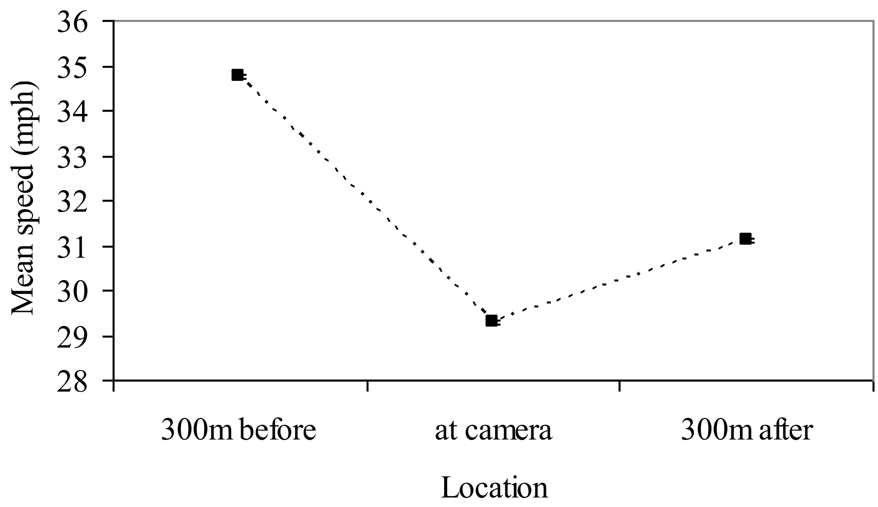

Figure 1.2 Mean speed for drivers above the 30mph speed limit at 300m before camera

Conclusions

This further analysis revealed that safety cameras reduce mean speed of those exceeding the speed limit to a speed that is below the speed limit. However, while their mean speed increases 300m further down the road, it is still 3.68mph less than the approach speed, and thus the traffic calming effect is persistent over distance with the target group of the safety cameras.

Interestingly, drivers who are within the speed limits at 300m before the camera also reduced their speed significantly by the time they passed the camera. Therefore fixed cameras are effective in reducing the speed of drivers above and below the speed limit, but there is a more persistent spatial effect for the target population of speed violators.

Experiment 1C: Spatial effect of safety cameras on top 10% of speed violators

For this analysis, only the highest ten percent of speeds recorded at each of the three measurement positions were compared, in order to investigate any effect of fixed safety cameras on the extreme violators.

Results

Descriptive statistics for the top ten percent show that there is still a reduction in speed from before to at the camera, but by less than 3mph, which is less of a reduction than seen with the full data set and > 30mph subset. Once again the variance actually increases from 300m before to at the camera to 300m after the camera, suggesting that some drivers are slowing down but others do not. A Levene's test for equality of error variance found that there was a significant difference in variance across the three measurement points ($F(2,16250) = 78.69$, $p < 0.01$).

Table 1.4 Descriptive statistics for highest speeders before, at, and after cameras

Time	N	*M*	*SD*	Variance	85^{th} %
300m before	5250	39.95	7.41	54.85	46
At Camera	5441	37.05	8.63	74.45	46
300m after	5562	39.16	8.88	78.80	48

A one-way ANOVA (Position: 300m before, at camera, 300m after) was conducted on vehicle speed. Results show that there was a highly significant main effect of Position on speed ($F(2,16250) = 174.08$, $p < 0.01$). Pairwise Bonferroni comparisons revealed that there was a highly significant reduction in mean speed of 2.90mph from 300m before the camera to at the camera ($p < 0.01$). Mean speed across sites from at the camera to 300m after the camera increased highly significantly 2.11mph ($p < 0.01$). Mean speed 300m after the camera was still highly significantly lower than mean speed 300m before the camera ($p < 0.01$), albeit by an average of only 0.80mph.

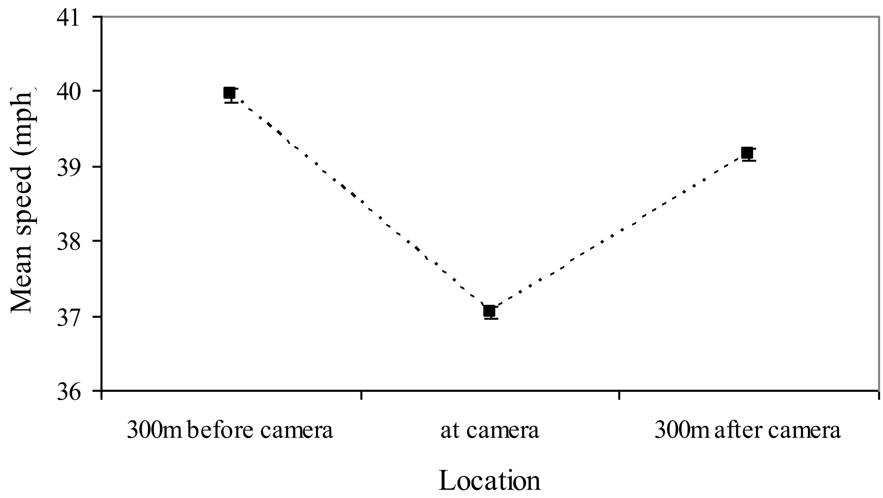

Figure 1.3 Top ten percent of vehicle speeds 300m before, at, and 300m after fixed camera

Conclusions

In this final analysis on the highest ten percent of speeders, the safety cameras still have a speed reduction effect, with average speed lowered by nearly 3mph. Average speed 300m after the camera rises again, but it is still lower than 300m before speed (-0.79mph). Unfortunately the average speed for the top ten percent of drivers at the camera reduces to only 37.05mph, which is still considerably higher than the 30mph speed limit.

Experiment 1D: Time of day effect of safety cameras

Analysis was conducted on the 300m data on speed behaviour around fixed cameras in order to investigate whether there was any effect of time of day on driver behaviour. Data was coded into three different time periods, night (11pm – 7am), peak (7am – 10am; 5pm – 7pm), and off-peak (10am – 5pm; 7pm – 11pm).

Results

Results show that the fixed safety cameras had the largest speed reduction effect on vehicles travelling during the night hours (-8.19mph), variance (-23.65), and 85th percentile (-7mph). During off-peak hours, there was a 4.88mph reduction in average speeds, and during peak hours there was a 4.57mph reduction in speeds.

Table 1.5 Descriptive statistics for speeds during night, peak and off-peak times, at 300m before, at, and 300m after camera

Position	N	*M*	*SD*	Variance	85th
Night					
300m before	2542	30.87	9.12	83.25	38
At camera	2606	22.67	7.72	59.60	31
300m after	2724	29.60	9.03	81.55	38
Peak					
300m before	18249	25.25	7.92	62.79	33.5
At camera	19788	20.68	7.66	58.75	29
300m after	20482	24.52	8.10	65.57	33.5
Off-peak					
300m before	31671	26.38	7.83	61.39	33.5
At camera	31972	21.50	7.86	61.77	29
300m after	32388	24.92	8.21	67.44	33.5

A two-way ANOVA (Position: 300m before, at camera, 300m after; Time of day: night, peak, off-peak) was conducted on vehicle speeds. While there was a significant effect of position on speed ($F(2,162413) = 2931.9$, $p < 0.01$), as well as a significant effect of time of day ($F(2,162413) = 997.75$, $p < 0.01$), there was also a significant interaction between spatial location and time of day ($F(4,162413) = 87.02$, $p < 0.01$). As illustrated in Figure 1.4, the average night speed 300m before the camera is 5.62mph faster than peak speeds, and 4.49mph off-peak speeds, but at the camera this disparity is reduced only 1.99mph faster than peak speeds, and just 1.17mph faster than off-peak speeds.

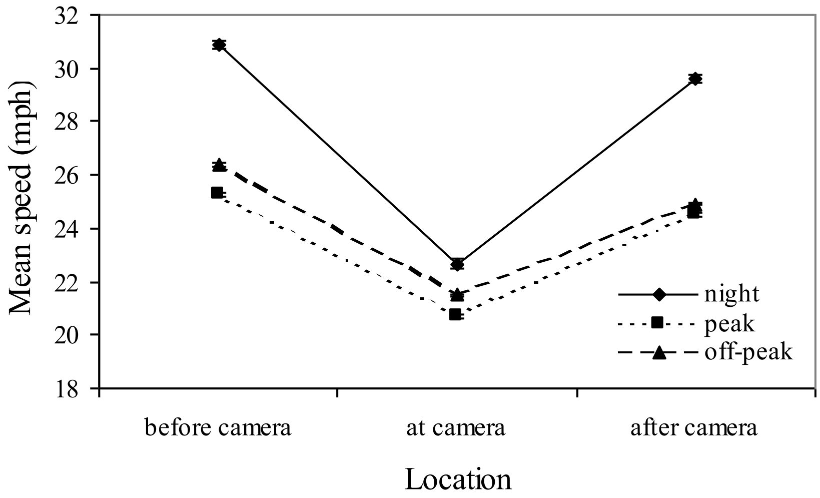

Figure 1.4 Speed as a function of spatial location and time of day

Conclusions

Therefore, the effectiveness of fixed safety cameras is more pronounced during the night when approach speeds are considerably higher. This analysis shows that fixed cameras are effective in reducing average and 85th percentile speed across the day, regardless of traffic flow density. However, it emphasizes the importance of safety cameras in reducing speed, variance in speed, and 85th percentile speed during night, the fastest period of the day.

Experiment 1E: Safety camera effect on different speed groups

Further analysis was conducted on the 300m data, investigating the speed reduction effect on different categories of speeding vehicles as they approached safety cameras. Experiment 1B demonstrated a global effect of safety cameras in reducing speed for vehicles travelling at over 30mph on approach (300m before), Experiment 1C showed a speed reduction effect for vehicles in the top 10% of recorded speed at 300m before the safety camera, and Experiment 1D showed an enhanced effect of safety cameras during night hours than during peak and off-peak hours. The current experiment was conducted in order to understand which group of drivers adjust speed on approach to safety cameras.

Results

At the '300m before' location, vehicle speeds were coded into four approach speed categories, less than 30mph, 31-35mph, 36-40mph, and 41+mph. The summary statistics for these speed categories can be seen in Table 1.6 below. The same percentage split was calculated for the 'at camera' location and the '300m after' location, in order to examine the effect of the safety cameras as a function of vehicle approach speed category.

Table 1.6 Summary statistics for speed categories at 300m before camera

	n	%	300m - at camera	300m before - 300m after
< 30mph	34010	64.83	-4.76mph	0.11mph
31-35mph	12808	24.41	-6.44mph	-4.89mph
36-40mph	4240	8.08	-4.78mph	-2.21mph
41+mph	1404	2.68	-2.08mph	0.33mph

The summary statistics in Table 2.6 illustrate that the 31-35mph approach speed category demonstrates the largest reduction in speed (-6.44mph), followed by the <30mph (-4.76mph) and the 36-40mph categories. The 41+mph category shows the smallest reduction in speed from 300m before to at the safety camera (-2.08mph). However, the safety cameras have an extended speed reduction effect from 300m before to 300m after the safety camera on both the 31-35mph (-4.89mph) and the 36-

40mph categories. The mean speeds for the four categories at all three spatial locations is illustrated in Figure 1.5 below.

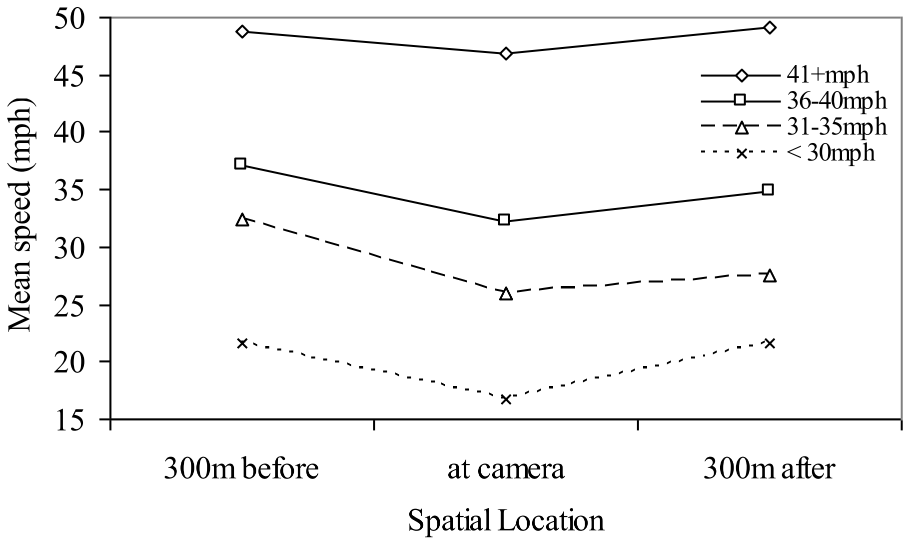

Figure 1.5 Mean speeds for the four speed categories at all three spatial locations.

A two-way ANOVA (Position: 300m before, at camera, 300m after; Speed category: < 30mph, 31-35mph, 36-40mph, 40+mph) was conducted on vehicle speeds. Results revealed that there was a highly significant effect of Position ($F(2,162410) = 4000.59$, $p < 0.01$), and of Speed category ($F(3,162410) = 42.53$, $p < 0.01$), as expected. There was also a significant interaction between Position and Speed category ($F(6,162410) = 1054.73$, $p < 0.01$).

Follow up analysis was conducted on the 41+mph speed category, examining whether there was a time of day effect on this most serious offender group, and thus whether there was an optimal time when safety cameras reduced speed for the highest speed category. To analyse the effect of time of day, the day was split into three time periods: peak (0700 – 0900, 1700 – 1900); off-peak (0900 – 1700, 1900 – 2300); and night (2300 – 0700). Raw data showed that while there was a reduction in speed from 300m before to at camera at both peak times (-1.15mph), and off-peak times (-2.72mph), the greatest effect was at night (-6.11mph), as illustrated in Figure 1.6. This degree of speed reduction is equivalent to the 6.44mph reduction found in the 30-35mph category at any time of day, as shown in the earlier analysis.

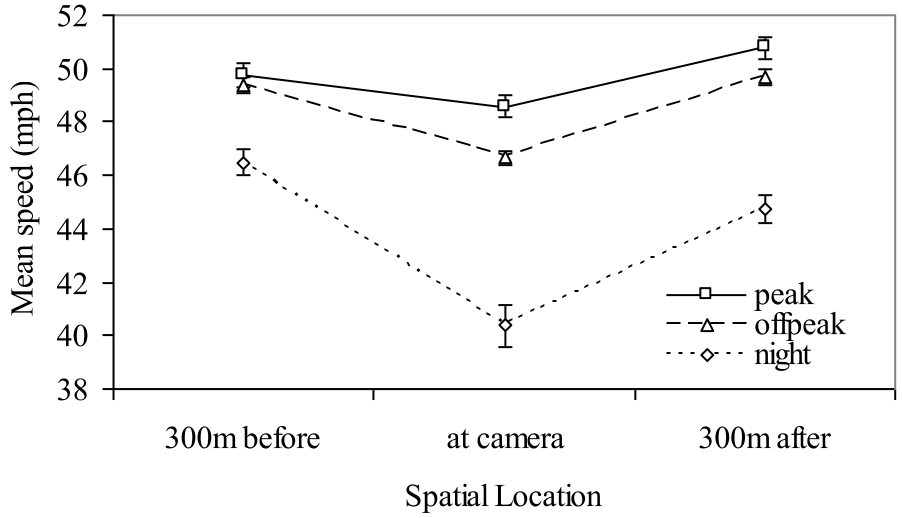

Figure 1.6 Mean speed at different traffic periods for the 41+ speed category only

Results of a two way ANOVA (Location: 300m before, at camera, 300m after camera; Time: peak, off-peak, night) on 41+mph category vehicle speeds revealed a significant effect of Location ($F(2,4732) = 43.14$, $p < 0.01$), and of Time ($F(2,4732) = 95.70$, $p < 0.01$), as well as a significant interaction between Location and Time ($F(4,4732) = 5.52$, $p < 0.01$).

<u>Conclusion</u>

The effect of safety cameras is most marked on vehicles that are approaching at speeds between 31-35mph and 36-40mph, with the speed reduction effect extending to at least 300m after the safety camera. Closer analysis of the 41+mph category revealed that while safety cameras have a modest effect on the highest offenders, when analysis is conducted on time period across the day a large speed reduction effect on this group is seen during night hours.

Experiment 2: Enforcement effect of safety cameras

An investigation was conducted on the effect of loading film in safety cameras in the Thames Valley region. Currently, there are 33 fixed cameras (10% of all housings) that were not loaded in 2003. The reasons were due to another camera at the same site being enforced (14), maintenance issues (10), housing replaced (1), or due to unenforceable reasons (8). Of the 33 unloaded cameras, 25 were not loaded in 2004 either.

Previous analysis of speeds from 300m before to at loaded fixed safety cameras has revealed that drivers reduce speed by 4.95mph on average on 30mph limit roads. This represents an 18.86% reduction in speed. One research question of interest is whether drivers are aware of cameras being unloaded, and thus do not moderate speed behaviour accordingly. Any speed reduction at unloaded safety cameras has implications for installing future safety cameras without enforcement, as well as for the issue of what to do with decommissioned safety cameras. In this scenario, the perception of penalties for speeding would be sufficient to reduce speed rather than actual penalty enforcement.

Two unloaded camera sites were identified as suitable for conducting research on the basis that they were unloaded from 2003 until the time of the research (July-August, 2004), were on a 30mph limit road, and had the sufficient, suitable road environment to conduct speed measurements at equivalent positions 300m and 300m after the camera site, as well as at the camera site itself.

Loaded fixed camera sites were required to compare the speed reduction effect of unloaded versus loaded cameras. Therefore, two loaded cameras were selected from seven cameras on 30mph limit roads that were investigated in an earlier study on the spatial effect of fixed cameras on speed. Two loaded cameras were selected on the basis that average speeds 300m before the sites were similar to that found 300m before the unloaded camera sites. The first loaded camera site was loaded from 19 days during 2003, and the second loaded site was loaded for 68 days in 2003, and 21 days up to July 2004. However, their average daily total of offences, 20.84 and 21.75 respectively, was very similar.

Method

Participants

A total of 2400 vehicle speeds were recorded. Only cars were included in the study. At all four fixed camera site 600 vehicles speeds were recorded, 200 at 300m before the camera, 200 at the camera, and 200 at 300m after the camera. The gender and age of each driver was also recorded, with the gender ratio at each site matched at male: female = 115: 85. The age of two drivers in the unloaded condition went unrecorded, and meant that only 2398 speeds were included in the analysis.

Apparatus

Vehicle speeds were recorded inconspicuously by a researcher using a hand-held MUNI QUIP K-GP Speedmeter. Speeds were noted down on paper, along with the age and gender of the driver.

Procedure

At each site, the researcher measured speeds in a parked car positioned at the side of the road in a way that did not obstruct the traffic flow. The speedmeter was pointed at an approaching car, and the trigger was pulled. The speed of the vehicle was presented on the speedmeter display and written down. As the car passed by, the researcher then noted the gender and age of the driver alongside the recorded speed.

Results

Overall, initial speed at the 300m before camera position was within one mile per hour between unloaded (M = 31.74mph; SD = 4.18mph) and loaded (M = 30.91mph; SD = 3.70mph) camera sites. There was a 5.11mph speed reduction from 300m before to at unloaded camera sites (16.09%), and a 4.69mph speed reduction from 300m before to at loaded camera sites (15.17%). This reduction in speed at unloaded sites is also equivalent to the 4.95mph reduction in speed at all seven loaded fixed camera sites in the original 300m survey. In this study, a speed reduction from 300m to 300m after at unloaded cameras of 1.10mph (3.47%) was higher than 0.60mph (1.94mph) at loaded cameras, but similar to the 1.20 (4.58%) found at all seven loaded fixed cameras.

Table 2.1 Descriptive statistics for unloaded and loaded cameras at 300m before, at, and 300m after camera

Position	*M*	*SD*	Variance	85^{th}	N
Unloaded					
300m before	31.74	4.18	17.43	36	399
At camera	26.63	2.86	8.16	29	400
300m after	30.63	3.78	14.31	34	399
Loaded					
300m before	30.91	3.70	13.73	34	400
At camera	26.22	2.69	7.25	29	400
300m after	30.31	3.70	13.70	34	400

Levene's test of equality of error variance revealed that there was a significant difference in speed variance across cameras and measurement positions ($F(5,2394) = 17.86$, $p < 0.01$).

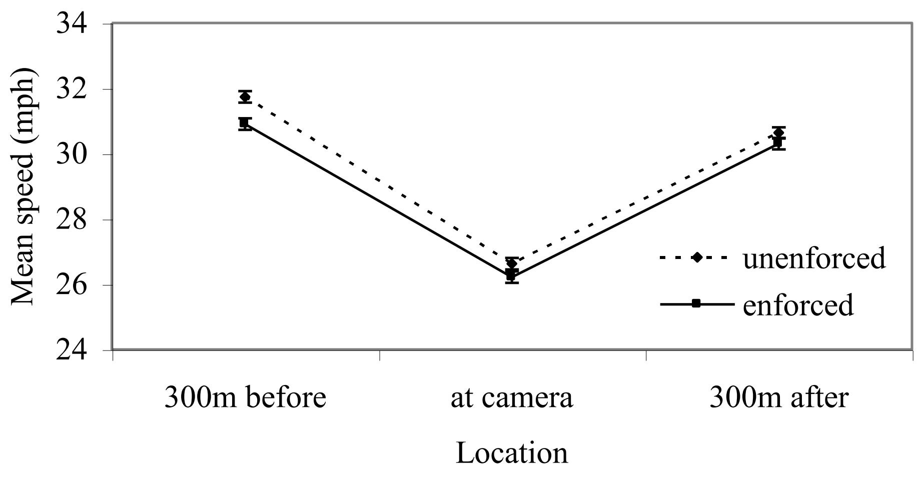

Figure 2.1 Speed at 300m before, at, and 300m after loaded and unloaded fixed safety cameras

A two-way ANOVA (Enforcement: loaded vs. unloaded; Position: 300m before vs. at camera vs. 300m after) with repeated measures on the last factor, was conducted with vehicle speed serving as the dependent variable. Results show that there was a significant effect of Enforcement on speed ($F(1,2394) = 13.22$, $p < 0.01$), and a significant effect of Position on speed ($F(2,2394) = 440.47$, $p < 0.01$). However, there was no significant interaction between enforcement and position ($F(2,2394) = 1.16$, $p = .31$). Post-hoc Bonferroni analysis revealed that for loaded and unloaded cameras, speeds reduced significantly from 300m before to at camera ($p < .01$), and then increase significantly from at camera to 300m after ($p < .01$).

Conclusions

A reduction in average speed, speed variance, and 85th percentile speed was witnessed from 300m before to at the fixed camera, with an increase in all variables from at to 300m after the cameras, as has previously been found in the fixed camera analysis. Although there was a slightly higher average speed at unloaded compared to loaded cameras, this was expected due to differences in road layout, environment etc., there was no significant interaction between loaded and unloaded cameras. This suggests that drivers moderate their behaviour equivalently at unloaded and loaded cameras. The results provide evidence that drivers reduce speed regardless of whether enforcement is conduct at the camera site, and thus future installation of fixed safety cameras would not necessarily require them to be loaded in order to have the equivalent speed reduction effect. The data have implications for the removal of decommissioned safety cameras in the sense that these cameras are introducing a decrease in speed and their removal is likely to result in an increase in speed.

Mobile safety cameras

Introduction

Stradling et al's (2003) survey on Scottish drivers' reactions to safety cameras at familiar locations and unfamiliar locations with safety camera signs, found that one third of drivers (34%:37% respectively) always stick to speed limits (p.113-4). However, on roads where they know safety cameras are, only 10% said they would slow down for the whole journey. When the camera location is not known, the percentage of drivers who slow down for the whole journey rises to 25%. At familiar camera locations, 51% of drivers said they slow down, but not necessarily for the whole journey, and that figure reduces to 33% where the cameras locations are unknown. Further analysis showed that highest degree of localised response to safety cameras was in the younger age groups (17-24; 25-34). The largest change in response when the location is not known is in the 17-24 age group. Where 68% only slow down in the vicinity of a known camera, 40% only do this when they do not know the location. This suggests that the presence of a fixed camera has more of a localised effect on speed, whereas an unknown camera (perhaps a mobile unit) can have more of an effect on speed across the whole journey, and this has greatest impact on the younger driver.

Behavioural studies have shown that the presence of safety cameras leads to a decrease in average speeds (De Waard and Rooijers, 1994; Holland and Conner, 1996; Vaa, 1997), with increased enforcement generally creating longer effects of speed reduction (see ETSC, 1999). For hidden cameras, Keall, Povey, and Frith (2001) found a reduction in higher percentile speeds and mean speed, as well as crash rates. Interestingly, another benefit of hidden cameras was the fall in speed on all roads, not just in safety camera areas, therefore "the deterrent effect of the cameras has been generalised beyond the safety camera areas" (Keall et al, 2001, p.282). Chen, Meckle, and Wilson (2002) also found evidence of mean speed reduction (unspecified) after the introduction of a photo radar enforcement zone, and a reduction of 2.8km/h in an additional monitoring site 2km from the enforcement zone. The authors suggest that the generalised effect is due to "the mobile nature of the photo radar and the unpredictability of their deployment in both time and location"

(Chen et al, 2002, p.137). However, the photo radar zones, and non-photo radar zones were interleaved on the same stretch of road, with non-photo radar zones extending from 0.4-5.9km, and so the road was in general densely populated by radars, and may have contributed to a lack of difference between radar and non-radar zones.

Experiment 3A: Day of week analysis

Investigation into whether the speed reduction effect of mobile camera enforcement is persistent or transient has not been researched previously in the literature. In relation to current mobile camera enforcement in Thames Valley, where enforcement on any given road by a mobile unit is intermittent by nature, the issue of speed choice in the presence and absence of mobile enforcement is critical. The speed reduction effect with fixed cameras has been shown to have a speed reduction effect of 4.95mph on average, with speeds reducing from 300m before to at camera, and despite rising from the camera to 300m after the camera, speeds remain 1.2mph lower at 300m after than at 300m after the camera. Compared to fixed camera sites, mobile enforcement reduces driver anticipation and expectancy of enforcement, and may have a more widespread deterrence effect due to drivers being unsure of detection.

Method

The method employed for this experiment is similar to that used for the spatial effect of fixed cameras (experiment 1A). Three SDR were placed on existing street furniture, one 300m before the site of the mobile camera van, one at the site of the mobile camera van, and one 300m after the site of the mobile camera van. Individual speeds were recorded, although due to a small variation in numbers of vehicles before, at, and after the camera site, it was not possible to track individual vehicles across the three measurement points. Instead a between-subject design was employed.

Speeds at all three SDR locations were recorded one the day before, the day of, and the days after mobile enforcement. A preliminary speed survey revealed that there were a reasonable proportion of drivers violating the speed limit (30mph) between 1pm and 3pm, and thus mobile camera enforcement was conducted at this time on the second day of the study.

For enforcement, a police officer parked a camera van at the side of the road so as not to obstruct passing traffic. Vehicles travelling in both directions were targeted using a Lastec Laser LTI 20/20 safety camera mounted in the rear of the van. The van was clearly marked with Police decals, and two camera signs were placed before the van (in both directions) to warn drivers that mobile enforcement might be taking place.

Results

Visual inspection of the data (see Figure 3.1) reveals that there is a 5.34mph reduction in speed during the enforcement time period from the day before mobile enforcement (*M* = 32.29mph, *SD* = 6.32mph) to the day of enforcement itself (*M* = 26.95mph, *SD* = 5.26mph). This was accompanied by a 7mph reduction in 85th percentile speed from the day before (39mph) to the day of enforcement (32mph), as well as a reduction in speed variance. The following day, average speed (*M* = 33.63mph, *SD* = 6.40mph), 85th percentile (41pmh), and variance in speed returned to approximately the pre-enforcement level.

Results of a one-way ANOVA (Day: day before, mobile enforcement day, day after) showed that there was an overall significant effect of Day on mean speeds ($F(2,3560) = 403.86$, $p < .01$, $\eta^2 = .18$). There was also a significant difference in variance of speed across days ($F(2,3560) = 33.15$, $p < .01$). A priori analysis using Bonferroni pairwise comparisons revealed that the mean speed on the day of mobile enforcement was significantly lower than mean speeds on the day before ($p < .01$), with mean speed the day after significantly higher than on the day of enforcement ($p < .01$), as well as the day before enforcement ($p < .01$).

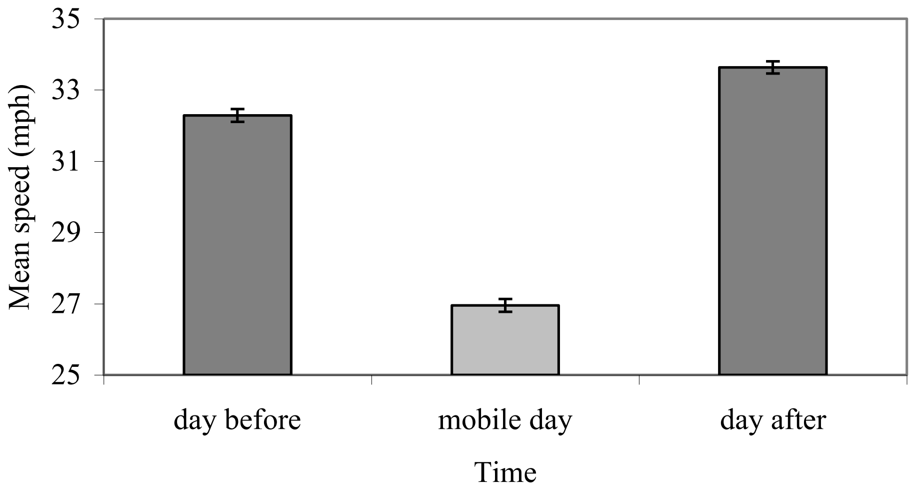

Figure 3.1 Mean speeds as a function of day

These experiments aimed to assess the immediate speed reduction effect of mobile enforcement compared to the days before and after. Results show that mobile enforcement leads to a significant decrease in average speed of 5.34mph. Mobile enforcement was conducted at a less expected site compared to established fixed cameras from the drivers’ perspective, and despite the use of clear signage on the police vehicle, accompanied by camera enforcement warning signs, there was still a significant speed reduction.

Experiment 3B: Hour of the day analysis

Analysis was conducted at one site on speeds measured in a two hour time period before, two hours during, and two hours immediately following mobile enforcement at the same site. This was to investigate whether there was any immediate carry-over effect after mobile enforcement has been conducted.

Method

The experimental set-up was as per Experiment 3A.

Results

Raw data presented in Table 3.1 reveal that there was a 6.23mph decrease in average speed from the hours before (*M* = 33.17mph, *SD* = 6.05mph), to hours during mobile enforcement (*M* = 26.95mph, *SD* = 5.26mph), as well as a 7mph drop in 85th percentile speed. In the hours after mobile enforcement, speeds increased by 5.38mph, and 85th percentile speeds increase by 7mph.

Table 3.1 Mean speed in the hours before, during, and after mobile enforcement

	N	*M*	*SD*	85th %ile
Before (0900–1100)	1066	33.17	6.05	39.00
SID (1100–1300)	1135	26.95	5.26	32.00
After (1300–1500)	1141	32.33	6.50	39.00

Results of a one-way ANOVA (Time: before, during, after) revealed that there was a significant main effect of Time on speeds ($F(2,3339) = 359.55$, $p < .01$, $\eta^2 = .18$), as well as a significant difference in variance of speed ($F(2,3339) = 33.05$, $p < .01$). A priori analysis using Bonferroni pairwise comparisons revealed that mean speed was significantly reduced during the hours during mobile enforcement, compared to the hours before ($p < .01$), with speeds increasing significantly after mobile enforcement ($p < .01$).

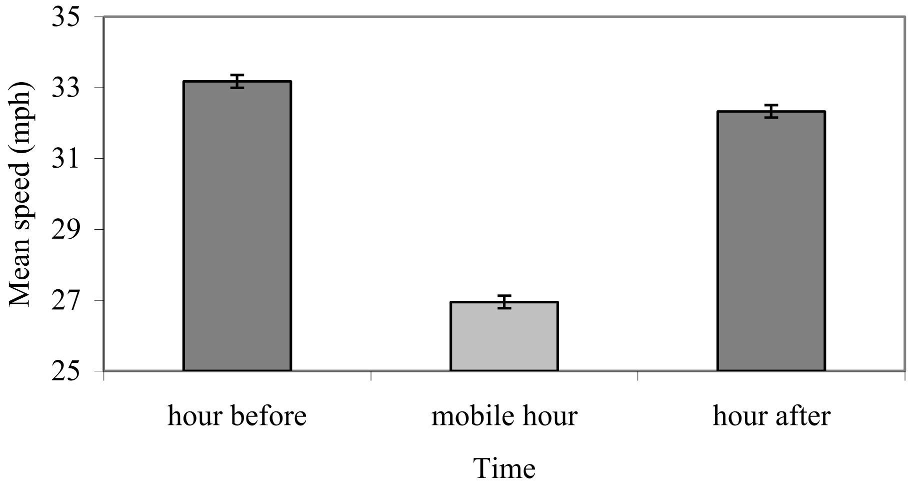

Figure 3.2 Mean speeds as a function of time

However, the mean speed after mobile enforcement was still significantly less than pre-mobile enforcement speeds by 0.84mph ($p < .01$). 85th percentile speed reduced by 7mph when mobile enforcement was conducted, and increased by 7mph after mobile enforcement ended.

Experiment 3C: Spatial effect of mobile enforcement

Research was conducted on driving behaviour 300m before the mobile safety camera, at the mobile camera, and 300m after the mobile camera on a 30mph road, as per the 300m study for fixed cameras. The aims were to investigate whether driving speed was reduced from before the mobile camera to the mobile camera position, and whether any speed reduction effect persisted beyond the mobile camera.

Method

All speed measurements were taken using Speed Detection Radars (SDR), with one positioned 300m before the mobile camera, one positioned at the mobile camera, and one positioned 300m after the mobile camera. Individual speeds of each passing vehicle were recorded as well as the time that they passed. A between-subjects design was employed, as there was a small variation in number of speeds recorded before, at, and after the camera, making it impossible to track individual drivers across the three measurement points.

Results:

A total of 11521 vehicle speeds were recorded by the three SDRs. However, due to concerns that speeds in one direction were miscalculated by one of the SDRs, it was decided to conduct analysis on the spatial effect of mobile enforcement in one direction only (n = 5731).

Results revealed that while speeds increased from 300m before to at mobile camera on the day before deployment (+3.46mph, +10.89%), and the day after deployment (+5.54mph, +17.35%), on the day of enforcement there was a reduction in speed from 300m before to at mobile camera (-1.89mph , -6.12%), resulting in a net reduction in vehicle approach speed of 5.35mph from the day before to the day of mobile enforcement, and of 7.43mph from the day of mobile enforcement to the day after mobile enforcement. This effect was persistent, with mean speed at 300m after the mobile (M = 34.73mph, SD = 4.49mph), still over 4mph lower than at the same location on the day before (M = 38.94mph, SD = 4.65mph) and day after (M = 40.14mph, SD = 4.98mph).

On the day of mobile enforcement, a reduced 85th percentile speed was recorded at camera (34mph), 4mph less than the day before (38mph) and 5mph less than the day after (39mph). Finally, variance in speed on the day of enforcement at the mobile camera location (24.48) was less than the day before (32.19), but the same as the day after (24.66).

Table 3.2 Descriptive statistics for speeds during day before, day of, and day after enforcement, at 300m before, at, and 300m after camera

Position	N	*M*	*SD*	Variance	85th
Day before					
300m before	630	31.86	7.37	54.30	39
At camera	619	35.28	5.67	32.19	41
300m after	623	38.94	4.65	21.60	44
Mobile day					
300m before	607	30.95	7.31	53.40	38
At camera	630	29.06	4.95	24.48	34
300m after	636	34.73	4.49	20.17	39
Day after					
300m before	672	31.92	7.66	58.75	39
At camera	657	37.46	4.97	24.66	42
300m after	657	40.14	4.98	24.77	45

A two way ANOVA (Time: day before, mobile day, day after; Location: 300m before, at camera, 300m after) was conducted on mean speeds. Results revealed that there was a significant effect of Time ($F(2,5722) = 362.10$, $p < .01$), as well as a significant effect of Location ($F(2,5722) = 568.03$, $p < .01$). There was also a significant interaction between Time and Location ($F(4,5722) = 67.61$, $p < .01$). Bonferroni pairwise comparisons revealed that there was a significant difference reduction in mean speed across locations between the day before and the day of enforcement ($p < .01$), and a significant difference increase in mean speed across locations between the day of and the day after enforcement ($p < .01$). There was also a significant difference increase in mean speed across locations between the day before and the day after enforcement ($p < .01$).

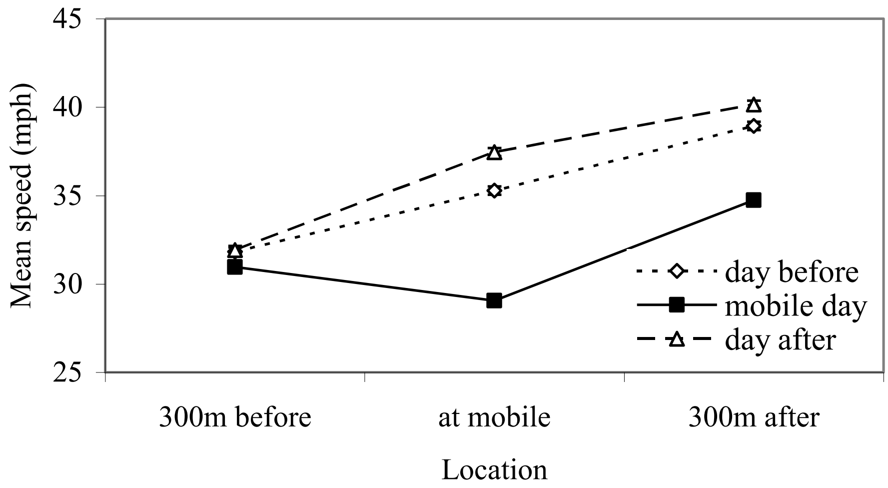

Figure 3.3 Mean speed from 300m before, to at mobile camera, to 300m after at the same time on the day before, the day of, and day after mobile enforcement.

<u>Conclusions</u>

It appears that mobile enforcement has a significant effect in reducing approaching vehicle speed by 5.34mph when compared to the day before and day after, and by 6.23mph from the hours before, during, and after, on the same stretch of road. The speed reduction effect disappears as soon as mobile enforcement ends, suggesting that the more often mobile enforcement is deployed at the roadside, the more often speeds will be reduced. The net reduction of vehicle approach speed on the day of mobile enforcement (5.34mph) compared to the day before enforcement, is also comparable to the speed reduction effect of fixed cameras from 300m before to at the camera site (-4.95mph), suggesting that fixed cameras are as effective as mobile enforcement despite their permanent status making them more susceptible to driver anticipation than unexpected mobile enforcement. The speed reduction effect is also seen to persist at least 300m beyond the enforcement site by 4.21mph compared to the day before.

Experiment 3D: close following

Further analysis was conducted on data collected from the study in Experiments 3A, 3B, and 3C, specifically looking at the time gap between vehicles. The research question was whether time gap at the mobile camera position on the day of enforcement was less than on the day before and the day after enforcement due to vehicle bunching together when passing the mobile camera van.

Method

Participants

Time gaps were measured during the two hour periods on the day before, day of, and day after mobile enforcement. Gaps over three seconds were not deemed to be a realistic time between vehicles in a normal traffic flow. Therefore, only time gaps of equal to or less than three seconds between vehicles were used in the analysis (n = 964). There were 314 time gaps of equal to or less than three seconds recorded on the day before mobile enforcement, 261 on the day of mobile enforcement, and 389 on the day after mobile enforcement.

Apparatus

The experimental set-up was the same as in Experiment 3A.

Procedure

A speed detection radar (SDR), positioned immediately behind the mobile camera, recorded the speed of vehicles as they passed the mobile camera, and also recorded the hour, minute, and second that the vehicle passed. Once all the data had been collected and downloaded from the SDR, the time gap between vehicles was calculated by subtracting the time one vehicle passed from the time of the vehicle that immediately preceded it. In order to assess a realistic close following scenario, only vehicles travelling at equal to or less than three seconds behind the vehicle in front were used in the analysis. Any vehicle travelling at further than two seconds behind another vehicle was not deemed to be close following, or having their speed regulate by the vehicle in front.

Results

Raw data revealed a 110ms increase in time gaps from the day before to the day of mobile enforcement (+6.84%), and an 110ms decrease in time gaps from the day of mobile enforcement to the day after (-6.36%), with no difference between the day before and the day after.

Table 3.3 Descriptive statistics for time gaps of three seconds or less between vehicles on the day before, during, and day after mobile enforcement

Position	*M* time	*SD*	N
Day before	1.65	0.48	314
Mobile day	1.76	0.44	261
Day after	1.65	0.48	389

Levene's test of equality of error variance revealed that there was a significant difference in variance of time gaps from the day before, during and day after mobile enforcement ($F(2,961) = 25.37$, $p < .01$).

A one-way ANOVA (Day: day before, mobile day, day after) was conducted on the length of time gaps, and results showed a significant effect of Day on the length of time gaps ($F(2,961) = 5.47$, $p < .01$). Bonferroni analysis showed that there was a significant increase in the length of time gaps between vehicles from the day before to the day of mobile enforcement ($p = .01$), and a significant increase in the length of time gaps between vehicles from the day of mobile enforcement to the day after ($p = .01$). There was no difference between length of time gaps between vehicles from the day before to the day after ($p = 1.00$). Results are presented in Figure 3.4.

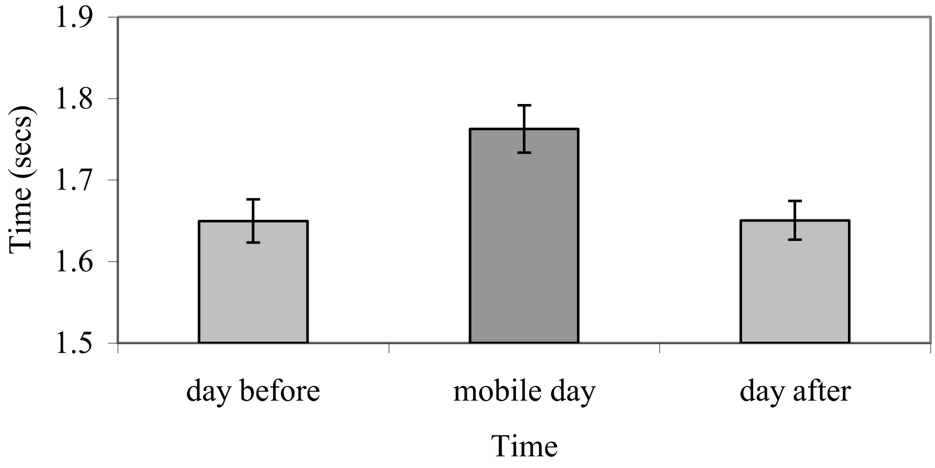

Figure 3.4 Length of time gap between vehicles the day before, day of, and day after mobile enforcement.

General conclusions

This experiment has shown that mobile enforcement has a dual safety effect. Results of this study have shown that mobile enforcement leads to a reduction in speed roughly equivalent to that of fixed cameras. In addition, the time gap between vehicles is extended by over five percent when mobile enforcement is being conducted. One argument counter to traffic calming devices is that while speeds might be reduced, so is the visible distance between the cars. This result shows that there is in fact a greater time gap between vehicles during mobile enforcement, and therefore a greater amount of reaction time. Therefore, not only is speed reduced when mobile enforcement is conducted, but there is greater time for drivers to react despite appearing visually closer to the car in front. In response to claims that traffic calming leads to close following, the experiment demonstrates that safety is not compromised by close following when reducing speeds during mobile enforcement. However, it should be noted that this experiment was conducted at a single site, and replication of these findings at other sites is necessary, in order to confident that it is a generic effect, and not a localised effect at the one site.

Roadside Feedback

Introduction

Roadside feedback signs have been increasingly deployed as a speed reduction technique with limited empirical support for its effectiveness in speed reduction. Roadside feedback signs provide educational information regarding vehicle speed to individual drivers. The roadside feedback sign is a flexible method of targeting known speed hotspots, and serve as a practical alternative to enforcement devices such as safety cameras, which require strict criteria regarding accident incidents at given sites.

Previous research into the effectiveness of roadside feedback signs has been limited, and results have been equivocal. While several studies have shown significant decreases in speeding after posting roadside feedback to drivers (e.g. Van Houten & Nau, 1981, 1983), other experiments have found that public feedback was not effective in increasing compliance with posted speed limits (Roqué and Roberts, 1989). However these experiments typically investigated the effects of informing drivers of the percentage of vehicles not speeding on previous day or week as a method to reduce speed, rather than giving individual vehicle speed feedback, and were conducted on a variety of roads with different speed limits.

For devices that give drivers feedback about their actual speed, Dart and Hunter (1976) found that roadside speed indicators had no significant effect on traffic speeds compared to other enforcement techniques of speed check zones, stationary patrol cars, and simulated pullovers.

However, Casey and Lund (1993) investigated the effect of a mobile roadside speedometer on traffic speeds using observers with handheld radars upstream, at, and downstream from a speedometer, with drivers at four different sites being presented with the speed limit, a "your speed" sign with the vehicle speed displayed underneath, and a police sign on the bottom. They found that average speeds were reduced by approximately 10% alongside the speedometer, and about 7% downstream from the speedometer. There was also a large reduction in the percentage of drivers speeding, from 15-20% to only 2% at one site, however there was a limited time halo, with speeds only reduced on days when the speedometer was actually deployed. The authors also found that “associated police enforcement activities were clearly important in regard to the long-term effectiveness of roadside speedometers” (Casey and Lund, 1993, p634). The police motif on the trailer may also have been a contributory factor in reducing speeds. In their introduction, Casey and Lund (1993) cite two studies, one where the message was “Police – you are speeding” was presented, leading to a marked reduction in drivers speeding 5mph over the limit (Moncaster and Eagle, 1978, Casey and Lund, 1993), and another where the driver speed was presented, along with a “Slow down” message, that did not significantly reduce driver speeds (Dart and Hunter, 1976, c.f. Casey and Lund, 1993). No study presenting driver speed without visible indication of police involvement/enforcement has been carried out.

In non-peer reviewed reports, a large-scale evaluation of the effect of vehicle-activated signs presenting only the speed limit roundel, and not the actual speed of the vehicle, demonstrated a significant reduction in mean speeds of between 2mph and 7mph after installation of VAS (Winnett and Wheeler, 2002). There was also an average 58% reduction in accidents on VAS sites (Winnett and Wheeler, 2002). However, results were analysed from binned data, which does not allow accurate calculation of mean and 85th percentile speeds. A report by South Gloucester Council (2002) also found a reduction in average speed of 4mph (range 1mph – 10mph), and an average reduction in 85th percentile speed of 4mph (range 1mph – 10mph), as well as a reduction in the percentage of vehicles exceeding the speed limit by 21% (range 1% - 50%), across 33 sign sites. There appeared to be a range of different signs presented to drivers (e.g. speed limit roundels, vehicles actual speed, standard warning sign, slow down message), as well as at a variety of locations (e.g. 30mph limits, 40mph limits, approaches to junctions, approach to school), but the report claimed “(signs) displaying the vehicle’s speed makes most drivers reduce their speed”. The methodological details were not clear in the report however, so the effect of different signs on speed choice at different locations are hard to specify.

The objective of the research is to investigate the effect of interactive roadside feedback for individual drivers, accompanied by positive or negative feedback depending on whether the passing driver drives past the feedback device within or exceeding the30mph speed limit respectively. The first aim is to examine whether there is a temporal effect of roadside feedback on mean speed during the hours it is deployed compared to the same time period the day before and the day after. The second aim is to investigate temporal effect of roadside feedback on mean speed during the hours it is deployed, compared to the preceding and following hours. The third aim is to examine any spatial effect of roadside feedback on speeds 300m before the feedback site, at the feedback site, and 300m after the feedback site on the day before, day during, and day after deployment of feedback devices. Analysis will also be conducted on the length of time gaps between vehicles before, during, and after roadside feedback is present, in order to investigate whether this form of traffic calming leads to close following behaviour. Finally, attitudes to speed related issues, as well as knowledge of roadside feedback devices, and the motivational factors underlying behaviour change in response to them, is assessed in a series of surveys conducted in an urban and rural community. While data from an initial provides a picture of public perception of speeding and speed reduction measures, a second survey will also be conducted in order to gauge any change in attitudes since a speed reduction campaign has been implemented with the communities.

Effect of roadside feedback across days

These experiments aimed to assess the speed reduction effect of roadside feedback, using SID, on the day of deployment compared to the same time period on the day before and days after.

Experiment 4A: Five day study

A study was conducted on speed behaviour the day before SID, the day of SID, and consequent days after SID on a 30mph speed limit road, in order to investigate: whether speeds are significantly reduced from the day before to the day of SID; and whether there is a persistent speed reduction effect over following days. In this study, speed behaviour was tracked on the following three days after SID deployment.

Method

One SDR was used to measure vehicle speed on a 30mph road. The SDR was placed unobtrusively on existing street furniture, and recorded speeds of vehicles passing in one direction (North). All vehicles were presented with their speed when the SID was triggered. Under 30mph, the speed plus happy face was presented. Over 30mph, the speed plus sad face were presented. There was no cut-off for speed presentation to deter people trying to register a fast speed. Vehicle speed was recorded by one SDR placed after the SID display. Analysis was conducted using 'binned' data, with 12 5mph bins from 0mph up to 61mph, and a 13^{th} open bin for all speeds above 61mph. The SDR recorded speeds for 7 consecutive days, with the SID being deployed between 11.30 and 13.00 on the 4^{th} day.

In this analysis, the speeds measured on the day SID was deployed (Monday) were compared with speeds measured at the exact same time (11.30 – 13.00) on weekdays when the SID was not deployed (Friday, Tuesday, Wednesday, Thursday). This was to investigate whether the deployment of SID has any effect on drivers passing through the same site on days after SID being present. Speeds on weekend days were not included in the analysis due to a difference in traffic flow compared to weekdays.

Results

Visual inspection of the data (see Table 4.1) reveals that there is a 5.42mph reduction in speed from the day before SID (36.13mph) to the day of SID itself (30.71mph).

This was accompanied by a 10mph reduction in 85th percentile speed, as well as a reduction in speed variance. The following day, average speed and speed variance returned to approximately the pre-SID level. The 85th percentile speed remained lower than pre-SID level, although this cannot be logically explained by the influence of SID.

<u>Table 4.1</u> Mean speeds on the day before SID, day of SID deployment, and days after SID deployment

	n	*M*	*SD*	variance	85th %
Friday (pre-SID)	188	36.13	5.08	25.78	43.50
Monday (SID)	201	30.71	4.27	18.20	33.50
Tuesday (post-SID)	196	35.72	5.24	27.49	40.75
Wednesday (post-SID)	177	35.14	5.29	27.98	38.50
Thursday (post-SID)	184	35.62	5.54	30.73	38.50

A one-way ANOVA (Day: Day before, SID day, 1 day after, 2 days after, 3 days after) on means speeds at the SID site revealed that there was an overall significant effect of Day on mean speeds ($F(4,941) = 38.279$, $p < .01$, $\eta^2 = .14$). There was also a significant difference in variance of speed across days ($F(4,941) = 2.89$, $p = .02$). Bonferroni pairwise comparisons revealed that the mean speed on the day of SID deployment (Monday) was significantly lower than mean speeds on all other days ($p < .01$), with no other significant differences in mean speeds between any other day.

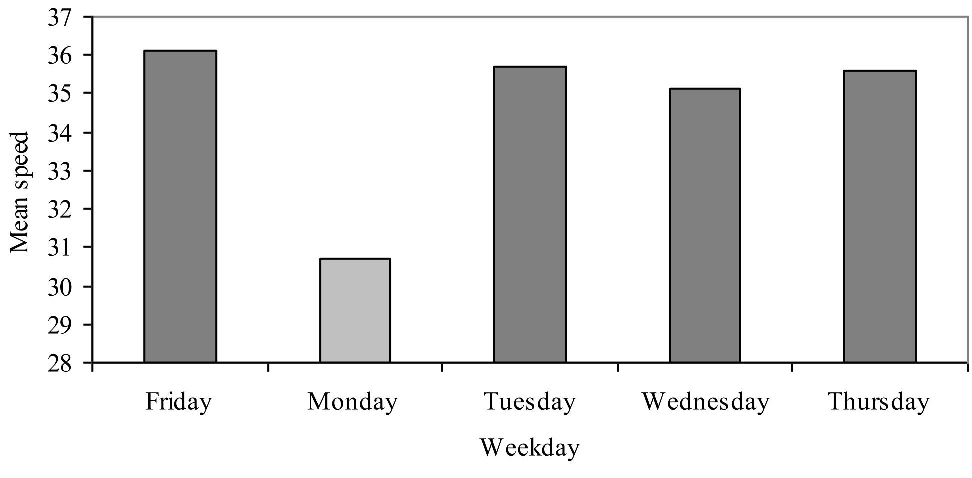

Figure 4.1 Mean speeds as a function of day (SID deployed on Monday)

Experiment 4B: SID use in urban area

A second study was conducted on speed behaviour the day before SID, the day of SID, and the day after SID on an urban 30mph speed limit road. No further days after SID deployment were monitored due to the finding in experiment 4A that mean speed rose to pre-SID level on the first day after SID was used. In order to further investigate the speed reduction impact of presenting drivers with individual roadside feedback via SID, average speed, variance in speed, and 85th percentile speeds were analysed.

Method

One speed detection radar (SDR) was used to measure vehicle speed on a 30mph road, positioned at the SID site. The SDR was placed unobtrusively on a lamppost, and recorded speeds of vehicles passing in both directions. Speeds were recorded over a 72-hour period, in order to provide data on speeds the day before SID deployment, the day of SID deployment, and the day after SID deployment.

On the day of deployment, one SID faced traffic travelling to the east, and was placed five meters in front of the SDR. The second SID was positioned on the other side of the road to face traffic travelling in to the west, and was placed parallel to the SDR. This allowed the SDR to pick up vehicle speed immediately after both SID displays. All vehicles travelling under 45mph were presented with their speed when the SID was triggered. Under 30mph the SID message alternated between presentation of the speed of the vehicle and a sad face. Over 30mph the SID message alternated between presentation of the speed of the vehicle and a sad face. Over 45mph, only the sad face was presented, as presenting the speed of the vehicle may have encouraged some drivers to try and register a fast speed.

Results

A total of 11318 vehicle speeds at the SID site were used for analysis during a two-hour off-peak period across three days, the day before SID was deployed (n = 3952), the day of SID deployment (n = 3767), and the following day (n = 3599). Mean speeds dropped from the day before SID (M = 33.59mph, SD = 7.47) to the day of SID deployment (M = 29.54mph, SD = 6.07mph). This speed reduction of 4.05 was also accompanied with a reduction in 85th percentile speed of 5mph from 41mph to 36mph. The day after SID was removed, mean speed rose to a similar speed as the day before SID deployment (*M* = 33.76mph, *SD* = 7.33mph). The 85th percentile speed increased back to the level it was the day before (41mph).

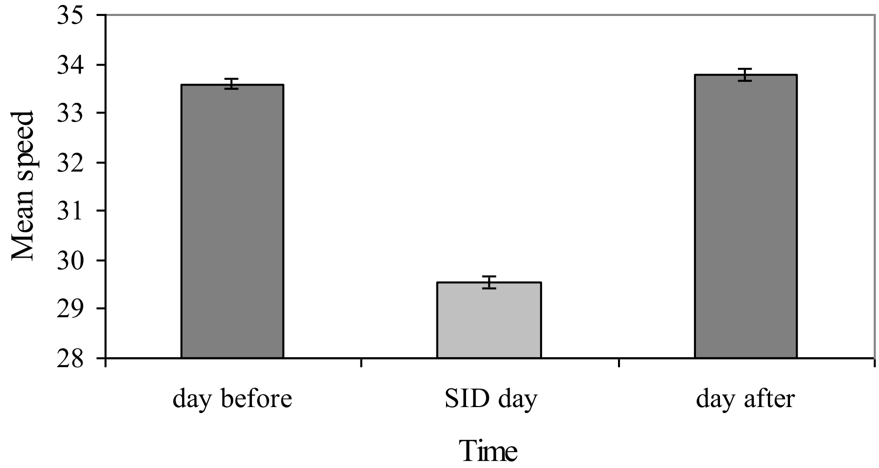

Figure 4.2 Mean speeds during the same time period on the day before SID deployment, during SID deployment, and the day after SID deployment at an urban site.

A Levene's test of equality of error variance revealed that there was a significant difference between the variance in speeds on the three days ($F(2,11315) = 112.69$, $p < 0.01$). Variance in speed on the day of SID deployment (33.80) was therefore significantly lower than the day before (55.73), and the day after (53.66) SID deployment. A one-way ANOVA (Day: before vs. SID vs. after) on vehicle speed revealed that there was a significant effect of speed ($F(2,11315) = 440.37$, $p = < 0.01$). Pairwise comparisons revealed that there was a significant drop in speed of 4.05mph from the day before to the day of SID deployment ($p < 0.01$), but a significant increase in speed of 4.22mph from the day of to the day after SID deployment ($p < 0.01$). There was no significant difference in speed between the day before and day after ($p = 0.86$).

General conclusions

The presence of SID had a significant effect in reducing vehicle speeds on two different 30mph limit roads of at least 4mph. There was no evidence of a persistent effect of SID on average speed during subsequent days, with average speeds returning to the pre-SID level on the first day after SID has been removed. This localised effect concurs with other findings in the literature (e.g. Casey & Lund, 1990), and highlights the benefit of SID as a mobile tool for focussed speed reduction in known speeding hotspots. It also demonstrates that the police sign accompanying the roadside feedback in the Casey & Lund (1990) study is not necessary.

Experiment 4C: SID use in rural area

A study was conducted on speed behaviour the day before SID, the day of SID, the day after SID, and two days after SID deployment on a 30mph speed limit road. This site differed from that in Experiment 4B, in that it was a rural village road rather than an urban road, and hence had a much reduced traffic flow. In order to investigate the speed reduction impact of presenting drivers with individual roadside feedback via SID, average speed, variance in speed, and 85^{th} percentile speeds were analysed.

Method

The method was as per Experiment 4B.

Results

A total of 1778 vehicle speeds at the SID site were used for analysis during a two-hour off-peak period across four days, the day before SID was deployed (n = 524), the day of SID deployment (n = 467), the following day (n = 378), and two days later (n = 409). Mean speeds dropped from the day before SID (M = 37.22mph, SD = 6.79mph) to the day of SID deployment (M = 32.15mph, SD = 5.41mph). This speed reduction of 5.07mph (-13.61%) was also accompanied with a reduction in 85^{th} percentile speed of 7mph from 43mph to 36mph. The day after SID was removed, mean speed rose by 3.47mph (M = 35.62mph, SD = 7.78mph), still 1.60mph lower than the day before SID deployment. The 85^{th} percentile speed increased back to the level it was the day before (43.15mph). However, two days after the mean speed returns to pre-SID deployment levels (M = 37.54mph, SD = 7.57mph), with 85^{th} percentile speed at 44mph.

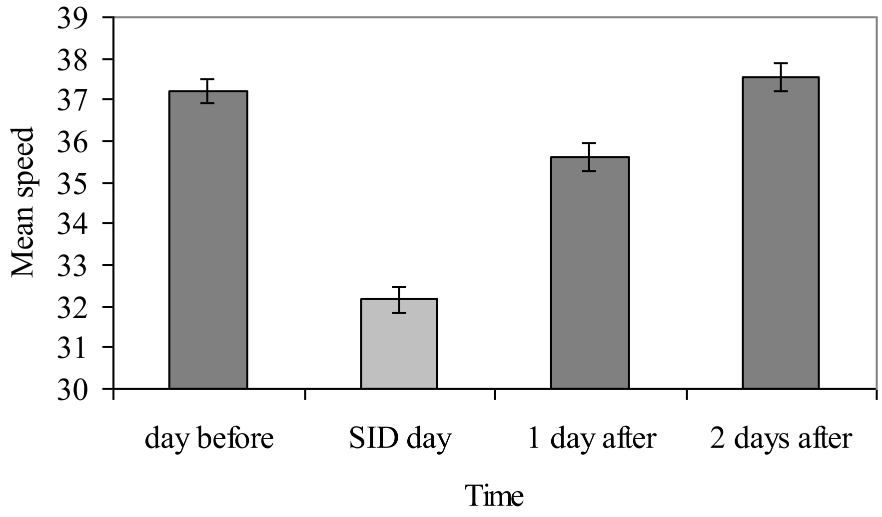

Figure 4.3 Mean speeds during the same time period on the day before SID deployment, during SID deployment, and the day after SID deployment at a rural site.

A Levene's test of equality of error variance revealed that there was a significant difference between the variance in speeds across the four days ($F(3,1774) = 17.36$, $p < 0.01$). A one-way ANOVA (Day: before vs. SID vs. 1 day after vs. 2 days after) on vehicle speed revealed that there was a significant effect of speed ($F(3,1774) = 59.58$, $p = < 0.01$). Bonferroni pairwise comparisons revealed that there was a significant drop in speed from the day before to the day of SID deployment ($p < 0.01$), and a significant increase in speed from the day of to the day after SID deployment ($p < 0.01$). There was a significantly lower mean speed one day after SID than one day before ($p < 0.01$), but no significant difference in speed between the day before and two days after ($p = 1.00$).

<u>Conclusions</u>

As with previous experiments, there is a significant reduction of mean speed when SID is deployed compared to the same time period the day before, when no SID was deployed. At this rural road site, the reduction was 5.07mph, in line with previous speed reduction effects found with SID. However, the day after SID deployment speeds did not return to pre-SID levels, as previously found. The reasons for this are unclear, although it should be noted that there were 146 less vehicle speeds recorded on the day after compared to the day before SID, as well as more variance in the speeds on the day after SID (60.51) than the day before SID (46.15), which may contribute to these difference as opposed to there being a carry-over effect of SID one day later. However, two days after SID deployment, speeds return to pre-SID levels, illustrating that SID is effective in reducing speeds, but that the effect is transient.

SID effect across hours

These experiments aimed to assess the immediate speed reduction effect of SID compared to the hours before and after deployment. The following four studies investigated any speed reduction effect over a briefer time period, and examine if there is an immediate carry-over effect.

Experiment 5: SID effect across hours (binned data)

Analysis was conducted at one site on speeds measured in a 1½ hour time period before SID was deployed, the 1½ hours when SID was deployed, and 1½ hours immediately following SID deployment at one site. This was to investigate whether there was any immediate carry-over effect after a SID has been deployed.

Method

The experimental set-up was as per Experiment 4B.

Results

Raw data presented in Table 5.1 reveal that there was a 6.71mph decrease in average speed from before SID to during SID deployment, as well as 10mph drop in 85th percentile speed. When the SID was removed, speeds increased by 4.5mph, and 85th percentile speeds increase by 6.25mph.

Table 5.1 Before, during, and after SID deployment

	N	*M*	*SD*	85th %ile
Before (10.30–11.30)	153	37.42	5.96	43.50
SID (11.30–13.00)	201	30.71	4.27	33.50
After (13.00–14.30)	164	35.21	6.61	39.75

Results of a one-way ANOVA (Time: Before, during, after) on mean speeds, showed a significant main effect of Time on speeds ($F(1,515) = 66.83$, $p < .01$), as well as a significant difference in variance of speed ($F(1,515) = 8.79$, $p < .01$). Bonferroni pairwise comparisons revealed that mean speed was significantly reduced during the 1½ hours when the SID was deployed, compared to the 1½ hours before ($p < .01$), with speeds increasing significantly 1½ hours once the SID deployment ended ($p < .01$).

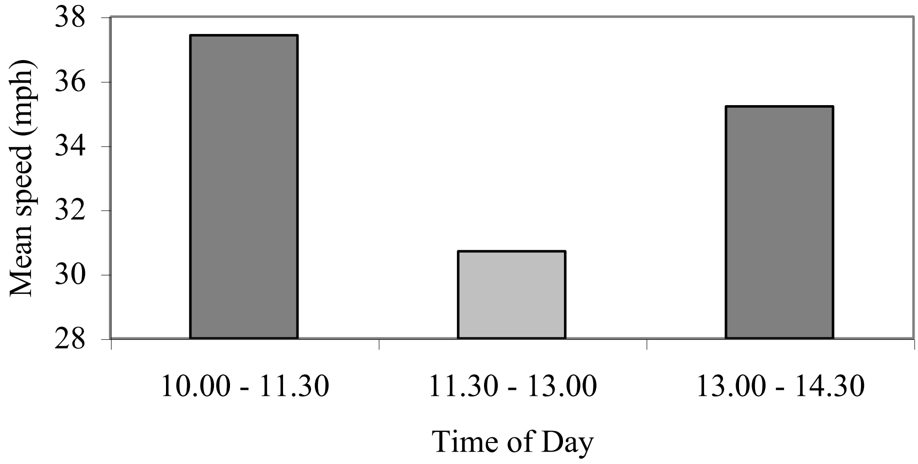

Figure 5.1 Mean speeds as a function of time (SID deployed 11.30 – 13.00)

However, the mean speed after the SID deployment was still significantly less than pre-SID speeds. 85th percentile speed reduced by 10mph when SID was present, but increased by less than 7mph after it was removed.

Experiment 6A: SID effect across hours at urban sites (individual speeds)

A series of experiments were conducted on vehicle speeds (using a SDR recorder) during the time period when a SID was deployed, and the hour before and hour(s) after the SID was deployed, in order to investigate the immediate temporal effect of SID. In these experiments, individual speeds were used in the analysis, unlike the 'binned' data analysed in Experiment 5A.

Experiment 6A

Two SID were erected during rush hour, in order to examine any speed reduction effect vehicle speed.

Method

The experimental set-up was as per Experiment 4B. In this study, two SID were activated between 07.50 and 08.50 hours, one facing northbound traffic and one facing southbound traffic.

Results

Bi-directional speeds were collected (data collapsed across north and south directions) for a total of 3252 vehicles. Raw data showed that there was a speed reduction of 13.02mph (-42.55%) from speeds in the hour before SID (*M* = 30.6mph, *SD* = 5.99mph) and the hour during SID (*M* = 17.58mph, *SD* = 6.69mph).

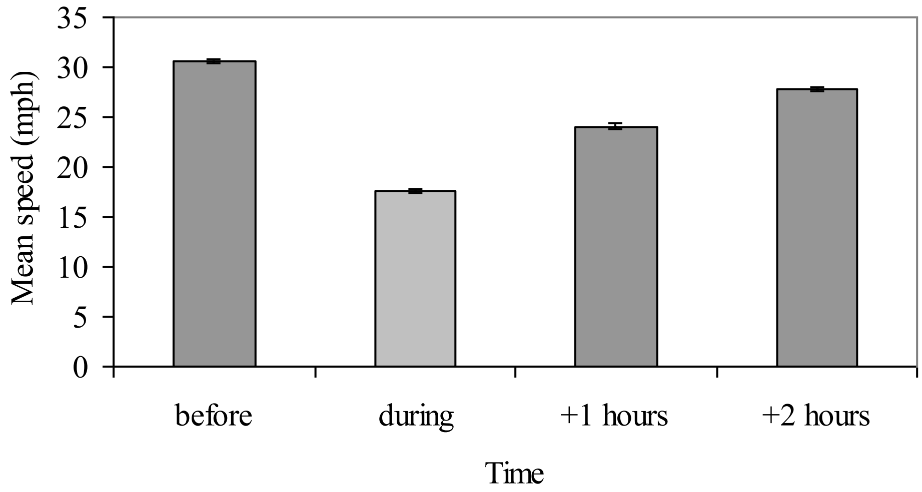

Figure 6.1 Mean speeds in the hours before, during, and after SID deployment

Results of a one-way ANOVA (Time: Hour before, hour during, 1 hour after, 2 hours after) on mean speeds showed that there was a significant difference effect of Time ($F(3,3249) = 603.14$, $p < .01$). Bonferroni pairwise comparisons revealed that SID deployment led to a significant reduction in mean speeds ($p < .01$). Speeds increased significantly in the time after SID was removed ($p < .01$), but were still significantly less than the speeds before SID deployment ($p < .01$). There was also a significant difference in variance in speed across time periods ($F(3,3249) = 30.47$, $p < .01$), as well as a reduction in 85th percentile speed of at least 6mph.

The fact that speeds in the hour after SID was removed remained significantly lower than speeds before SID deployment could be due to the road safety vehicle remaining on site to remove the SID, and its presence contributing to a suppressed speed when no speed feedback was being presented. It is also worth noting that the study was conducting across a time period where traffic flow varied considerably from before (*n* = 527), to during (*n* = 1089), to +1 hours (*n* = 959), to +2 hours (*n* = 677). This may have had a confounding effect on results, particularly at the critical time point of during SID deployment, when traffic flow increased by more than double, which could have contributed to the lowering speeds regardless of the effect of SID. For this reason the results must be treated with caution, and further experiments were conducted to gain a more reliable assessment of the speed reduction effectiveness of SID.

Experiment 6B: SID at urban site across peak and off-peak hours

A second study was conducted on an urban street with a 30mph speed limit, between 08:30 and 11:30. Again, the time period was around rush hour time, but overlapped only with the hour before SID deployment. The traffic flow in this study was relatively stable across before (n = 338), during (n = 252), and after SID (n = 266) time periods, with the higher flow found in the before SID period (which would lead to a lessening of the effect of SID rather than any exaggeration).

Method

The experimental set-up was as per Experiment 6A, except that the SID only presented individual vehicle speeds to traffic going in one direction (east). Therefore analysis was only conducted on traffic heading east. Speed was only measured across one hour before, one hour during, and one after SID deployment, as data from the Experiment 6A suggested that speeds two hours after SID deployment were no different to speeds one hour before.

Results

Results of this study showed that there was a speed reduction of 6.74mph from before SID (M = 37.34mph, SD = 6.93mph) to during SID deployment (M = 30.60mph, SD = 4.99mph), as well as the variance in speed being halved from before (48.05) to during (24.91), and 85th percentile speed being reduced by 9mph from before (44mph) to during (35mph). Average speed in the hour after SID deployment rose (M = 35.44mph, SD = 6.11mph), but was 1.9mph less than speed the hour before, and 85th percentile (42mph) was 2mph lower than the hour before.

A one-way ANOVA (Time: Hour before, hour during, hour after) on mean speeds revealed that there was a significant difference effect of Time ($F(2,853) = 88.8$, p <

.01). Bonferroni pairwise comparisons revealed that SID deployment led to a significant reduction in mean speeds ($p < .01$). Speeds increased significantly in the time after SID was removed ($p < .01$), but were still significantly less than the speeds before SID deployment ($p < .01$). There was also a significant difference in variance in speed across time periods ($F(2,853) = 11.28$, $p < .01$), as well as a reduction in 85th percentile speed of 9mph.

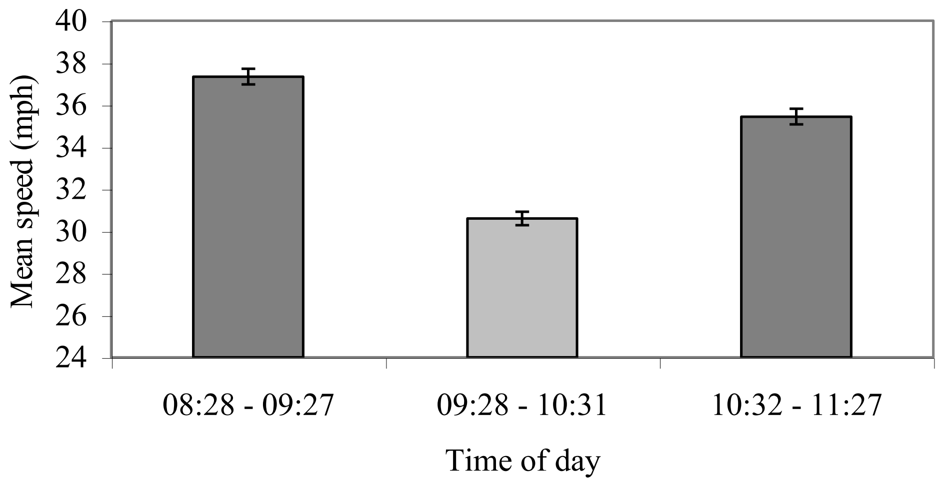

Figure 6.2 Mean speeds in the hours before, during, and after SID deployment at an urban site across peak and off-peak hours.

The results of this study show that SID has an immediate effect in reducing vehicle speed from the hour before to the hour during deployment. Even after the SID has been removed, the speeds remain lower than before SID. The reasons for this are unclear, although it may be that a continued presence of the road safety vehicle could have caused a prolonged speed suppression.

<u>Experiment 6C: SID at an urban site during off-peak hours</u>

The investigation into any speed reduction effect created by SID was continued at the same urban site as in experiment 6B, but during off-peak hours only in order to control for traffic flow and the potential difference in driver characteristics (e.g. commuters and non-commuters). On this occasion, there was a SID presenting individual speeds to vehicles travelling in both directions, and the before, during, and after time periods were increased from one hour to two hours. This was done in order to dilute any potential speed reduction effect caused by the presence of the road safety vehicle whilst erecting and dismantling the SID in the time period immediately before and after deployment.

Method

The experimental set-up was as per Experiment 6B.

Results

A total of 4132 vehicle speeds were recorded at the SID site for the two hours before SID deployment (*n* = 1270), two hours during SID deployment (*n* = 1280), and the two hours after SID deployment (*n* = 1582). There was a 6.28mph reduction in mean speed from before (*M* = 34.82mph, *SD* = 5.86mph) to during SID deployment (*M* = 28.54mph, *SD* = 3.68mph). Mean speed increased by 5.66mph from SID deployment to the hours after SID deployment (*M* = 34.20mph, *SD* = 5.75mph).

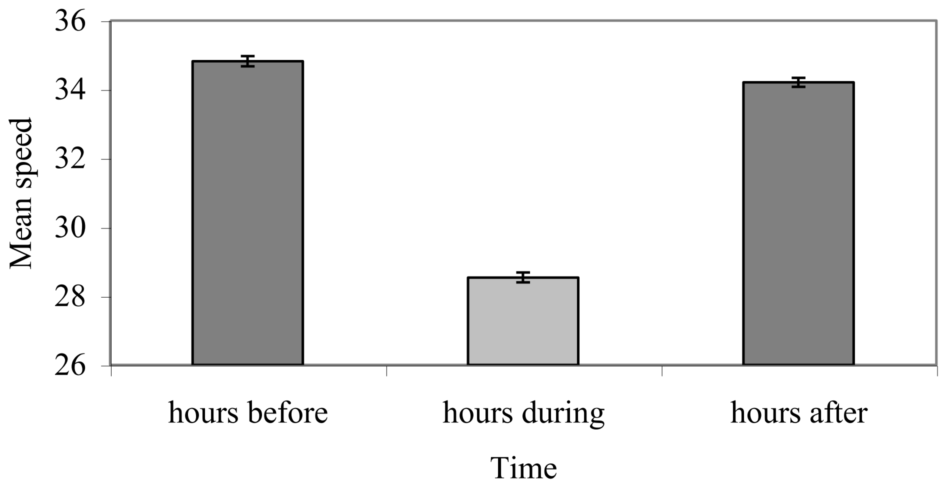

Figure 6.3 The change in mean speed from the hours before, to the hours during, to the hours after SID deployment at an urban site during off-peak hours.

Across the same period there was a similar effect of SID on speed variance, with speed variance reducing from before (55.73) to during SID deployment (36.80), followed by an increase from during SID to after SID deployment (53.66). A Levene's test of equality of error variance revealed that the variance in speed at the three time points was significantly different ($F(2,4129) = 118.93$, $p < 0.01$). The 85th percentile speed was also reduced by 5mph from before SID (41mph) to during SID (36mph), and rose back to the same level as the before SID speed in the hours after deployment (41mph).

A one-way ANOVA (Time: hours before, hours during, hours after) on mean speed revealed a significant main effect of Time ($F(2,4129) = 573.03$, $p < 0.01$). Subsequent pairwise comparisons showed that the 6.28mph reduction in mean speed from the hours before to the hours during SID deployment was significant ($p < 0.01$). The increase in mean speed from the hours during to the hours after SID deployment was also significant ($p < 0.01$). However, the mean speed in the hours after SID deployment was significantly lower by 0.62mph than the hours before SID deployment ($p = 0.01$).

Therefore, there is a significant speed reduction effect of SID during an extended time period for SID deployment of two hours. However, there still appeared to be a small but significant decrease in mean speed from the hours before to the hours after SID (0.62mph), which might be explained by an increase in traffic flow of approximately 300 vehicles during the hours after compared to the hours before and during SID.

Experiment 6D: SID at a rural site during off-peak hours

A second experiment was conducted on vehicle speeds (using a SDR recorder) during the two hours when a SID was deployed, two hours before, and two hours after the SID was deployed, in order to investigate the immediate temporal effect of SID. This was a replication of the study in Experiment 6C, except that the site chosen was a rural village as opposite to an urban carriageway.

Method

The method was as in Experiment 6C.

Results

A total of 1479 vehicle speeds were recorded at the SID site for the two hours before SID deployment ($n = 517$), two hours during SID deployment ($n = 467$), and the two hours after SID deployment ($n = 495$). There was a 4.09mph reduction in mean speed from before (M = 36.24mph, SD = 6.89mph) to during SID deployment (M = 32.15mph, SD = 5.41mph). Mean speed increased by 3.78mph from SID deployment to the hours after SID deployment (M = 35.94mph, SD = 7.07mph). Across the same period there was a similar effect of SID on speed variance, with speed variance reducing from before (47.53) to during SID deployment (29.32), followed by an increase from during SID to after SID deployment (49.96). A Levene's test of equality of error variance revealed that the variance in speed at the three time points was significantly different ($F(2,1476) = 19.24$, $p < 0.01$). The 85^{th} percentile speed was also reduced by 6mph from before SID (42mph) to during SID (36mph), and rose back to 1mph higher than before SID speed in the hours after deployment (43mph).

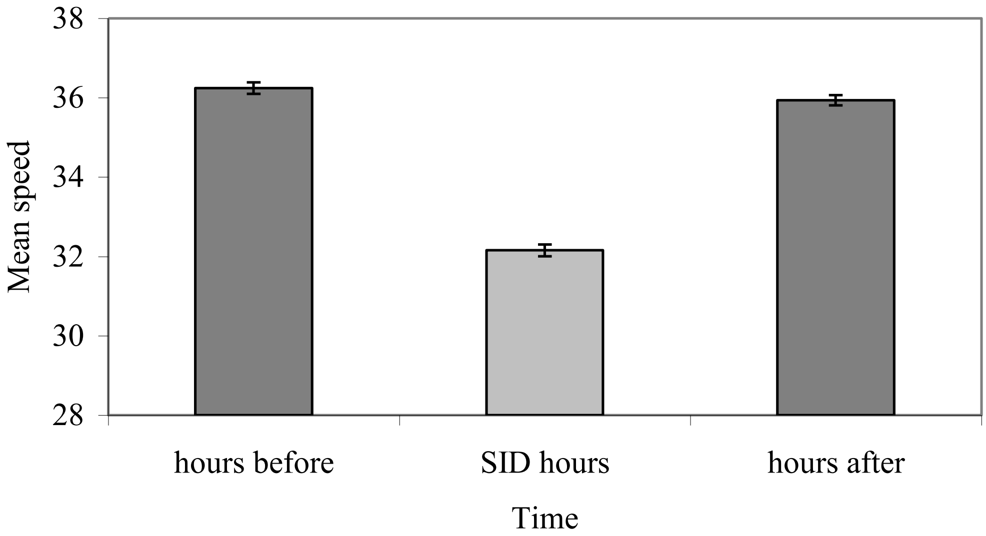

Figure 6.4 The change in mean speed from the hours before, to the hours during, to the hours after SID deployment at a rural site.

A one-way ANOVA (Time: hours before, hours during, hours after) on mean speed revealed a significant main effect of Time ($F(2,1476) = 58.50$, $p < 0.01$). Subsequent Bonferroni pairwise comparisons showed that the 4.09mph reduction in mean speed from the hours before to the hours during SID deployment was significant ($p < 0.01$). The increase in mean speed from the hours during to the hours after SID deployment was also significant ($p < 0.01$). The mean speed in the hours after SID deployment was not significantly lower than the hours before SID deployment ($p = 1.00$).

Therefore, there is a significant speed reduction effect of SID during the time period for SID deployment of two hours. However, this significant decrease in mean speed from the hours before to the hours during SID does not carry over once the SID has been removed.

General conclusion

The results of these four experiments consistently demonstrate the speed reduction effect of SID immediately before, during, and immediately after deployment. Results reveal a significant decrease in vehicle speeds once the speed feedback is presented by SID. In all but one study, vehicle speeds remain lower than before SID deployment after SID has been removed. This suggests that speeds can be reduced when SID is present, and that there is carry-over effect of speed reduction in the hours immediately after SID deployment.

SID effect across spatial location

Further analysis was conducted on the data collected for Experiments 4B/6C at an urban site, and Experiment 4C/6D at a rural site, in order to investigate any spatial effect on speeds due to feedback through SID deployment.

Experiment 7A: Spatial effect of SID at an urban site

Approach speeds were recorded 300m before the SID site, passing speeds were recorded at the SID site, and departing speeds were recorded 300m after the SID site on a 30mph urban carriageway. Through this analysis, it was possible to monitor whether drivers were slowing down for the SID and then speeding up once they had passed, similar to the study on speeding behaviour around fixed cameras (see experiment 1A), on top of the temporal analysis previously conducted in Experiments 4-6.

Method

Three speed detection radars (SDR) were used to measure vehicle speed on a 30mph road, one positioned at 300m before the SID site, one at the SID site, and one 300m after the SID site. All SDR were placed unobtrusively on existing street furniture, and recorded speeds of vehicles passing in both directions. Speeds were recorded over a 72-hour period, in order to provide data on speeds the day before SID deployment, the day of SID deployment, and the day after SID deployment. At total of 100660 vehicle speeds were recorded during this time period, with analysis conducted on subsets of this data.

Due to the limitations of the SDR, it was not possible to track individual vehicles passing through the three data recording points. Therefore, an independent subjects design was employed throughout the analysis.

Results

A total of 11,318 vehicle speeds were recorded at 300m before the SID, at the SID site, and 300m after SID. This was done at the same time on the day before, the day of, and the day after SID deployment in order to investigate the effect of SID on speeds on the approach, at, and departure of the SID site compared to when it wasn't present.

Results revealed that while speeds increased from 300m before SID to SID itself on the day before deployment (4.10mph), and the day after deployment (4.22mph), on the day of deployment there was a 2.70mph reduction in speed from 300m before SID to SID itself. This effect was persistent, with mean speed at 300m after SID still 2.35mph lower than at 300m before SID on the day of deployment, compared to marginally higher speeds at 300m after SID than 300m before SID on the day before (+ 0.17mph) and day after SID deployment (+ 0.26mph). With regards to 85th percentile speed, on both the day before and the day after, the same trend was evident at 300m before SID (39mph), at the SID site (42mph), and 300m after SID (41mph). However, on the day of SID deployment a reduced 85th percentile speed was recorded at 300m before SID (38mph), at the SID site (32mph), and 300m after SID (36mph), with the most dramatic reduction at the SID site (-10mph), and the 300m after SID site (-5mph) compared to the day before and day after. Finally, variance in speed on the day of deployment at the SID site was less than half that of the day before or after.

A one-way ANOVA (Time: day before vs. SID day vs. day after) was conducted on speeds at the 300m before SID location, to investigate whether speeds were equivalent across the three days. Results showed that there was a significant effect of Time on speed ($F(2,3727) = 8.35$, $p < 0.01$). Pairwise comparisons revealed that at 300m before the SID site speed was significantly lower on the day of deployment than the day before ($p < 0.01$) or after ($p < 0.01$), by a margin of 0.92mph and 1.03mph respectively.

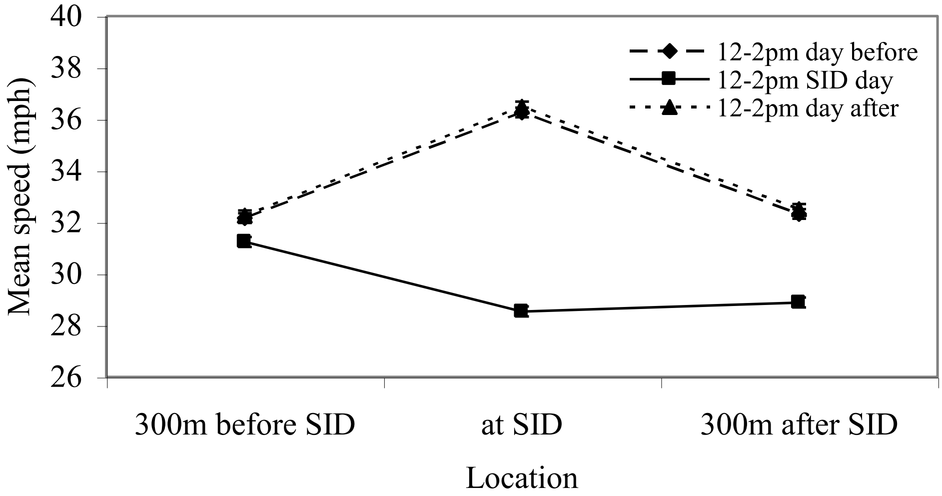

Figure 7.1 The change in mean speed from 300m before, to at SID, to 300m after SID at the same time on the day before, the day of, and day after SID deployment, at an urban site.

A two-way ANOVA (Time: Day before, day during, day after; Location: 300m before, at SID, 300m after) was conducted on mean speeds. Results revealed that there was a significant effect of Time ($F(2,11309) = 462.97$, $p < 0.01$), as well as a significant effect of Location ($F(2,11309) = 141.54$, $p < 0.01$). There was also a significant interaction between Time and Location ($F(4,11309) = 110.07$, $p < 0.01$). Bonferroni pairwise comparisons revealed that while there was no significant differences in mean speed between the day before and the day after ($p = 0.82$), mean speed on the SID day across locations was significantly lower than on the day before ($p < 0.01$) and the day after ($p < 0.01$). Further Bonferroni pairwise comparisons showed that mean speed was significantly different at all three spatial locations ($p < 0.01$). When the SID was not present, mean speed increased from 300m before SID to at SID, and then reduced from at SID to 300m after SID. However, on the day of SID deployment, mean speed decrease from 300m before to at SID, and then rises by only 0.35mph from at SID to 300m after the SID.

<u>Experiment 7B: Spatial effect of SID at a rural site</u>

A replication of Experiment 7A was attempted at a rural location in order to examine whether the spatial effect of SID applies across different sites.

Approach speeds were recorded 300m before the SID site, passing speeds were recorded at the SID site, and departing speeds were recorded 300m after the SID site. Through this analysis, it was possible to monitor whether drivers were slowing down for the SID and then speeding up once they had passed, on top of the temporal analysis previously conducted in experiments 4-6.

Method

The experimental method was as per Experiment 7A.

Results

A total of 4196 vehicle speeds were recorded at 300m before the SID, at the SID site, and 300m after SID. This was done at the same time on the day before, the day of, and the day after SID deployment in order to investigate the effect of SID on speeds on the approach, at, and departure of the SID site compared to when it wasn't present.

Results revealed that while speeds increased from 300m before SID to SID itself on the day before deployment (4.47mph), and the day after deployment (3.32mph), on the day of deployment there was only a 1.57mph increase in speed from 300m before SID to SID itself. This effect was persistent, with mean speed at 300m after SID increasing only by 0.15mph than at SID on the day of deployment. With regards to 85th percentile speed, on both the day before and the day after, the same trend was evident at 300m before SID (42mph and 43mph respectively), at the SID site (43mph and 43.15mph respectively), and 300m after SID (39mph on both days). However, on the day of SID deployment a reduced 85th percentile speed was recorded at 300m before SID (39mph), and at the SID site (36mph), but not at 300m after SID (39mph), therefore the SID deployment led to a 3mph reduction in 85th percentile speed between 300m before and at SID. Finally, there was a greater reduction in speed variance from 300m before to at SID on the day of deployment (72.37 to 29.32) than on the day before (80.48 to 46.15), or the day after (92.59 to 60.51).

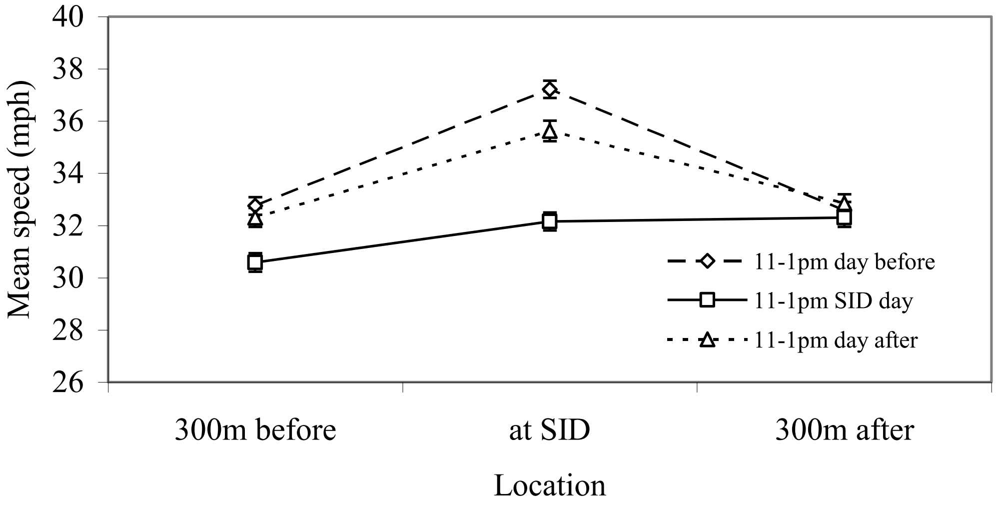

Figure 7.2 The change in mean speed from 300m before, to at SID, to 300m after SID at the same time on the day before, the day of, and day after SID deployment at a rural site.

A two-way ANOVA (Time: Day before, day during, day after; Location: 300m before, at SID, 300m after) was conducted on mean speeds. Results revealed that there was a significant effect of Time ($F(2,4187) = 42.53$, $p < 0.01$), as well as a significant effect of Location ($F(2,4197) = 64.42$, $p < 0.01$). There was also a significant interaction between Time and Location ($F(4,4187) = 12.58$, $p < 0.01$). Pairwise comparisons revealed that there was a significant differences in mean speed between the SID day and the day before ($p < 0.01$), and between the SID day and the day after ($p < 0.01$), but there was also a significant difference in speeds between the day before and the day after ($p = 0.04$). Further pairwise comparisons showed that mean speed was significantly different at all three spatial locations ($p < 0.01$). On all days the mean speed increased from 300m before SID to at SID. However, on the day of SID deployment the increase in mean speed increased from 300m before to at SID was less than half the increase in mean speed on the day before and the day after. Therefore, at a known speeding site where speeds increase at the middle of the road, the SID reduces the increase in speed by over 50%.

<u>Conclusions</u>

It appears that SID has a considerable temporal effect in reducing vehicle speed by around 4-6mph. This is compared to both the same time period on the day before, or the hours immediate before SID deployment. This speed differential is significant when considering the argument that a reduction of 1mph leads to a 5% decrease in accidents (Finch, Kompfner, Lockwood, and Maycock, 1994). This speed reduction effect appears to carry over into both the hours after SID deployment, and the days after SID deployment.

With regards to spatial effect, at two known speeding sites, one urban and one rural location, where there was an increase in speed from 300m before the SID to at the SID, at the urban site the presence of SID caused a drop in speed from 300m before to at the SID. At the rural site, the presence of SID reduced the increase in speed from 300m before to at SID by half the increase when SID wasn't present, leading to a net speed reduction of at least 3mph at the SID sign compared to the day before and after SID deployment. The speed reduction effect 300m further down the road was evident for the urban site, but not for the rural site.

Close following

There has been limited research conducted on the effect of speed calming measures on close following, and whether the safety benefits of a reduction in speed are countered by a reduction in the time gap between vehicles that decreases safety.

Experiment 8: Close following at an urban SID sites

Further analysis was conducted on data collected from Experiments 4B/6C/7A at an urban site, specifically to investigate the time gap between vehicles.

The research question was whether time gap at the SID site on the day of SID deployment was less than on the day before and the day after SID was present due to vehicle bunching together when passing the SID.

Method

Participants

Overall, 11,587 time gaps were measured during the two hour periods on the day before, day of, and day after SID deployment. Time gaps over three seconds were not deemed to be a realistic time between vehicles in a normal traffic flow. Therefore, only time gaps of equal to or less than three seconds between vehicles were used in the analysis (total = 3862). There were 1376 time gaps of equal to or less than three seconds recorded on the day before SID, 1194 on the day of SID, and 1292 on the day after SID deployment.

Apparatus

The same experimental set-up was employed as in Experiment 4B/4C.

Procedure

A speed detection radar (SDR), positioned immediately behind the SID display, recorded the speed of vehicles as they passed the SID display, and also recorded the hour, minute, and second that the vehicle passed. Once all the data had been collected and downloaded from the SDR, the time gap between vehicles was calculated by subtracting the time one vehicle passed from the time of the vehicle that immediately preceded it. In order to assess a realistic close following scenario, only vehicles travelling at equal to or less than three seconds behind the vehicle in front were used in the analysis. Any vehicle travelling at further than three seconds behind another vehicle was not deemed to be close following, or having their speed regulate by the vehicle in front.

Results

Raw data revealed a 90ms increase in time gaps from the day before to the day of SID deployment (+4.69%), and a 120ms increase in time gaps from the day of SID deployment to the day after (-5.75%).

Table 8.1 Descriptive statistics for time gaps of less than three seconds between vehicles on the day before, during, and day after SID deployment

	M gap	*SD*	N	*M* speed
Day before	1.98	0.76	1376	32.35
During SID	2.07	0.74	1194	28.65
Day after	1.95	0.75	1292	32.87

Levene's test of equality of error variance revealed that there was no significant difference in variance of time gaps from the day before, during and day after SID deployment ($F(2,3859) = 0.07$, $p = 0.94$).

A one-way ANOVA (Day: Day before, day during, day after) was conducted on the length of time gaps, and results showed a significant effect of Day on the length of time gaps ($F(2,3859) = 8.56$, $p < 0.01$). Post-hoc Tukey analysis showed that there was a significant increase in the length of time gaps between vehicles from the day before to the day of SID deployment ($p = 0.03$), and a significant increase in the length of time gaps between vehicles from the day of SID deployment to the day after ($p < 0.01$). There was no difference between length of time gaps between vehicles from the day before to the day after ($p = 0.64$). Results are presented in Figure 8.1.

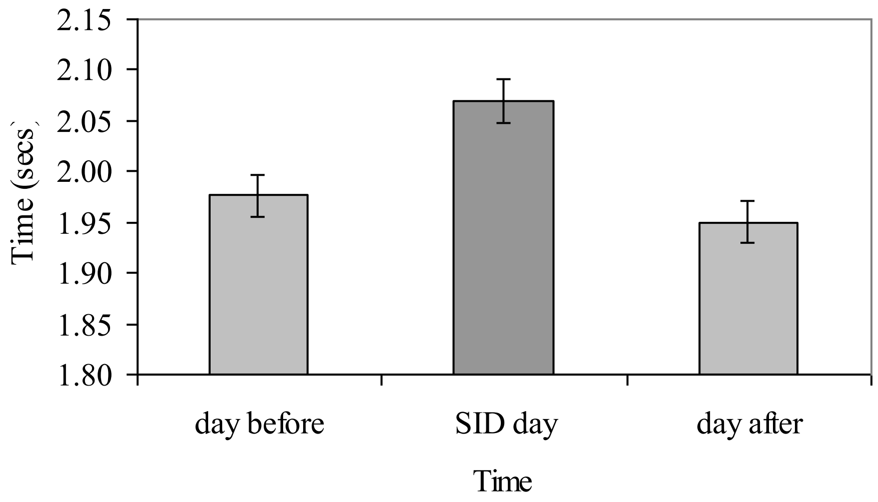

Figure 8.1 Length of time gap between vehicles the day before, day of, and day after SID deployment.

One argument counter to traffic calming devices is that while speeds might be reduced, so is the distance between the cars. This result shows that there is in fact a greater time gap between vehicles when SID is deployed, and therefore a greater amount of reaction time.

Further analysis was conducted by multiplying the average time gap by the average speed of vehicles, in order to calculate what the distance between vehicles was. Results are displayed graphically in Figure 8.2. This suggests that while vehicles are physically closer together when SID is displayed, this is misleading as the time gap is greater during SID deployment due to reduced speeds, and therefore drivers have an increased time in which to react.

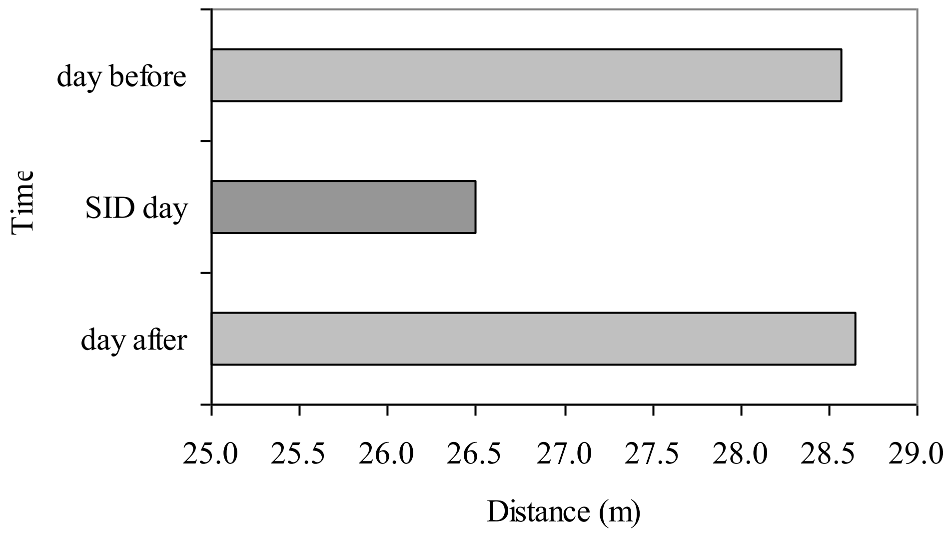

Figure 8.2 Close following distance across days at urban site

Conclusions

This experiment has shown that SID has an enhanced safety component over and above the speed reduction effect seen in previous research, specifically that the time gap between vehicles is extended by at least 4.69%. Therefore, not only is speed reduced when SID is present compared to when it not deployed, but there is greater time for drivers to react despite being physically closer to the car in front. In response to claims that traffic calming leads to close following, the experiment demonstrates that safety is not compromised by close following when reducing speeds at a SID site.

Roadside feedback knowledge

Having demonstrated the effectiveness of roadside feedback devices on reducing vehicle speeds, the mechanisms of its effectiveness remain unknown. It may be that drivers mistakenly perceive it as another form of enforcement

Experiment 9: Driver knowledge/awareness of feedback devices

In order to investigate what the causal effects of reducing speed are when approaching a SID device, a survey of drivers was conducted.

Questionnaires were distributed at a public show from a road safety stand. Items in the questionnaire asked for drivers' demographics (gender; age; years driving), as well as whether drivers had driven past and/or read about both safety cameras and SID, and whether they thought the numbers of either device should increased, decreased or stay the same.

The aim of the questionnaire was to assess driver knowledge of SID compared to knowledge of safety cameras. It was hypothesised that more drivers correctly know the consequences of speeding past a safety camera, compared to speeding past a SID. With regards to the behaviour and social norm items of the questionnaire, it was hypothesised that drivers would slow down if their speed was above 30mph if they approached a safety camera and a SID, as well as reporting that others would expect them to slow down for both a safety camera and SID. Finally, it was hypothesised that a greater proportion of drivers would be in favour of increasing SID than safety cameras.

Results

A total of 140 questionnaires were returned. Thirteen questionnaires were incomplete, leaving a total of 127 questionnaires for data analysis. There were 67 male respondents (*M* age = 42.96, *SD* = 12.88), and 60 female respondents (*M* age = 42.87, *SD* = 11.67). Males reported having more driving experience (*M* = 24.14 years, *SD* = 12.52) than female drivers (*M* = 20.80 years, *SD* = 11.52), but this difference was not significant ($t(125) = 1.56$, $p = .12$).

Table 9.1 Sum responses to the questionnaire items relating to experience of safety cameras and SID.

Item	Device	N	Yes	No	Don't know
Have you ever driven past one of these roadside devices before?	Camera	127	123	4	0
	SID	127	117	10	0
Before today have you ever read information about the function of these devices	Camera	127	75	51	1
	SID	127	59	67	1

The data presented in Table 9.1 shows that the majority of drivers had driven past both a safety camera (96.85%), and a SID (92.13%) before, illustrating comparative levels of experience with both the traditional enforcement device of the safety camera, and the new feedback device of the SID. Participants were then asked whether they knew the function of each device. Figure 9.1 illustrates that the majority of participants were aware that if a vehicle drives past a safety camera above the speed limit, the driver will be liable to receive fine/points on their licence (95.28%), and if a vehicle drives past a SID above the speed limit, the driver will not be liable to receive fine/points, but receive feedback about the speed they are travelling at (87.40%).

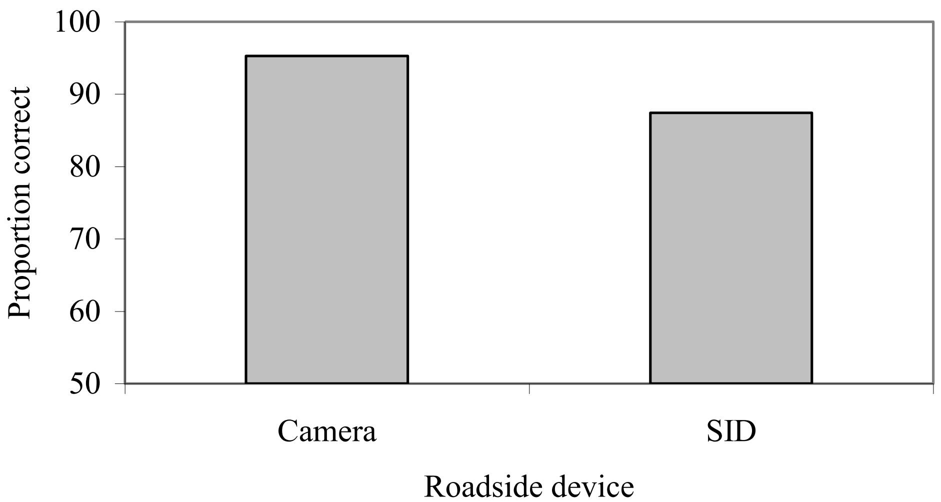

Figure 9.1 Proportions of correct responses about the consequences of driving past a safety camera or SID over the speed limit.

With regards to the behaviour and social norm items of the questionnaire, Table 9.2 shows that the majority of participants reported that they would slow down if their speed was above 30mph if they approached a safety camera and a SID, as well as reporting that others would expect them to slow down for both a safety camera and SID. A dependent test revealed that there was no significant difference in the ratings participants gave about whether they would slow down ($t(126) = 1.20$, $p = .23$), but there was a significant difference between ratings of whether others would expect them to slow down ($t(126) = 3.10$, $p < .01$), with participants agreeing more strongly with the statement that others would expect them to slow down for a safety camera (*M* rating = 4.28, *SD* = .83), than the statement that others would expect them to slow down for a SID (*M* rating = 4.07, *SD* = .85).

<u>Table 9.2</u> Sum responses to the questionnaire items relating to experience of safety cameras and SID.

Item	Device	Totally disagree	Disagree	Neither	Agree	Totally agree
If my speed was above 30mph as I approached this device, I would reduce my speed	Camera	4	4	6	49	64
	SID	2	4	9	62	50
If my speed was above 30mph as I approached this device, most people I know would expect me to reduce my speed	Camera	3	1	9	58	56
	SID	2	6	11	70	38

Finally, Figure 9.2 illustrates that drivers were mixed over whether the number of safety cameras should increase, decrease, or stay the same, but were overwhelmingly in favour of increasing SID.

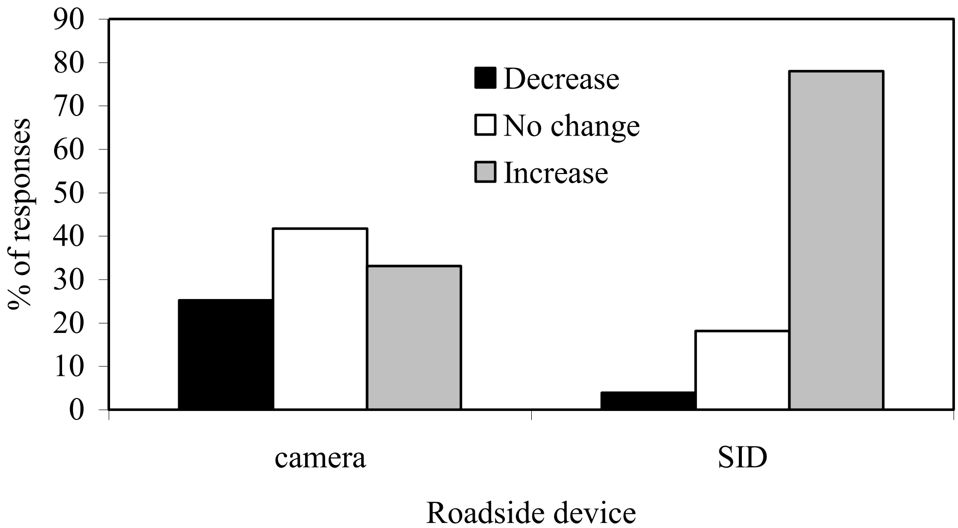

Figure 9.2 Sum responses on whether the number of safety cameras and SID should be decreased, stay the same, or increase.

Discussion

Results show that drivers have had similar experience of both enforcement devices (safety cameras), and feedback devices (SID), and are aware of their function. However, despite knowing that driving past SID at over 30mph will not result in any punishment, drivers report that they would act the same as they would at a safety camera, and reduce their speed. This is also in light of their reporting that others would be less likely to expect them to slow down for SID than for safety cameras. The issue of enforcement appears not to be the motivating factor in slowing down for SID, and this behaviour, either reported (as in this experiment) or in situ (as in the previous experiments), cannot be easily explained by the pressure of social norms. The underlying mechanisms for drivers to reduce their speed therefore remains unclear, and more detailed probing of drivers' attitudes is required.

Finally, with regards to drivers attitudes about the number of these devices, responses to increasing, decrease, or keeping safety camera numbers the same are equivocal, whereas drivers' attitudes to SID are more accepting, with 77.95% of drivers stating that the numbers of SID should be increased (compared to 33.07% for safety cameras). It should also be noted that there were more people who believed that there should be an increase in safety cameras than those who believe that there should be a decrease in safety cameras.

In summary, drivers are familiar with SID and understand its function is as a feedback device. Despite no threat of enforcement, drivers will slow down for a SID in the same manner that they would slow down for a safety camera. Furthermore, drivers report being supportive of increasing SID numbers on the roadside.

Experiment 10A: Ratings to speed and other community problems

A second survey aimed to investigate what issues were ranked as the greatest problems in an urban and a rural community. This was in part to test the degree to which participants felt each problem was a concern in their area, and in part to provide results to support an initial survey in the same communities which revealed that speeding motorists were ranked as the biggest problem in their areas. This finding prompted the introduction of a Community Speedwatch Project (CSP) in two test communities, one urban and one rural. The CSP is a scheme that trains members of the local community to address anti-social driving through the use of SID.

Before and after comparisons

Once the national reassurance community speedwatch project has been fully implemented, and speed management through the use of SID by local community members has been conducted on a regular basis at the test sites, the survey will be distributed again in order to assess any change in perceptions of local problems, the awareness of SID use in the local community, the behavioural, moral, and social norm ratings regarding the effect of SID, as well as the social acceptability of SID.

Method

Participants

Two trial neighbourhoods were selected within Thames Valley, in order to represent one urban and one rural community. A total of 4300 questionnaires were delivered by hand to all households in two neighbourhoods, 2,300 in the rural community, and 1,900 in the urban community. A freepost envelope was included with the questionnaire. Respondents were categorised by sex and age groups, with age groups defined as 0-16, 17-25, 26-40, 41-60, 61-70, and 71 and over.

Stimulus material

An integral feature of the national reassurance CSP is using citizen-focused policing to target visible crime and disorder, and engaging the local people in identifying the key problems in their area. An initial survey of all households in the target communities revealed that, out of a list of twenty-two issues, participants ranked the following ten issues as the greatest problems in their area (in alphabetical order): Antisocial behaviour from children or youths; burglary; drug abuse or drug dealing;

fear of going out at night; fly tipping; litter; noise at night; speeding motorists; under-age drinking; and vandalism or criminal damage. These ten problems then served as the list of issues in the current questionnaire that participants were asked to rate on a five point scale (1 = not concerned; 5 = very concerned). This enabled us to confirm findings of the initial survey, as well as take a measure of the degree to which participants felt each issue was a problem.

Results

The total number of questionnaires returned was 1218. The return rate was 29.35% for the village community, and 28.68% for the urban community, making a total return rate of 29.00%.

Community analysis

A total of 1115 participants completed ratings of all 10 problems. The mean ratings of participants' level of concern for individual problems are presented below in Figure 10.1, illustrating that 'speeding motorists' were rated as the problem of most concern across both communities.

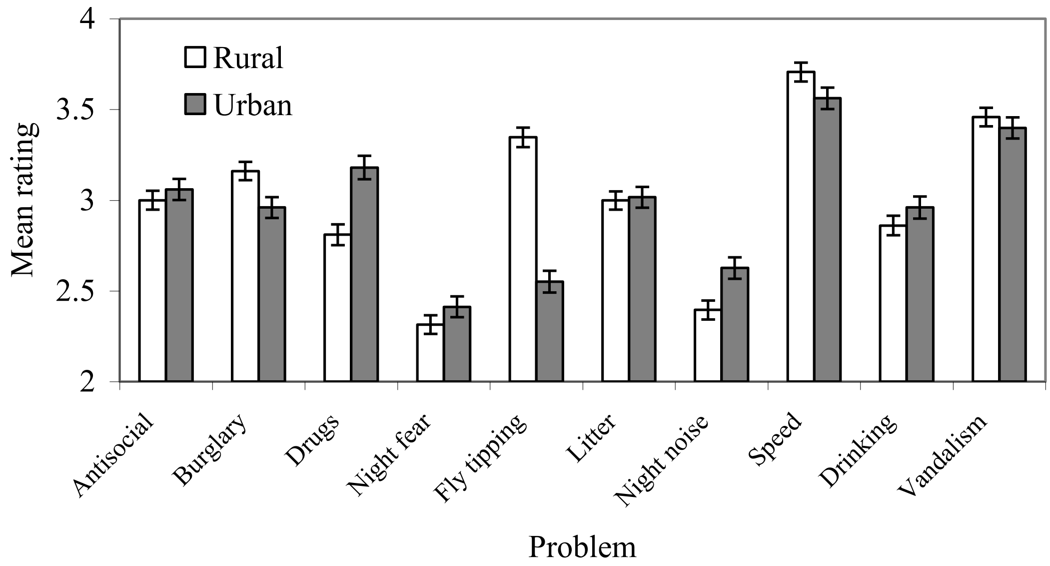

Figure 10.1 Mean ratings of participants' level of concern for individual problems (1 = not concerned; 5 = very concerned), as a function of site.

In order to compare ratings as a function of community site (see Figure 2) A two-way ANOVA (Site: Urban, rural; Problem: Antisocial, burglary, drugs, night fear, fly tipping, litter, night noise, speed, drinking, vandalism), with repeated measures on the last factor revealed a significant effect of Problem on mean ratings (F (7.59, 8527.04) = 159.13, $p < .01$, $\eta^2 = .12$). Within-subjects contrasts revealed that 'speeding motorists' were rated as a significantly greater concern than all other problems ($p < .01$). There was no significant effect of Site (F (1, 1123) = .34, $p = .56$, $\eta^2 < .01$), but there was a significant Problem x Site interaction (F (7.59, 8527.04) = 28.75, $p < .01$, $\eta^2 = .03$).

With both communities rating speeding motorists as the problem they are most concerned about, data from the remainder of the questionnaire, relating to driving behaviour, SID awareness, and social acceptability of SID, was collapsed across both communities for further analysis on gender effects (male, female), and age group effects (0 – 40, 41 – 60, 61+).

In order to analyse gender effects on ratings of community problems, a two-way ANOVA (Gender: Male, female; Problem: Antisocial, burglary, drugs, night fear, fly tipping, litter, night noise, speed, drinking, vandalism), with repeated measures on the last factor revealed a significant effect of Problem on mean ratings (F (9, 10017) = 163.13, $p < .01$, $\eta^2 = .13$), and a significant Problem x Gender interaction (F (9, 10017) = 11.49, $p < .01$, $\eta^2 = .01$), but no significant effect of Gender (F (1, 1113) = .03, $p = .87$, $\eta^2 = .00$). Planned Comparisons using independent t-tests revealed that females reported significantly greater concern than males for speeding motorists (t(1193) = 2.86, $p < .01$), and fear of going out a night (t(1185.07) = 6.57, $p < .01$), whereas males reported significantly greater concern than females for vandalism (t(1183.10) = 2.34, $p = .02$). Males actually rated their concern about vandalism (M = 3.55, SD = 1.25) slightly higher than speeding motorists (M = 3.54, SD =1.34), but there was no significant difference between ratings for both problems (t(542) = .35, p = .73, 95% CI: -.15 to .10). See Figure 10.2 for an illustration of mean ratings for each problem as a function of gender.

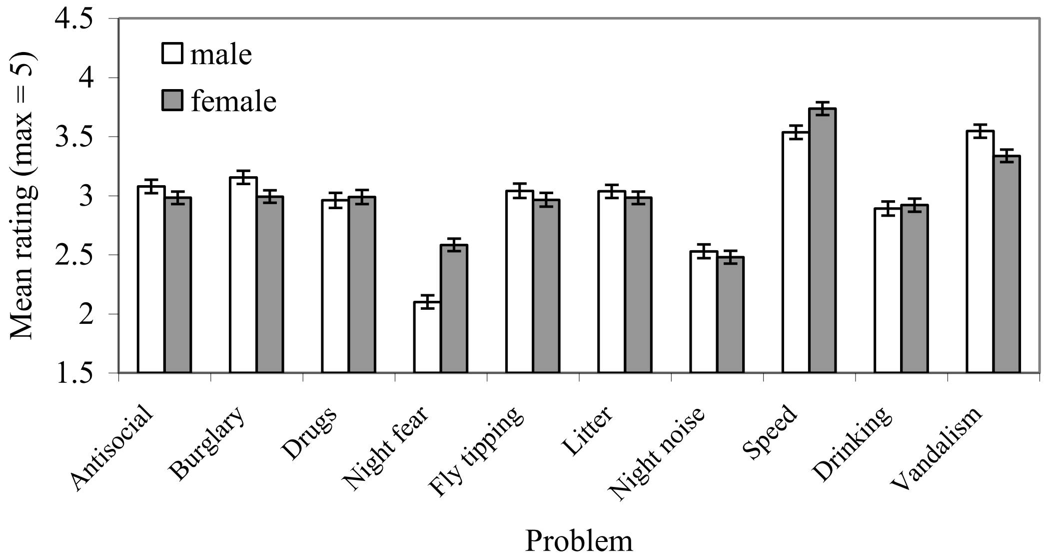

Figure 10.2 Mean ratings of participants' level of concern for individual problems (1 = not concerned; 5 = very concerned), as a function of gender.

For analysis of age effects on ratings of community problems, a two-way ANOVA (Age: 0 - 40, 41 – 60, 61+; Problem: Antisocial, burglary, drugs, night fear, fly tipping, litter, night noise, speed, drinking, vandalism), with repeated measures on the last factor, revealed a significant effect of Problem on mean ratings (F (9, 10062) = 147.52, $p < .01$, $\eta^2 = .12$), and a significant effect of Age (F (1, 1118) = 30.95, $p < .01$, $\eta^2 = .05$). There was also a significant Problem x Age interaction (F (18, 10062) = 5.93, $p < .01$, $\eta^2 = .01$). Post-hoc Tukey tests revealed that mean ratings across all problems by the 0-40yrs age group were significantly lower than both the 41-60yrs group ($p < .01$), and the 61+yrs group ($p < .01$), with no difference in mean ratings between the 41-60yrs and 61+yrs groups ($p = .10$). Further analysis on ratings for 'speeding motorists' alone, using a one-way ANOVA (Age: 0 - 40, 41 – 60, 61+), revealed a significant effect of age group (F (2, 1199) = 3.43, $p = .04$, $\eta^2 = .01$), with post-hoc Tukey tests revealing no significant difference between 0-40yrs and 41-60yrs ($p = .50$), and 41-60 and 61+yrs groups ($p = .21$), for level of concern about speeding motorists, but a significant difference between 0-40yrs and 61+yrs groups ($p = .03$).

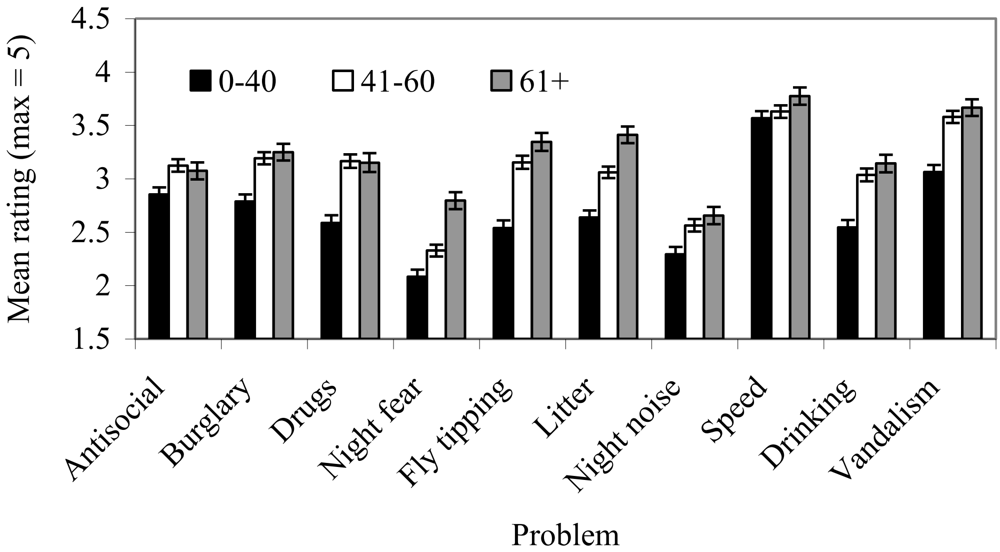

Figure 10.3 Mean ratings of participants' level of concern for individual problems (1 = not concerned; 5 = very concerned), as a function of age group.

Experiment 10B: Attitudes to speeding

An additional analysis was conducted on gender differences in perceptions of local problems, ratings of behavioural, moral, and social norm items regarding the effect of SID, and responses regarding the social acceptability of SID.

Method

The moral norm of driver behaviour was tested by asking participants to indicate their agreement or disagreement with the contention that 'It is acceptable to drive down 30mph residential streets at 35mph', on a scale from one to five (1 = totally disagree; 5 = totally agree). The moral norm of speed enforcement was tested by asking participants to indicate their agreement or disagreement with the contention that 'It is acceptable to enforce speed limits on 30mph residential streets', on a scale from one to five (1 = totally disagree; 5 = totally agree).

Participants' were then presented with a picture of a SID and asked to respond yes, no, or don't know regarding whether they had ever driven past one, seen one in their neighbourhood, and seen/read any information about the devices. This was a gauge of general driver awareness of SID, so that the response frequencies before and after the national reassurance project launch could be compared, and thus assess whether the project raised awareness of SID. Participants were also given the following statement 'If a vehicle drives past this device above the speed limit, will the driver…', and asked to respond by ticking either 'Be liable to receive fine/points on their licence' or 'Not be liable to receive fine/points, but receive feedback about the speed they are travelling at'. This was to assess whether driver understanding of what SID does changes over time by allowing comparison between response frequencies before and after the project.

Participants were then asked to indicate the extent of their agreement or disagreement with a series of statements, on a scale from one to five (1 = totally disagree; 5 = totally agree), each statement addressing behavioural or normative beliefs in order to measure attitude to the behaviour and subjective norm.

Behavioural intention:	If my speed was above 30mph as I approached this device, I would reduce my speed.
Subjective norm:	If my speed was above 30mph as I approached this device, most people I know would expect me to reduce my speed.
Police enforcement:	If my speed was above 30mph as I approached this device, I would reduce my speed for fear of police detection
Moral norm:	If my speed was above 30mph as I approached this device, I would reduce my speed because I ought to, and not for fear of police detection.

Finally the social acceptability of SID was assessed by the item 'Do you think we should increase or decrease the number of these devices?', which participant were require to tick either decrease, stay the same, or increase.

Results

Attitudes to speed limits and enforcement

An independent t-test revealed that females (M = 1.76, SD = .98) disagreed more than males (M = 1.94, SD = 1.05) with the statement 'it is acceptable to drive down a 30mph residential street at 35mph' ($t(1194) = 3.14$, $p < .01$, 95% CI: .07 to .30). A second independent t-test showed that females (M = 1.76, SD = .98) agreed more than males (*M* = 1.76, *SD* = .98) with the statement 'it is acceptable to enforce speed limits on 30mph residential streets' ($t(1196) = 2.82$, $p < .01$, 95% CI: .05 to .26).

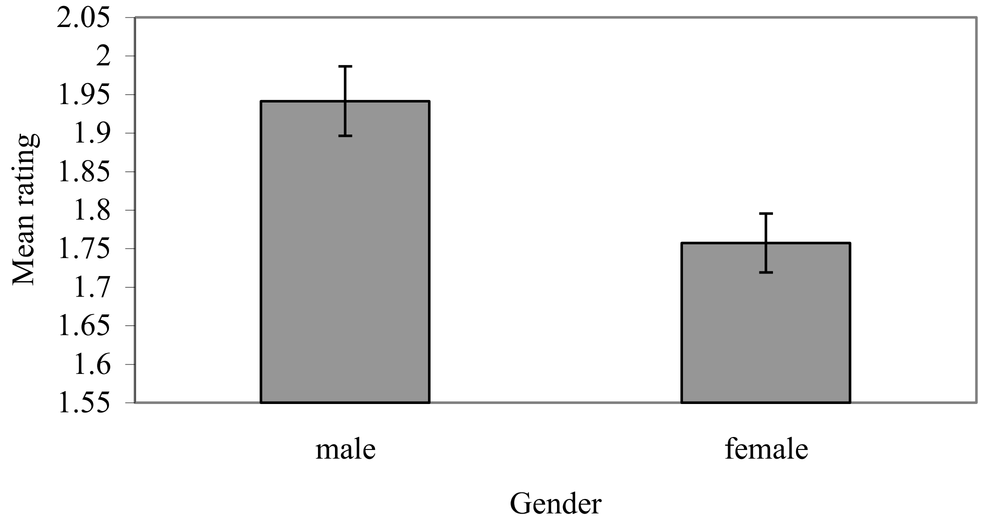

Figure 10.4 Male and female ratings for attitudes towards driving at 35mph in a 30mph residential street (1 = totally disagreed; 5 = totally agreed)

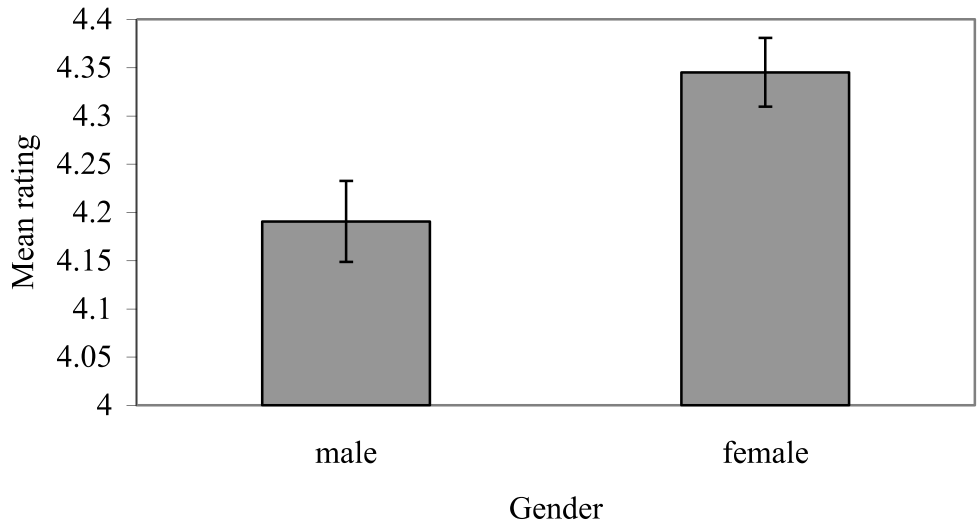

Figure 10.5 Male and female ratings for attitudes towards enforcing speed limits on 30mph residential streets (1 = totally disagreed; 5 = totally agreed)

For analysis of any age effects, a one-way ANOVA (Age: 0 - 40, 41 – 60, 61+) revealed that there was a significant effect of age on mean ratings for driving at 35mph in a 30mph residential street (F (2, 1198) = 6.75, $p < .01$, $\eta^2 = .01$). Post-hoc Tukey tests revealed that the 61+yrs age group disagreed more than both the 0-40yrs ($p = .01$) and the 41-60yrs age groups ($p < .01$) with the statement 'it is acceptable to drive down a 30mph residential street at 35mph', but there was no difference between the 0-40yrs and the 41-60yrs age groups ($p = 1.00$).

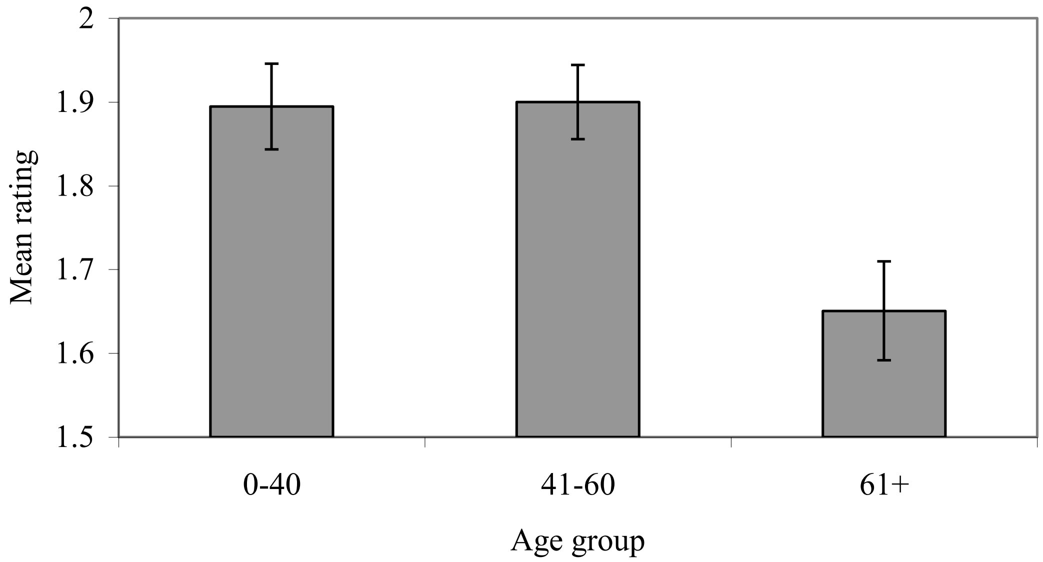

Figure 10.6 Mean ratings for attitudes towards driving at 35mph in a 30mph residential street (1 = totally disagreed; 5 = totally agreed), as a function of age group

A one-way ANOVA (Age: 0 - 40, 41 – 60, 61+) revealed that there was no significant effect of age on mean ratings for enforcing speed limits on a 30mph residential street (F (2, 1198) = 1.37, $p = .26$, $\eta^2 = .00$).

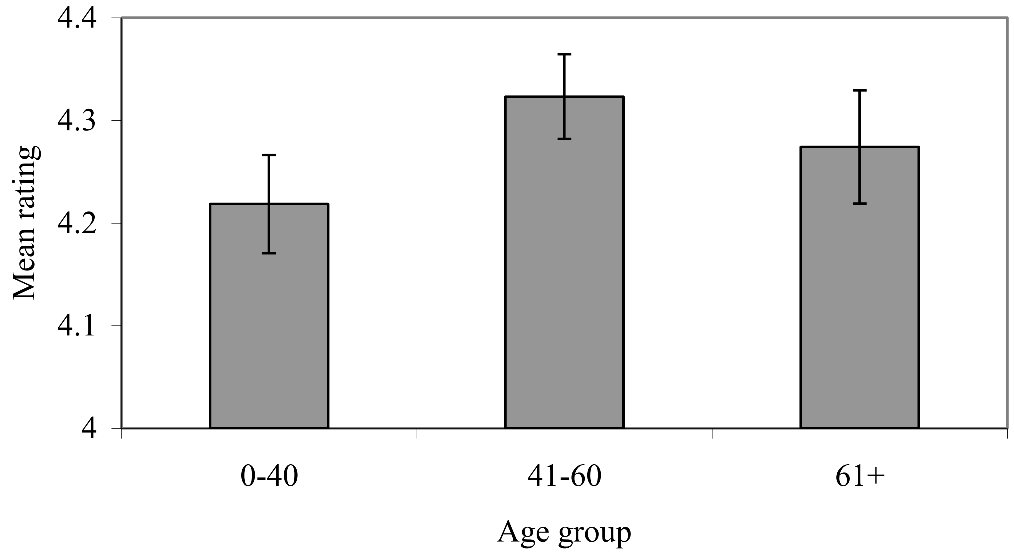

Figure 10.5 Mean ratings for attitudes towards enforcing speed limits on 30mph residential streets (1 = totally disagreed; 5 = totally agreed), as a function of age groups.

SID Knowledge

For assessment of knowledge of SID, analysis was conducted on the whole group, and no gender or age differences were examined. The percentages of all responses to the three items relating to SID awareness are presented in Table 10.1. below. Visual inspection of data reveals that the majority of respondents have driven past a SID before (85.6%), but only just over half have actually seen SID in their neighbourhood (52.8%). Finally, only just over a third of respondents have ever read or heard information about what SID is or does (35.1%).

Table 10.1 Percentages of participants aware of the presence of SID

Question	Yes	No	Don't know	Missing
Have you ever driven past a SID before?	85.6	10.7	2.3	1.4
Have you ever seen SID in your neighbourhood?	52.8	43.8	2.8	0.6
Have you ever seen/heard information about SID	35.1	59.7	4.4	0.9

Participants were then asked whether they knew what the consequences of driving past SID above the speed limit, and given the option of responding that a driver would receive a fine and points on their licence (perceiving SID as an enforcement device), or that a driver would receive feedback about the speed they were driving and not a fine and points on their licence (perceiving SID as a feedback device). Percentage responses for both categories are presented in Table 10.2, and reveal that the majority of participants knew that SID is a feedback device.

Table 10.2 Percentage of participants aware of the function of SID

Question	Fine/points	Feedback	Missing
If a vehicle drives past this device above the speed limit, what will the driver receive?	11.7	82.3	6.0

Attitudes to speed

With regards to the statements regarding behavioural, social norm, enforcement, and moral attitudes to speeding, participants overall agreed that they would slow down if they approached SID travelling above 30mph (M = 4.42, SD = .70), that other people would expect them to slow down (M = 4.19, SD = .77), and that they would slow down because they ought to (M = 4.26, SD = .84). However, on average they rated the statement that they would slow down for fear to police detection more as 'neither agree nor disagree (M = 4.32, SD = 1.22), reflecting the earlier result that 82.3% of participants correctly indicated that they knew SID was a feedback device as opposed to an enforcement device.

A series of independent t-tests were conducted in order to test for any gender effects in responses to each item. Results revealed that females rated all statements significantly higher that males, specifically they agreed more than males with the statement 'If my speed was above 30mph as I approached this device, I would reduce my speed' by a marginally significant difference (t(1180) = 1.94, p =.052, 95% CI: -.001 to .16). Females rated their agreement of the statement 'If my speed was above 30mph as I approached this device, most people I know would expect me to reduce my speed' significantly higher than males (t(1169) = 4.48, p < .01, 95% CI: .11 to .29). Female ratings were also significantly higher in agreement for the statements 'If my speed was above 30mph as I approached this device, I would reduce my speed for fear of police detection' ($t(1157) = 3.56$, $p < .01$, 95% CI: .12 to .40), and for the statement 'If my speed was above 30mph as I approached this device, I would reduce my speed because I ought to, and not for fear of police detection' ($t(1169) = 2.45$, $p = .01$, 95% CI: .02 to .22). Ratings of all four statements by males and females are displayed in Figure 10.6 below.

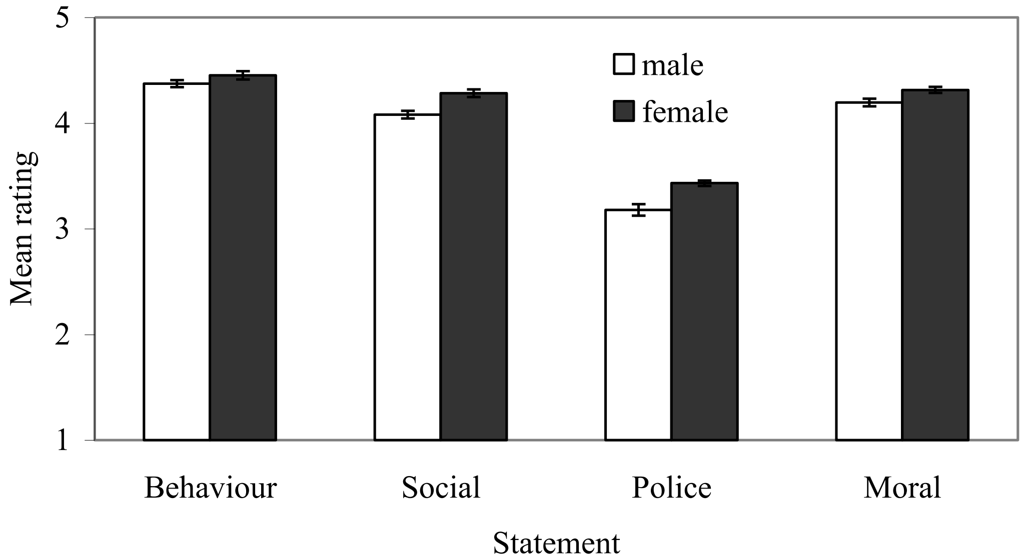

Figure 10.6 Male and female ratings for behavioural, social norm, enforcement, and moral attitudes to speeding (1 = totally disagreed; 5 = totally agreed).

For age differences one way ANOVAs (Age: 0 - 40, 41 – 60, 61+) were conducted on mean ratings of agreement/disagreement with the four attitude statements. Results revealed that there was no effect of age on mean ratings of agreement with the statements 'If my speed was above 30mph as I approached this device, I would reduce my speed' (F (2, 1152) = .05, $p = .95$, $\eta^2 < .01$), 'If my speed was above 30mph as I approached this device, most people I know would expect me to reduce my speed' (F (2, 1152) = 1.11, $p = .33$, $\eta^2 < .01$), and 'If my speed was above 30mph as I approached this device, I would reduce my speed for fear of police detection' (F (2, 1152) = 1.23, $p = .29$, $\eta^2 < .01$). However, there was a significant effect of age on agreement with the statement 'If my speed was above 30mph as I approached this device, I would reduce my speed because I ought to, and not for fear of police detection' (F (2, 1152) = 3.05, p = .05, η^2 < .01). Post hoc Tukeys tests revealed that the 0-40yrs age group's mean level of agreement was significantly less than the 61+yrs age group (p = .04), with no significant difference between the 0-40yrs and 41-60 age groups (p = .29), and the 41-60yrs and 61+yrs age groups (p = .44). Ratings of all four statements by the three age groups are displayed in Figure 10.7 below.

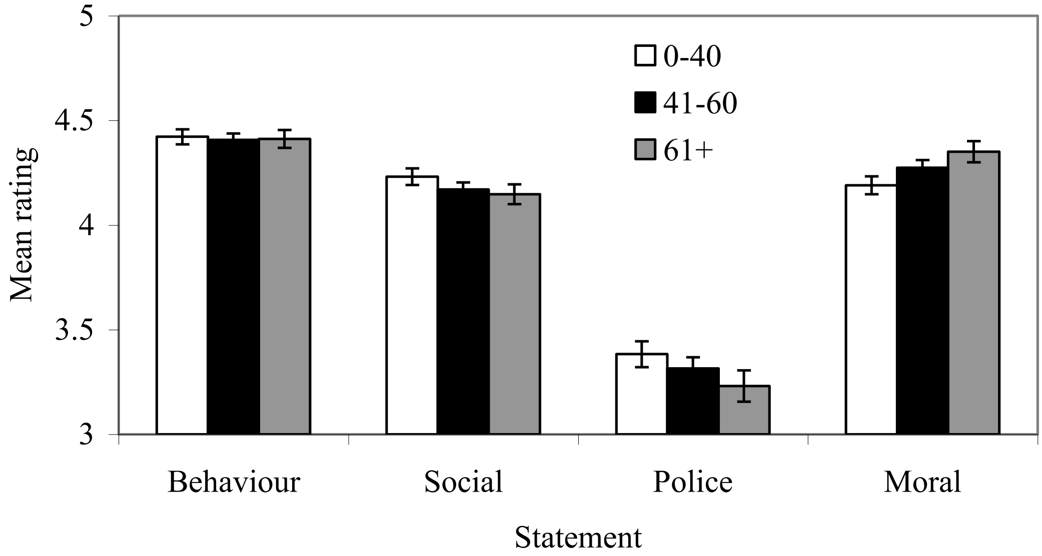

Figure 10.7 Mean ratings for behavioural, social norm, enforcement, and moral attitudes to speeding (1 = totally disagreed; 5 = totally agreed), as a function of age group.

Social Acceptability

Finally, with regards to the social acceptability of SID as a speed management device, participants were asked to rate whether there should be an increase, no change, or decrease to the number of SID deployed.

For gender differences, the percentage of responses are displayed in Figure 10.8, showing that the majority of males (73.3%) and females (80.8%) advocated an increase in the use of SID, and only a small percentage of males (5.4%) and females (1.6%) actually thought there should be a decrease.

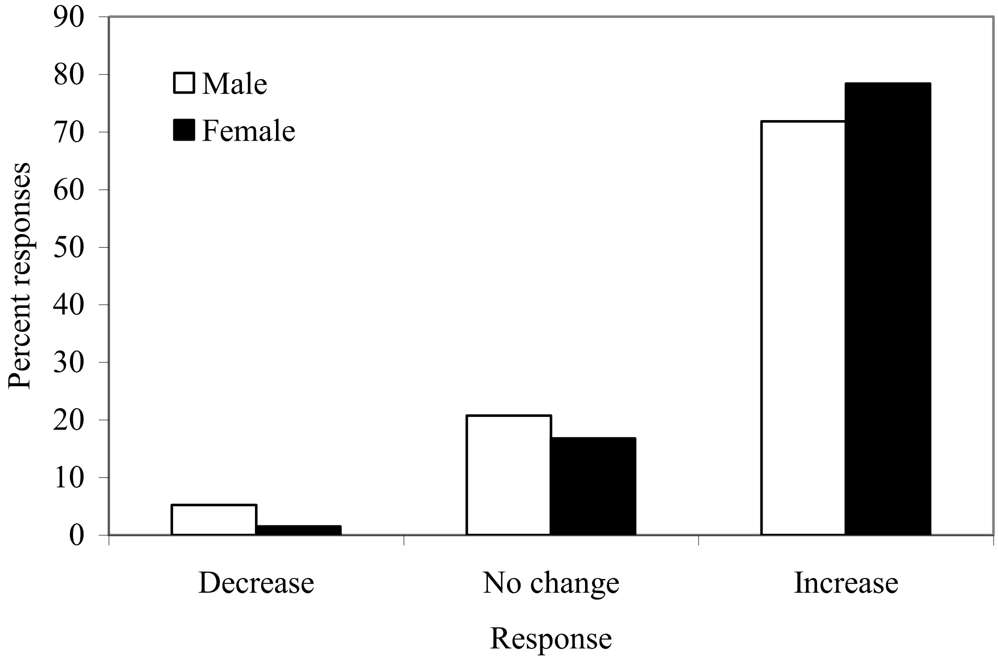

Figure 10.8 Percentage of responses to the number of SID by gender

For age difference, the percentage of responses are displayed in Figure 10.9. Results show that the 0-40yrs age group report the greatest support for an increase in SID (79.64%), followed by the 41-60yrs group (78.47%), with a slightly smaller percentage of the 61+yrs group reporting support for an increase (71.99%).

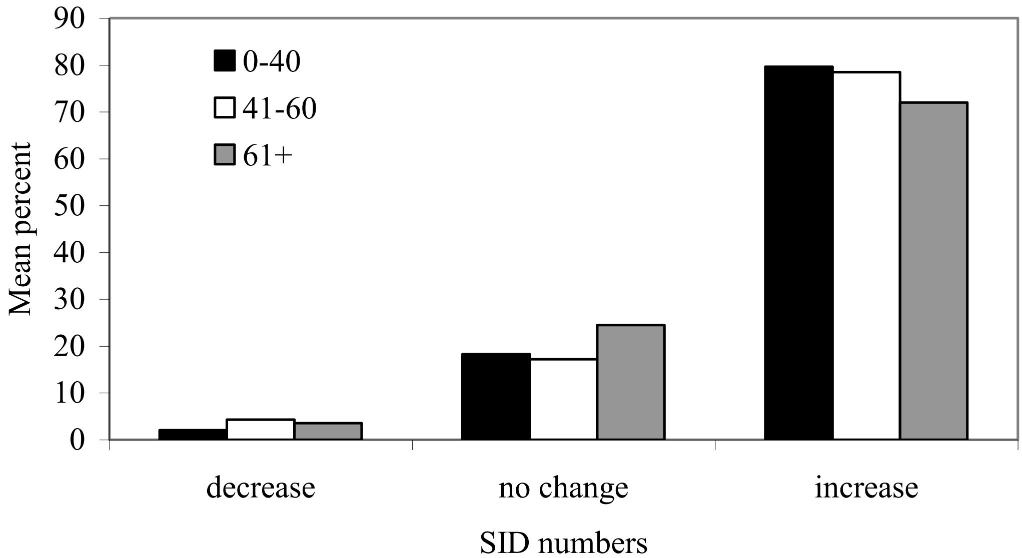

Figure 10.9 Percentage of responses to the number of SID by age group

Discussion

Results of the Experiment 10A have shown that in both rural and urban communities speeding motorists is the problem of greatest concern from local residents, rated significantly greater than the next highest concerns of vandalism and burglary. The level of concern regarding speeding motorists (M = 3.64, SD = 1.31) was between 'Concerned' and 'Quite concerned' on the rating scale. While there was no overall difference in the rating of concern by male and female participants, analysis of ratings for individual problems revealed that females rated 'speeding drivers' and 'fear of going out at night' a greater concern than males did, whereas males rated 'vandalism' as a greater concern than women did. Males also rated their concern with speeding motorists the same as their concern with vandalism. The 0-40yrs age group rated themselves less concerned overall with community problems than the 41-60yrs and 61+yrs groups, and with the 61+yrs group rating themselves more concerned about speeding motorists than the 0-40yrs age group.

When participants were presented with a range of questions relating to driving behaviour in Experiment 10B, there was a significant gender differences found. Females disagreed more than males with the acceptability of driving down a 30mph residential street at 35mph, and agreed more than males with the acceptability of police enforcement on 30mph residential streets. With regards to age groups, the 61+yrs group disagreed more than the other groups with the acceptability of driving down a 30mph residential street at 35mph, but all age groups reported a statistically similar agreement with the acceptability of police enforcement on 30mph residential streets.

With regards to awareness of SID, the majority of participants had driven past a SID before (85.6%), but only just over half (52.8%) had seen a SID in their neighbourhood. Even less had read or seen any information regarding SID (35.1%). These three items will be compared to responses after the Community Speedwatch Project has been introduced to the two neighbourhoods, in order to see whether the project increases the profile of SID. The majority of participants (82.3%) recognised that SID was a feedback device rather than an enforcement device, so it is possible that understanding of the function of SID might not increase after the project has been introduced due to the high level of understanding that already exists.

For the items relating to attitudes and behaviours to SID, overall, participants rated that they agreed with the statements that they would slow down for SID if they approached it at over 30mph, that others would expect them to slow down if they approached at over 30mph, and that they would slow down because they ought to and not because of fear of detection. The average rating for the statement that they would slow down for fear of police detection was lower than all other statements, concurring with the information that most participants were aware that SID was a feedback device and not an enforcement device. However, this item was rated as slightly above the 'neither agree nor disagree' level, which was unexpected, as it was believed that participants knew it was only a feedback device then they would rate themselves as disagree that they would slow down for fear of police detection. This could be due to two factors. First, participants could only respond that the function of SID was either feedback or enforcement with no option to say don't know. Therefore they might be guessing that it is a feedback device, with a neither agree nor disagree to slowing down for fear of police enforcement reflecting their lack of confidence. Second, drivers may believe that it is primarily a feedback device, but that there is still a risk that enforcement could take place, and thus any belief that SID is more than simply feedback means they did not actually disagree that they slow down for fear of police enforcement. Results of analysis on gender differences revealed that females agreed to a greater extent than males with all four statements, illustrating a gender bias to response patterns across all measures. Finally, there were no age differences for the statements relating to behaviour, social norm, and police enforcement statements, but the 60+yrs age group reported greater agreement than the 0-40yrs group with the statement that they would slow down for SID because they ought to, and not for fear of police detection.

With regards to the social acceptability of SID, the majority of respondents indicated that there should be an increase in the number of SID, with females more in favour than males for an increase, and males more in favour than females for a decrease. Interestingly, a greater percentage of 0-40yrs age group advocated an increase in SID than the 61+yrs group, who were more likely to advocate no change in SID numbers.

Future research

Based on the finding that residents' ranked speeding as the greatest concern in their neighbourhood, a structured programme of community-led speed control, using roadside feedback devices, has been created. It is the focus of the research to compare the current 'before' perceptions of speed and other community problems, knowledge of SID, and attitudes to speeding, with a second 'after' survey. This will allow the assessment of whether the implementation of a community speedwatch project leads to a decrease in relative concern regarding speeding motorists compared to other community problems, the specific level of concern regarding speeding motorists, any change in knowledge of SID, and any changes in attitudes to speeding as a result of the project.

References

Casey, S.M., and Lund, A.K. (1993). The effects of mobile roadside speedometers on traffic speeds, *Accident, Analysis and Prevention*, *25*, 627-634.

Corbett, C. (1995). Road traffic offending and the introduction of safety cameras in England: the first self-report survey. *Accident Analysis and Prevention*, *27*, 345-354.

Department for Transport (2004). Managing speeds on our roads. http://www.dft.gov.uk/stellent/groups/dft_rdsafety/documents/pdf/dft_rdsafety_pdf_029005.pdf

De Waard, D. and Rooijers, T. (1994). An experimental study to evaluate the effectiveness of different methods and intensities of law enforcement on driving speed on motorways. *Accident Analysis and Prevention*, *26 (6)*, 751-765.

European Transport Safety Council (1999). Police enforcement strategies to reduce traffic casualties in Europe. http://www.etsc.be/rep_road3.htm.

Finch, D.J., Kompfner, P., Lockwood, C.R., and Maycock, G. (1994). Speed, speed limits and accidents. *Project Report 58 S211G/RB*, Crowthorne: Transport Research Laboratory.

Gains, A., Heydecker, B., Shrewsbury, J., and Robertson, S. (2004). The national safety camera programme: Three-year evaluation report. London: PA Consulting Group.

Harper, J (1991) Traffic violation detection and deterrence: implications for automatic policing. *Applied Ergonomics*, *22*, 189-197.

Hauer, E., Ahlin, F.J., and Bowser, J.S. (1982). Speed enforcement and speed choice. *Crash Analysis and Prevention*, *14*, 267-278.

Holland, C.A., and Conner, M.T. (1996). Exceeding the speed limit: an evaluation of the effectiveness of a police intervention. *Accident Analysis and Prevention*, *28 (5)*, 587-597.

Kennan, D. (2002). Safety cameras – the true effect on behaviour. *Traffic Engineering and Control*, *April 2002*, 154-161.

Kennan, D. (2004). Safety cameras – how do drivers respond? *Traffic Engineering and Control*, *March 2004*, 104-111.

Kronberg, H., and Nilsson, G. (2000). Automatic speed enforcement. Speed behaviour before and after installation of camera boxes on E4 between Iggesund and Hudiksvall. *Swedish National Road and Transport Research Institute*, Report: VTI meddelande 906. http://www.vti.se/pdf/reports/M906.pdf.

Mountain L.J., and Hirst, W.M. (2004). Costing lives or saving lives? A detailed evaluation of the impact of safety cameras on safety, *Traffic Engineering and Control*, vol. 45 (8), 280-287.

Shinar, D., and Stiebel, J. (1986). The effectiveness of stationary versus moving police vehicle on compliance with speed limit. *Human Factors*, *28*, 365-371.

South Gloucestershire Council (2002). Vehicle activated signs report. Road Safety Engineering team. www.southglos.gov.uk/acrobat/roadSafety/VASReport.pdf

Stradling, S.G., and Campbell, M. (2002). The effects of safety cameras on drivers. *Proceedings of the RoSPA 67th Road Safety Congress, March 2002*.

Vaa, T. (1997). Increased police enforcement: Effects on speed. *Accident Analysis and Prevention*, *29 (3)*, 373-385.

Van Houten, R., and Van Houten, F. (1987). The effects of a specific speed prompting sign on speed reduction. *Accident Analysis and Prevention*, 19 (2), 115-117.

Van Houten, R., Nau, P., and Marini, Z. (1980). An analysis of public posting in reducing speed behavior on an urban highway, *Journal of Applied Behavior Analysis*, *13*, 383-395.

Van Houten, R., Nau, P. (1981). A comparison of the effects of posted feedback and increased police surveillance on highway speeding, *Journal of Applied Behavior Analysis*, *14*, 261-271.

Winnett, M.A., and Wheeler, A.H. (2002). Vehicle-activated signs – a large-scale evaluation. TRL Report TRL548.
http://www.trl.co.uk/static/dtlr/pdfs/TRL548.pdf.